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Five-year Spectrum Outlook 2009–2013

ACMA's spectrum demand analysis and indicative work programs for the next five years.

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Canberra Office
Purple Building, Benjamin Offices
Chan Street, Belconnen
PO Box 78,
Belconnen ACT 2616
Tel: 02 6219 5555
Fax: 02 6219 5200

Melbourne Office
Level 44, Melbourne Central Tower
360 Elizabeth Street, Melbourne
PO Box 13112 Law Courts
Melbourne VIC 8010
Tel: 03 9963 6800
Fax: 03 9963 6899
TTY: 03 9963 6948

Sydney Office
Level 15, Tower 1 Darling Park
201 Sussex Street, Sydney
PO Box Q500
Queen Victoria Building NSW 1230
Tel: 02 9334 7700, 1800 226 667
Fax: 02 9334 7799

Foreword

ACMA's *Five-year Spectrum Outlook for 2009 to 2013* (the Outlook) explores the many important issues around current and future expected spectrum demand and sets out ACMA's indicative work programs for the next five years. It outlines the spectrum management approaches, activities and guiding principles that will inform the ongoing consideration and resolution of current and emerging issues and ACMA's priorities and indicative timings.

The Outlook is divided into two publications. This publication outlines the different types of radiocommunications services available, the issues affecting those services and ACMA's strategic approach to addressing them. The second publication contains Appendix D to the Outlook, which includes the Australian frequency audit table. The table provides a detailed description of the various uses of the radiofrequency spectrum and possible future uses.

Rapid technological change is presenting new challenges to traditional approaches to spectrum management, including the traditional, centralised 'command and control' approach. Meeting the increased demand arising from new and increasingly sophisticated radiocommunications technologies is now a key challenge, while reviewing and reassessing our approach to more efficient uses of spectrum offers us new opportunities.

The Outlook includes an assessment of these competing demands for different parts of the radiofrequency spectrum, and explores the merits of the alternative approaches to spectrum management. The framework and tools used to manage the spectrum are being reviewed and revised in the context of the contemporary communications landscape, with the consistent aim of maximising the public benefit derived from the use of the spectrum.

This Outlook is a most tangible part of ACMA's commitment to consultation, cooperation and collaboration with industry, the Australian public, other government agencies and international regulators on all spectrum matters. It is intended to be a 'living document' and will be updated annually, with the first update scheduled to be released at the beginning of 2010. I therefore encourage comment on an ongoing basis.

With this in mind, the Outlook will evolve and continue to be shaped by our ongoing experiences, observations and evaluation of spectrum use in Australia.

Chris Chapman
Chairman

Acknowledgements

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- AsiaSpace
- Asciano Ltd (Pacific National)
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- Australasian Railway Association
- Australian Rail Track Corporation
- Australian Broadcasting Corporation
- Australian Crime Commission
- Australian Maritime Safety Authority
- Australian Mobile Telecommunications Association
- Australian National University
- Australian Radio Communications Industry Association
- Australian Telecommunications Users Group Limited
- Australian Wireless Audio Group
- Bureau of Meteorology
- Commercial Radio Australia
- Commonwealth Scientific and Industrial Research Organisation
- Community Broadcasting Association of Australia
- Consultel IT&T Pty Ltd
- Corruption and Crime Commission of Western Australia
- Department of Defence
- Department of Emergency Services (Queensland Government)
- Ericsson
- Free TV Australia
- Foxtel
- Geoscience Australia
- GHD Pty Ltd
- Gibson Quai-AAS Pty Ltd
- Global VSAT Forum
- Google Australia
- Grant and Jenny Spong
- Horizon Broadband Communications
- Hutchison
- Infrastructure, Transport, Regional Development and Local Government Portfolio (including Airservices Australia, Civil Aviation Safety Authority and Office of Transport Security)
- Inmarsat
- Intel
- Intelsat Asia Carrier Service
- Law Enforcement Security Radio Spectrum Committee
- Motorola
- National Coordinating Committee for Government Radiocommunications
- NSW Government
- NSW Independent Transport Safety and Reliability Regulator
- NSW Police
- Northern Territory Police, Fire and Emergency Services
- Optus
- Ovum Pty Ltd
- Project Outcomes Pty Ltd
- Queensland Rail Network
- Qualcomm
- RailCorp NSW
- Reach Pty Ltd
- Sky Station Australia
- Stratos Global
- Telstra
- Unwired Australia
- Victoria Police
- Victorian Government Radio Spectrum Task Force
- Vodafone
- WiMAX Forum

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1 Introduction

The Australian Communications and Media Authority (ACMA) manages Australia's radiofrequency spectrum. The continual evolution and increasing sophistication of wireless technologies, and the rapidly growing and competing demand for spectrum from different users and services, means that spectrum management is becoming increasingly challenging. Part of ACMA's task is to balance the needs of existing spectrum users with facilitation of spectrum access for new technologies.

The purpose of this *Five-year Spectrum Outlook 2009–2013* (Outlook) is to provide greater insight and transparency for industry about the pressures on spectrum and the direction of ACMA's spectrum management work in the short and medium term, and to facilitate meaningful discussions with stakeholders about emerging pressures for change to spectrum access arrangements.

This Outlook should be considered in conjunction with ACMA's spectrum management principles. The spectrum management principles describe the framework that will guide ACMA's response to the demand pressures identified in this Outlook, and place in context ACMA's intended approach to band-specific issues and other significant spectrum management issues over the next five years. These issues include the rollout of digital television services; the approach to any spectrum released following the cessation of analog television services[1]; government spectrum holdings; expiring spectrum licences; the availability of spectrum for wireless access services (WAS); and options for improving access to the 400 MHz band.

ACMA has also released the *Australian Radiofrequency Spectrum Plan 2009* (the Spectrum Plan), which specifies the allocation of frequency bands to radiocommunications services in Australia. This Outlook and the attached *Appendix D—Frequency Audit Table* (published as a separate document) support the Spectrum Plan by providing more detailed information about the current and possible future use of spectrum in Australia.

The research undertaken by ACMA in the creation of this Outlook indicates increasing competitive pressures on certain parts of the spectrum that have the most desirable characteristics for a range of emerging and evolving applications, particularly in the range 400 MHz to 6 GHz.

[1] ACMA recognises that, under section 31 of the *Radiocommunications Act 1992*, decisions about the future requirements of broadcasting are made by the Minister. These observations apply to radiocommunications decisions within ACMA's purview; for example, about spectrum that may be removed from the broadcasting services bands following the cessation of analog television services.

Although it appears that user demand is outstripping spectrum availability in certain geographic locations, there are also signs that the utilisation of some frequency bands could be improved. Examples of this appear to be the 400 MHz and 900 MHz UHF land mobile and fixed link bands. An indication of congestion in these bands is that many licence applicants have been unable to secure use of the channels they had originally sought and this in turn hinders appropriate utilisation of the band. In some cases, a move to an alternative band can solve the problem, albeit at a potentially higher cost to the prospective licensee. In other cases, the substitutability of such alternative bands is precluded through equipment unavailability or other technical reasons.

Possibly the most significant opportunity to reconsider the arrangements for high- value spectrum is provided by the government decision to switch to digital terrestrial television broadcasting and phase out analog television broadcasts, and the related decisions concerning the spectrum left vacant (the ‘digital dividend’). In addition to options to increase the number of television and/or radio broadcasting services, there are a number of possible non-broadcasting options for the ‘digital dividend’ spectrum such as WAS, which includes cellular mobile telephony (‘3G’ and beyond), wireless broadband access and mobile television. There is also broadcaster demand for the ‘digital dividend’ spectrum for enhanced services and coverage.

This Outlook is part of ACMA’s approach to consultation on spectrum matters, and is intended to provide greater transparency and insight for industry about the direction of ACMA’s spectrum management work. It is intended to be a ‘living document’; that will be updated annually, and is always open to comment and feedback from stakeholders.

1.1 Purpose

This Outlook consolidates the fundamental issues expected to affect the spectrum requirements of key radiocommunications services over the next five years, and outlines ACMA’s proposed actions to address these issues. In addition, it highlights spectrum requirements that could arise for radiocommunications services beyond 2013.

In responding to these issues, ACMA will:

1. review tools used in managing the spectrum, including reviewing its approach to technical frameworks, licensing, setting annual charges for apparatus licences and allocation methodologies;
2. undertake some wide-ranging projects that may affect a number of bands and a wide group of stakeholders, such as:
   - (i) considering various issues relating to government spectrum use following the Independent Review of Government Spectrum Holdings (IRGSH);
   - (ii) assisting the government in determining its approach to any spectrum released following the cessation of analog television broadcasting; and
   - (iii) assisting the government in determining its approach to the management of expiring spectrum licences;. and
3. review its approach to planning, licensing and pricing in particular bands.

The content of this Outlook, particularly the indicative work programs, will be updated annually in response to changing priorities and demands. This Outlook and the consultation processes underlying it are not intended to be a substitute for separate and targeted industry consultation on specific spectrum management issues. For this reason, any observations on proposed approaches to, or solutions for, emerging problems may represent ACMA's preliminary thinking only.

The indicative work programs provided in this Outlook do not reflect all the work ACMA can undertake concerning radiocommunications issues. Items in the work programs predominantly relate to issues that may have a significant impact on spectrum demand or spectrum management over the next five years. ACMA undertakes a range of other work relating to radiocommunications such as:

- changes to the licensing and allocation frameworks to reflect incremental changes to the services available within the current bands; and
- reviewing tools used in managing the spectrum, including reviewing ACMA's approach to technical frameworks, licensing, setting annual charges for apparatus licences and allocation methodologies.

In addition, the work plans will be updated annually, and are not rigid. Indicative work priorities are flexible and may change between editions of the Outlook. New issues can arise at any time, which may require urgent attention from ACMA, and may take precedence over work specified in the Outlook.

The Outlook builds on *From DC to Daylight—Accounting for Use of the Spectrum in Australia* (*From DC to Daylight*), which was published by the Australian Communications Authority in 2004. That publication described for the first time the current users of the radiofrequency spectrum in Australia. This Outlook is more comprehensive in its assessment of current spectrum use and key issues, and introduces indicative work plans, along with more detailed outlines of ACMA's important spectrum planning projects.

Comments on this Outlook will assist ACMA in making decisions about the possible future planning, licensing, pricing and allocation arrangements for the radiofrequency spectrum. However, nothing in it should be taken to bind ACMA or the government to any particular course of action in later processes.

1.2 Methodology

The first phase in the development of this Outlook was the estimation of spectrum requirements for radiocommunications services over the next five, 10 and 15 years. To assist in this work, ACMA engaged several consultants in 2007 to research and gather information on current and future predicted spectrum requirements. The consultants researched Australian and overseas demand studies, and undertook an analysis of Australian trends. Stakeholders also provided the consultants with valuable information about their estimated future spectrum requirements. The information from these consultancies, along with ACMA's own detailed examination of domestic and international trends in spectrum use, formed the basis for identification of the likely future pressure points on spectrum. ACMA then formed its initial thoughts on how spectrum demands might be addressed.

In identifying and discussing spectrum demand it is important to note that 'demand' incorporates both user demand for services as well as pressure from drivers such as World Radiocommunication Conference (WRC) outcomes and international markets. The predicted pressure points and ACMA's proposed initial approaches to managing those pressures have been extracted to form indicative work programs for the next five years.

Though the consultancies attempted to predict spectrum requirements 10 and 15 years into the future, this Outlook focuses primarily on spectrum requirements over the next five years. This is because the rate of developments in wireless technologies means that there is a high level of uncertainty in any predictions beyond this timeframe. Though there is also an inherent degree of uncertainty in predicting spectrum requirements over the next five years, consideration in advance of the likely pressure points on spectrum is valuable for two reasons. First, it should ensure ACMA's work priorities are closely linked to actual emerging demand pressures. Second, it should provide a greater degree of industry certainty about ACMA priorities and promote dialogue with spectrum users about these priorities. Annual updates should keep the plan current and also reflect the reality that predictions are uncertain. This Outlook is designed to provide transparency about ACMA's views on and knowledge of spectrum demand and a preliminary indication of ACMA's proposed approaches to addressing demand pressures.

ACMA would like to thank the stakeholders that provided input to the consultancies, and the public consultation process on the draft Outlook.

1.3 Scope and structure

This Outlook considers the range of the radiofrequency spectrum from about 500 kHz to 80 GHz, though the spectrum between 400 MHz and 6 GHz is generally where most of the competing demand exists.

Some current and future uses of spectrum by the Department of Defence have been considered in this report, including information the Department of Defence contributed to the public consultation process undertaken by ACMA following the release of the draft Outlook (see section 1.4). However, a comprehensive analysis of the Department of Defence's spectrum demands for the future has not been undertaken at this stage and ACMA intends to consult further with the Department of Defence about its spectrum requirements.

Chapter 1 provides an introduction to the Outlook, outlining the purpose and scope of the Outlook, the methodology by which it was created, and details on the consultation process for parties interested in providing submissions.

Chapter 2 contains an overview of ACMA's spectrum management decision-making framework. It outlines the legislative basis for spectrum management in Australia, the spectrum management principles that articulate ACMA's approach to managing and planning the spectrum, and the information-gathering and work planning processes that ACMA uses to manage the spectrum.

Chapter 3 identifies the principal underlying drivers of spectrum demand, which include international developments, technological change, and consumer needs such as mobility and broadband access.

Chapter 4 discusses some of the key spectrum management projects that ACMA will undertake over the next five years. This includes work that will be undertaken to review tools used to manage the spectrum, and wide-ranging projects that may affect a number of bands and a wide group of stakeholders, such as:

- activities resulting from the outcomes of the IRGSH;
- the management of expiring spectrum licences; and

- the approach to any spectrum released following the cessation of analog television broadcasting.

Chapter 5 contains an analysis and estimation of spectrum requirements of the following radiocommunications services over the next five years:

- Aeronautical—includes the aeronautical mobile service, but excludes the aeronautical mobile-satellite service and the aeronautical radionavigation service.
- Broadcasting—includes all terrestrial television and radio broadcasting services.
- Fixed—includes all fixed point-to-point (P-P) systems, but excludes point-to-multipoint (P-MP) fixed wireless access systems (included under WAS).
- Land mobile—includes 'traditional' government and non-government land mobile services.
- Maritime—includes the maritime mobile service, but excludes the maritime mobile-satellite service and the maritime radionavigation service.
- Radiodetermination—includes the radiolocation, radionavigation, and radionavigation-satellite services.
- Satellite—includes the fixed-satellite, mobile-satellite and broadcasting-satellite services.
- Space sciences—includes the radio astronomy service, earth exploration-satellite service, space research service, space operations service, meteorological aids service and meteorological-satellite service.
- Wireless access—includes fixed wireless access (FWA), broadband wireless access (BWA), radio local area networks and mobile telephony services. Mobile television is also included as the method of delivery of this emerging application is more closely linked to BWA than any other service.

For each service, there is also a brief discussion about the spectrum requirements that may arise beyond 2013.

Chapter 6 contains ACMA's indicative spectrum management work programs for the next five years. The first work program contains ACMA's spectrum management projects and tasks categorised into relevant frequency bands or portions of the spectrum. It is based on the assessment of future spectrum requirements undertaken in Chapter 5, and also includes current spectrum management projects (listed in Appendix A). The second work program contains the significant projects discussed in Chapter 4, as well as spectrum management tasks that are not attributable to a specific frequency band.

Appendix A contains information on the frequency bands that ACMA is either currently examining or will soon commence working on. For each band, there is a brief overview of its current usage, identification of the significant issues affecting the band, and an outline of the actions that ACMA will take to address the issues.

Appendix B provides a breakdown of the spectrum into several broad frequency bands for reference.

Appendix C is a detailed list of the acronyms and abbreviations contained in this Outlook.

Appendix D: Frequency Audit Table (separate document) describes allocations and licensing of radiofrequency spectrum in Australia and is current to October 2008. It is provided for information purposes only. The Frequency Audit Table also includes a number of bands formerly associated with the Australian footnote AUS62, as found in the Australian Radiofrequency Spectrum Plan for the 43.5-47 GHz band, which identifies bands that may be used in the future for the purposes of defence. In the Frequency Audit Table, these bands are now identified by the footnote 'F2'.

1.4 Consultation process

The draft Outlook was released prior to ACMA's radiocommunications conference, *RadComms08*, held in Melbourne from 30 April to 2 May 2008. This allowed interested parties to familiarise themselves with the draft Outlook in order to facilitate discussion at the conference.

A public consultation period followed the release of the draft Outlook, during which ACMA invited comments and feedback from industry regarding the information in the Outlook and the value of the initiative more generally. ACMA also sought information from stakeholders regarding spectrum demands and/or any additional issues that stakeholders felt should be addressed in this Outlook. This consultation was intended to facilitate constructive dialogue with stakeholders of the radiocommunications industry and to ensure that their views are adequately reflected in this Outlook.

The consultation period on the draft Outlook formally closed on 31 July 2008. During the comment period, 49 submissions were received, which are available on ACMA's website[2]. These submissions will prove extremely valuable in shaping ACMA's forward thinking on spectrum management.

This Outlook is intended to be a 'living document' that is open to industry feedback at any time. ACMA will update and publish it on an annual basis to take account of changing priorities and demands. As such, ACMA is interested in hearing from parties who would like to discuss the issues raised in this Outlook. ACMA will consider the value of meetings, workshops and seminars based on the level of interest and availability of resources. ACMA's advisory group, the Radiocommunications Consultative Committee (RCC), also provides an opportunity for representatives of the various radiocommunications sectors to engage with ACMA on the issues covered in this Outlook.

The consultation strategy outlined here is in line with ACMA's overall approach to consultation on spectrum matters, which it announced in early 2008[3].

Written comments may be forwarded at any time to:

Manager
Policy and Research Section
Spectrum Planning Branch
Australian Communications and Media Authority
PO Box 78
Belconnen ACT 2616

Fax: (02) 6219 5256
Email: spectrum.outlook@acma.gov.au

Media enquiries should be directed to Donald Robertson, telephone (02) 9334 7980.

[2] *Submissions to the Five-year Spectrum Outlook 2009–2013 discussion paper*, can be found at: www.acma.gov.au.
[3] More detail of ACMA's consultation approach can be found at: www.acma.gov.au.

Any other enquiries may be directed to the Spectrum Outlook Project Manager, telephone (02) 6219 5555 or email spectrum.outlook@acma.gov.au.

1.4.1 PUBLICATION OF SUBMISSIONS

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

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

ACMA will not automatically accept all claims of confidentiality. ACMA will consider each claim for confidentiality on a case-by-case basis. If ACMA accepts a confidentiality claim, it will not publish the confidential information unless required to do so by law.

When can ACMA be required by law to release information?

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 court subpoena. ACMA will seek to consult submitters of confidential information before that information is provided to another body or agency, but ACMA cannot guarantee that confidential information will not be released through these or other legal means.

2 Spectrum management decision-making framework

Legislative basis for Australian spectrum management

ACMA is responsible for managing the radiofrequency spectrum in accordance with the *Radiocommunications Act 1992* (the Act) and section 9 of the *Australian Communications and Media Authority Act 2005* (the ACMA Act). The object of the Act (section 3 included below) provides broad guidance to ACMA in the execution of its spectrum management responsibilities. While not providing detailed guidance, an understanding of the Act's object is an essential starting point in any consideration of Australia's spectrum management environment.

The object of the Act is to provide for management of the radiofrequency spectrum in order to:

- maximise, by ensuring the efficient allocation and use of the spectrum, the overall public benefit derived from using the radiofrequency spectrum;
- make adequate provision of the spectrum:
  - for use by agencies involved in the defence or national security of Australia, law enforcement or the provision of emergency services; and
  - for use by other public or community services;
- provide a responsive and flexible approach to meeting the needs of users of the spectrum;
- encourage the use of efficient radiocommunication technologies so that a wide range of services of an adequate quality can be provided;
- provide an efficient, equitable and transparent system of charging for the use of spectrum, taking account of the value of both commercial and non-commercial use of spectrum;
- support the communications policy objectives of the Commonwealth Government;
- provide a regulatory environment that maximises opportunities for the Australian communications industry in domestic and international markets;
- promote Australia’s interests concerning international agreements, treaties and conventions relating to radiocommunications or the radiofrequency spectrum.

To ensure that these objectives are met, ACMA has developed a number of principles that articulate its approach to managing the spectrum.

Spectrum management principles

The principles are intended to guide ACMA's management of the radiofrequency spectrum within its existing legislative responsibilities and government policy settings. The key theme of the principles is that maximising the overall public benefit from use of the radiofrequency spectrum requires balanced application of both regulatory and market mechanisms.

The principles have been adopted by ACMA but will not (and cannot) override the law, such as the *Radiocommunications Act 1992* (the Act) and other relevant legislation. ACMA's decision-making processes are conducted in accordance with statutory requirements and, in particular, are guided by the object of the Act. The principles therefore provide additional guidance to stakeholders about the approach that ACMA will take to decision-making.

ACMA decision-making is also subject to other law such as ministerial direction. For example, section 14 of the *Australian Communications and Media Authority Act 2005* provides that the Minister for Broadband, Communications and the Digital Economy may give written directions to ACMA in relation to the performance of its functions and the exercise of its powers. ACMA must perform its functions and exercise its powers in accordance with such a direction.

ACMA will take account of the principles of good regulatory process outlined in *Rethinking Regulation: Report of the Taskforce on Reducing the Regulatory Burden on Business* (Regulation Taskforce 2006)[4]. In accordance with those principles, ACMA recognises that effective consultation with affected parties at all stages of the regulatory cycle is an integral element of the spectrum management process.

ACMA will use a total welfare standard as its overarching framework for assessing the costs and benefits of different regulatory and market mechanisms for specific spectrum management issues, where appropriate. ACMA recognises that the assessment of costs and benefits using a total welfare standard approach will often need to take into account both quantitative and qualitative factors.

ACMA's spectrum management principles are consistent with the principles of good regulatory process. They provide directions that will generally result in welfare being maximised and, together with use of a total welfare standard, articulate ACMA's proposed standard approach to spectrum regulation. ACMA's decision making framework, including the principles and total welfare standard, is set out schematically in Figure 1.

In summary, the principles are as follows:

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

More information about each of the principles is provided below.

[4] The Report can be accessed from: www.regulationtaskforce.gov.au,

1. ALLOCATE SPECTRUM TO THE HIGHEST VALUE USE OR USES

The first paragraph of the object of the Act is to maximise the overall public benefit derived from using the radiofrequency spectrum, by ensuring the efficient allocation and use of the spectrum (s.3(a)).

Public benefit will be maximised where spectrum is allocated to the highest value use or uses, i.e. the use or uses that maximise the value derived from the spectrum by licensees, consumers and the wider community.

The second paragraph of the object of the Act explicitly requires that adequate provision of spectrum be made for use in the defence or national security of Australia, law enforcement or emergency services, and for use by public or community services (s.3b). In assessing the highest value use or uses of the spectrum, ACMA will also consider this paragraph of the object of the Act, the community benefits derived from these services and any other relevant matters.

2. ENABLE AND ENCOURAGE SPECTRUM TO MOVE TO ITS HIGHEST VALUE USE OR USES

ACMA will seek to set conditions of use that will allow and encourage spectrum licensees to move spectrum to its highest value use or uses with a minimum of regulatory intervention.

The highest value use of spectrum will change over time as technology develops, consumer and social preferences evolve, and as the circumstances of licensees change. Allowing spectrum to move to the highest value use as quickly and easily as possible following its initial allocation will maximise the overall public benefit derived from the spectrum. This requires a regulatory system that has the flexibility to enable licensees to adapt spectrum access and usage to both market requirements and technological advances.

A change in use may be facilitated through trading or third-party authorisation, or by the same licensee employing its spectrum for a different use.

Allowing spectrum to move to the highest value use quickly and easily will ensure that associated benefits are realised quickly, without the delay and costs of regulatory intervention.

3. USE THE LEAST COST AND LEAST RESTRICTIVE APPROACH TO ACHIEVING POLICY OBJECTIVES

Planning, licensing, allocation and compliance measures should aim to minimise the total cost of achieving the objectives of spectrum management, including the cost to government, licensees and the community. Under good regulatory practice, all benefits and costs of regulations, including compliance costs, are rigorously assessed. The least cost and least restrictive approach will reduce regulatory burdens and allow greater freedom for spectrum licensees to optimise their use of the spectrum.

ACMA will operate as efficiently as possible to minimise the total cost of spectrum management.

Equally importantly, minimising the total cost of spectrum management will require a focus on regulatory effectiveness, taking into account developments in technology and conditions in affected markets. Only regulations that generate the greatest net benefit for the community, taking into account all the impacts, will be adopted.

4. TO THE EXTENT POSSIBLE, PROMOTE BOTH CERTAINTY AND FLEXIBILITY

ACMA will promote both certainty and flexibility. If there is any conflict between these two objectives, ACMA will seek an outcome that provides the greatest net benefit for industry, consumers and the wider community.

Licensees need stable and predictable regulatory arrangements and sufficient certainty about tenure to be confident about investing in equipment and services. This maximises the public benefit from spectrum use by reducing the risk of market failures arising from uncertainty and risk aversion. This need for certainty may at times conflict with the necessity for ACMA to change regulatory arrangements to facilitate innovation and allow access to new or expanded uses for spectrum.

Licences also need to be flexible to allow licensees or third party users to change their use of the spectrum or to facilitate the trade of spectrum to another licensee for a different use. This need for flexibility may at times conflict with the desire of other licensees for certainty, particular in relation to interference management.

These are examples of the types of issues that ACMA may encounter as it seeks to accommodate both certainty and flexibility in its management of the spectrum.

5. BALANCE THE COST OF INTERFERENCE AND THE BENEFITS OF GREATER SPECTRUM UTILISATION

ACMA will balance the cost of interference and the benefits of greater spectrum utilisation to ensure the most efficient result that maximises total welfare.

Where spectrum utilisation can be increased by amending regulatory rules, and is accompanied by levels of interference that are not harmful, ACMA will consider relaxing measures for frequency coordination and interference mitigation.

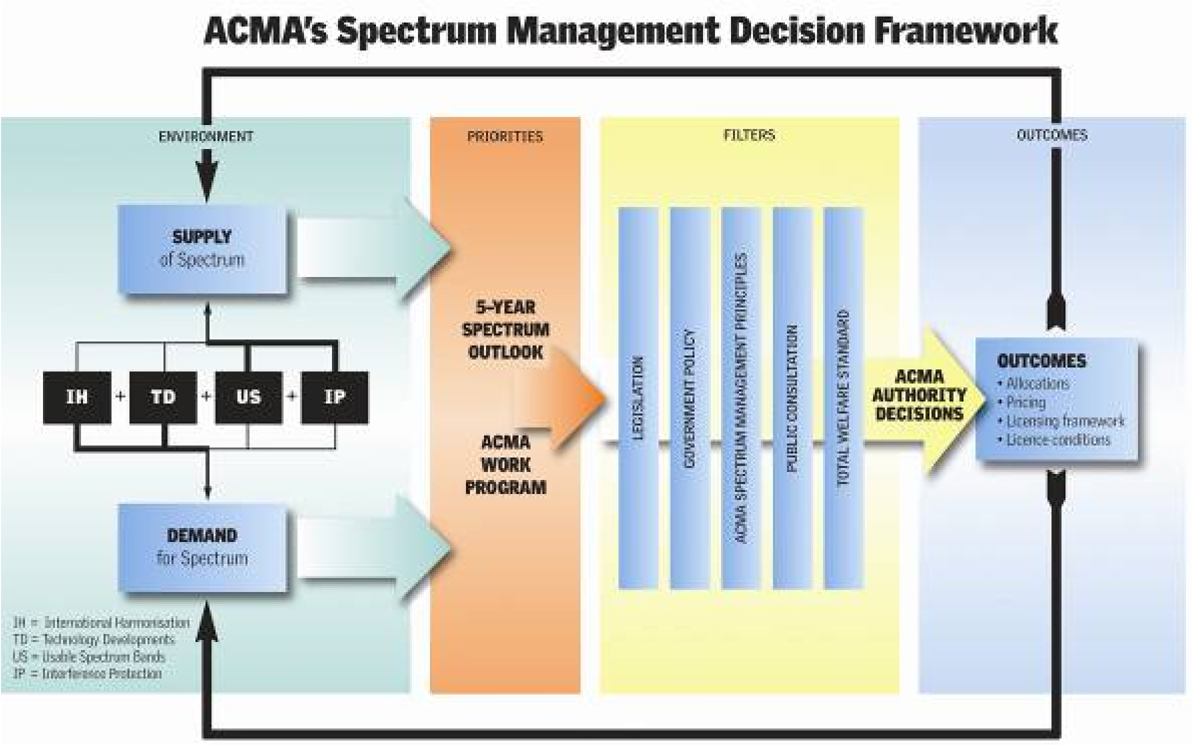
The point at which the cost of interference outweighs the benefits of greater spectrum utilisation will differ for various applications. There is no radiofrequency environment with a complete absence of potentially interfering signals. The point at which interference becomes harmful depends on the service type, application and user.

Spectrum management: information-gathering and work planning process

As outlined in the previous section, in order to meet this challenge in a consistent and effective way, ACMA proposes to adopt certain principles of good regulatory process, assess the appropriate range of possible solutions to a given issue using a total welfare standard, and apply an agreed set of spectrum management principles.

Figure 2.1 illustrates ACMA’s spectrum management decision making framework. It shows the use of the principles and the role of this document in the overall process for making decisions about spectrum management.

Figure 2.1: ACMA's spectrum management decision making framework



In many cases, the decision making process will require a significant amount of information from sources external to ACMA. ACMA generally uses the information gathering and work planning methodology outlined below to ensure that significant planning, licensing and pricing decisions are well informed, robust and meaningful. This process ensures that ACMA has a clear understanding of the technical, economic and social environments governing users and services, which then enables ACMA to implement spectrum management decisions that address these needs.

Broadly, the methodology involves the following steps:

Step 1: Environmental scan

An important element of spectrum management is understanding the likely future demand for spectrum. To develop an understanding of such demand, ACMA uses industry information gathered both formally, through such mechanisms as public discussion papers, and informally via ongoing industry interactions. This Outlook is always open for comment from industry, and is itself a mechanism through which ACMA's knowledge of the current Australian radiocommunications environment, spectrum management issues and corresponding industry views can be updated. In addition, particular drivers of spectrum demand are examined. These drivers are used to predict the probable 'pressure points' on spectrum over the next few years. Chapter 3 of this document identifies some of the main drivers that ACMA considers in analysing demand for spectrum.

Step 2: Assess future spectrum needs

After analysing the spectrum demand drivers, ACMA assesses the current and anticipated future spectrum requirements of radiocommunications services. This involves looking at the drivers in an Australian context and identifying the spectrum and implementation implications for Australia.

These implications may involve factors such as current spectrum utilisation in a given band, international trends and consumer demand. ACMA then considers, generally on a service-by-service basis, the issues currently affecting spectrum demand and those that will potentially affect spectrum over the next five years and beyond. Using this information, ACMA then develops proposals to address these issues. During this process, it may be useful for ACMA to liaise with industry stakeholders to clarify details related to key spectrum management issues, and to ensure that industry views continue to be adequately identified and addressed.

Chapter 5 of this document sets out in detail ACMA's assessment of the current factors affecting spectrum on a service-by-service basis and also considers the future demands for spectrum where possible.

Step 3: Develop indicative spectrum management work programs

The outcomes of ACMA's identification and assessment of spectrum needs leads to the development of indicative spectrum management work programs. One of the work programs sets out the frequency bands that ACMA is currently reviewing and those frequency bands where review work will soon commence. This includes:

- an identification of the significant issues facing the frequency band;
- an outline of ACMA's proposed approach for managing and addressing these issues; and
- ACMA's proposed timeframe and priority for commencing the work.

In addition, there is a work program that contains some of ACMA's more significant and high priority spectrum management projects that may affect a number of frequency bands and a wide group of stakeholders (discussed in Chapter 4). The outcomes of these projects will have relevance for the way in which ACMA approaches other spectrum management tasks and projects. Spectrum management tasks that are not attributable to a specific frequency band are also included in this work program.

The release of the indicative spectrum management work programs is in addition to band and service specific discussion papers that ACMA releases from time to time. ACMA's draft indicative spectrum management work programs are set out in Chapter 6 of this document.

Step 4: Implementation

ACMA's indicative spectrum management work programs will be used as the basis for spectrum management work undertaken by ACMA. Importantly, the work programs will be living documents that will be constantly reviewed to ensure their relevance to current trends in radiocommunications.

ACMA will seek to ensure the continuing relevance of the work programs through ongoing research and stakeholder consultation, both nationally and internationally. ACMA undertakes extensive consultation through the regular release of targeted public discussion papers, industry liaison and through its RCC, its preparatory groups and the Australian Radiocommunications Study Groups (ARSGs).

The indicative spectrum management work programs are intended to be 'rolling' work programs, and will be updated and published each year.

3 Spectrum demand drivers

Demand for access to the radiofrequency spectrum is driven by a diverse range of factors. The demand from users of technology is in itself generated by a wide range of motives, such as the desire for mobility, networking and access to broadband. Potential users of the spectrum may have conflicting requirements, not all of which can always be accommodated. Greater spectral efficiency can be achieved through digitalisation and improvements in technology, along with increased use of interference mitigation techniques to facilitate spectrum reuse. However, there is also an increasing number of services and users that want access to spectrum.

Factors that can drive demand for spectrum include:

- **International developments:** ACMA’s spectrum management activities are dependent on, but also contribute to, the work of the International Telecommunication Union (ITU) and Asia-Pacific Telecommunity (APT). Since Australia is a signatory member of the ITU Convention, ACMA, as the representative of Australia’s interests in the ITU, is obliged to follow the ITU Radio Regulations. While Australia reserves its sovereign right to use its spectrum for its interests, this is only on the condition that undue interference is not caused to radiocommunications services of other countries. ACMA also considers international standards such as those of the Institute of Electrical and Electronics Engineers (IEEE) and the European Telecommunications Standards Institute (ETSI) when developing domestic spectrum arrangements.
- **International markets:** Australia is a technology importer rather than manufacturer, so it is likely to be beneficial to follow international deployments to an extent, very often to take advantage of economies of scale and associated reductions in equipment costs, and also to facilitate international roaming. International manufacturers and operators with significant commercial interests may want access to the Australian market, or conversely, Australians may want access to technologies emerging overseas.
- **Accelerating pace of change:** There is an accelerating pace of change in technology and services, which is being driven by the information technology revolution and continuing scientific innovation. New and innovative ways to use the spectrum are being developed all the time, which means that there is demand to provide spectrum for an increasing range of technologies and applications, and greater potential for gains in spectral efficiency. Benefits are likely to accrue if the spectrum management regime enables technologies capable of sharing spectrum to be deployed where appropriate.

- **Customer demand for high data rate applications:** The growing communications needs of the public and industry mean that more and more information has to be transmitted in as short a time as possible. This is shown in the trend of exponentially growing data rates, which often corresponds to an increase in system bandwidth and hence occupied spectrum, despite the spectral efficiency enhancements normally associated with the emergence of new technologies.
- **Government demand for spectrum:** As with the broader spectrum user community, the dual challenge of mobility and increased data bandwidth will see the demand for spectrum by government agencies increase. Importantly, in some cases government use of the spectrum is substantially different to that commonly used by the broader community, with a strong emphasis placed on use of the spectrum to support remote sensing applications such as radar and passive[5] Earth observations. In terms of bandwidth used, Defence is the largest single user (government or non-government) of spectrum in Australia and is therefore a major influence on spectrum demand generally. Under Australian legislative arrangements[6], there are certain bands, or particular services within them, that are designated to be used principally for the purposes of defence. Federal, state and territory governments are also significant users of spectrum. This sector, which includes law enforcement, defence, security and emergency services agencies, has indicated a need for sufficient capacity to meet peak demand in major emergencies and adequate protection to maintain high quality of service, as well as increasing requirements for both interoperability and data communications. Other government organisations that have unique spectrum requirements include railway authorities, utilities administrators and scientific organisations.
- **Environmental factors:** These are factors that prevent or make it difficult to make frequency assignments to users in certain frequency bands or geographical areas. These include spectrum congestion, antenna sizes (that need to be large to meet a certain performance level but may be disagreeable to the public), and demographics and terrain (that can limit services to particular areas that quickly become congested).
- **Frequency dependent propagation characteristics:** These characteristics can drive demand for particular parts of the spectrum. Lower frequencies generally propagate further, but higher frequencies allow higher bandwidths and hence higher data rates. The propagation characteristics of high frequency (HF)[7] spectrum allow over the horizon communications using ionospheric reflection; very high frequency (VHF)[8] and ultra high frequency (UHF)[9] spectrum suit both long range line-of-sight (LOS) communications and mobile non-LOS applications by diffracting into valleys and over some terrain; and microwave frequencies above 1 GHz suit fixed LOS applications and satellite communications. However, rain attenuation can be a problem for frequencies above about 10 GHz.
- **Competition:** Radiocommunications licences are subject to provisions of the *Trade Practices Act 1974* which prohibit acquisitions that result in a substantial lessening of competition. The benefits of greater market competition are numerous, and include greater choice and lower prices for users, and more efficient and innovative markets.

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[5] Passive services involve only the reception of electromagnetic radiation for their operation, as opposed to active services which also include stations intended to transmit radiocommunication signals.
[6] Australian Footnotes AUS1 and AUS11 of the *Australian Radiofrequency Spectrum Plan.* AUS1 and AUS9 designate whole bands to be used principally for the purposes of defence, while AUS11 does the same for a particular service within the noted band.
[7] HF is the range 3–30 MHz.
[8] VHF is the range 30–300 MHz.
[9] UHF is the frequency range 300–3000 MHz; however, the term is generally only used for frequencies below 1000 MHz.

This means that spectrum management can often involve making spectrum access arrangements for a number of operators which can occupy more spectrum than an approach that involves a single monopoly provider. However, this must be balanced against commercial and technical viability.

- **Economic climate:** Use of the radiofrequency spectrum is often associated with significant investment required to establish business, infrastructure and equipment. Since the economic environment will have a significant impact on the confidence of industry stakeholders to engage in such investments and the corresponding risks, it will also affect the demand for use of the spectrum. This consideration is especially important in light of the recent events that have lead to what has been referred to as a global economic crisis.

In addition to the above general factors that can drive spectrum demand, there are a range of drivers that come specifically from the needs of end users. These needs range from those that are personal and are part of everyday life, those that facilitate the operations of business and industry, to those that relate to a higher level enhancement of the overall knowledge, wellbeing and safety of the community.

Some of the current main end user needs are listed below:

- **Access to broadband:** Broadband is recognised as a key economic enabler; for example, it underpins the development of e-commerce and e-health, and can provide significant improvements in the delivery of education and government services. Broadband demand is also driven by the desire for people to have greater access to entertainment material. This means that access to broadband is a strong driver for spectrum demand. In populated areas, 'last mile'[10] broadband services can be delivered via existing telephone line infrastructure or optical fibre to a large number of customers in the area of service of an exchange. The area of service is limited by the performance of the telephone cable, which typically only allows for delivery up to a few kilometres from the exchange. In rural and remote areas, factors such as the lower density of customers and the costs of establishing infrastructure can make wireline last mile delivery unviable. Terrestrial wireless technologies can avoid the high capital costs associated with the installation of fixed wireline and cable and are potentially faster to deploy. It can serve much larger areas and hence requires far fewer exchanges, and it also removes the need to establish specific connections to each user. Satellites can cover much larger areas and therefore can also be an important component of the delivery process.
- **Choice of delivery model:** Wireless technology can expand the options available to consumers, and the options available to network service providers seeking to deliver high data rate applications to customers. For example, the advantages of using wireless technology over wireline and cable options to provide broadband access (as discussed above) make WAS attractive to large operators, who typically provide a wide range of services on a national or wide area basis. It also gives opportunities for smaller operators to compete in localised markets providing niche services. As a result, wireless technology may both reduce the cost of serving some areas and increase competition.
- **Connectivity:** Before last mile delivery, there must be interconnection between the service provider and the local exchanges. In Australia, there are many areas where wired infrastructure is not a viable option for these links (due to difficulties with terrain and

[10] The 'last mile' is the final link in delivering connectivity from a communications provider (at the local exchange or base station) to the end user terminal. The term 'last mile' can be misleading, as in some cases wireless access can be provided at up to 50 km from the base station.

infrastructure costs). As such, fixed links (mainly P-P) will continue to play an important role in connectivity. Fixed links also play a vital role in communications delivery for numerous spectrum users, including government networks, emergency services, utilities and mining operators, and act as a backhaul enabler for networks including mobile telephony and satellite. As the spectrum requirements of these users and services grows, so too do the spectrum requirements for fixed links to support and complement them.

- **Mobility:** The delivery of services by radio has several attractions in comparison to other delivery methods nominally providing access ‘anywhere, anytime’ for nomadic and mobile voice and broadband services. These favourable characteristics of WAS may be expected to fuel demand for these services, and may be a particularly strong driver in metropolitan areas, despite the generally adequate provision of wireline solutions. Other factors, such as the considerable growth in laptop ownership, and the increasing requirement for mobility both in the workforce and socially, may also drive the demand for spectrum for WAS.
- **Sensing and monitoring:** Small scale applications are generally used to automate time consuming and resource intensive processes (such as remote monitoring of weather information), and include condition and environmental sensing, and radiofrequency identification (RFID)[11] systems. Larger scale applications are more focussed on providing additional functionality, such as sensing and imaging for meteorological, space research and military purposes. Larger scale applications are often characterised by large bandwidth requirements.
- **Automation of daily activities:** Automation involves communications between electronic devices with very limited, if any, human intervention. Automated temperature control, remote control of household appliances, and automobile monitoring systems are some examples of such ubiquitous automatically networked and interconnected devices.
- **Remote control:** Closely related to the automation of processes is the remote control of devices and instruments that in many cases reduce the use of human resources and can remove human presence from dangerous situations and inhospitable environments. One of the most significant examples of this is the unmanned aerial vehicle (UAV), in addition to telemetry, telecommand and control operations for other unmanned vehicles and missiles. Smaller scale applications such as garage door openers and radio controlled toys have also become part of everyday life.
- **Navigation and traffic control:** Smaller scale applications include civilian GPS[12] positioning and navigation, and automotive radars for intelligent cruise control systems. Larger scale applications for navigation and surveillance of aircraft and ships include ground based, airborne and shipborne radars, automatic dependent surveillance broadcast (ADSB), and GPS augmentation systems (including capability for landing guidance).
- **Networking**: The removal of wires from buildings facilitates network maintenance and provides flexible network arrangements. The most common example of this is the use of Wi-Fi in the 2.4 GHz and 5.8 GHz bands, and future ubiquitous use is expected to employ ultra wideband (UWB) technology. Networking also plays a major part in the automation of processes using sensing and control (see above).

[11] RFID systems have a variety of applications. A typical used is in the tracking of stock in retail supply chains. By attaching tags to boxes and/or pallets of stock (or even individual items), and linking the tag readers to a central computer database, stock can be easily followed as it travels from manufacturer to warehouse to retailer by scanning the item and updating the database each time it is moved to a new location. RFID tags are most visible in use as anti-theft systems installed in supermarkets and shopping centres.

[12] Global Positioning System, a US satellite positioning system.

4 Key spectrum management projects

The purpose of this chapter is to provide an overview of some of ACMA's more significant and high priority projects for the short and medium term. These projects are overarching and may affect a number of bands and a wide group of stakeholders. The outcomes of these projects will have relevance for the way in which ACMA approaches other spectrum management tasks and projects, including those set out in Chapter 5.

This chapter does not recommend any particular courses of action for these projects. These issues will be the subject of comprehensive individual consultation processes. When analysing these issues, ACMA will consider how to apply the spectrum management principles detailed in Chapter 2. In particular, the tools which ACMA uses to manage spectrum will be reviewed in order to determine their ability to deliver on the aims embodied in the principles such as flexibility, incentives and the minimisation of costs and restrictions.

The following three projects are outlined in this chapter:

- the Independent Review of Government Spectrum Holdings;
- the management of expiring spectrum licences; and
- the 'digital dividend'; that is, the spectrum that is to be vacated when terrestrial analog television services cease.

Independent Review of Government Spectrum Holdings

To assist ACMA to undertake its spectrum management responsibilities, the Independent Review of Government Spectrum Holdings (IRGSH) was commissioned in late 2006. The final report was supplied to ACMA in April 2007. The IRGSH was intended to assist ACMA to better achieve an appropriate balance between government use of the radiofrequency spectrum and its use by the broader community.

The final report of the review was released in April 2008, along with ACMA's preliminary response to the review's recommendations[13]. Stakeholder views were sought on both the review and ACMA's response. It is intended that this work will lead to the development of a government spectrum management strategic plan.

Three of the major areas identified in the review relate to:

- increased transparency in the use of spectrum by government bodies;
- the need for increased sharing of government spectrum; and

[13] The consultation paper on the IRGSH can be found on ACMA's website at: www.acma.gov.au.

- increased use of market approaches to improve the management of government spectrum.

These recommendations are, to a large extent, consistent with ACMA's broader approach to spectrum management, including the spectrum management principles described in Chapter 2. However, a large body of work will be necessary before detailed measures for implementation can be developed for some of the recommendations.

A critical element in these considerations is that ACMA understands and acknowledges the importance of spectrum to many government bodies and the importance of these services and activities to the nation. Accordingly, while ACMA is committed to reviewing the spectrum management arrangements for government spectrum holdings, it is equally committed to maintaining the provision of adequate spectrum, under appropriate arrangements, to meet the needs of government.

During the comment period, which closed on 31 July 2008, ACMA received a wide range of comments. A number of comments emphasised the importance of government use of spectrum and the associated public benefit of such use, whilst other responses reflected the varying industry views on the increased use of market based allocation of government spectrum holdings in particular[14]. These comments are being considered in depth as part of the IRGSH project and are not discussed in detail in this document.

Expiring spectrum licences

A significant issue for the government over the next five years will be the expiry of spectrum licences. Some of these licences are high value and government decisions will have significant implications for industry. ACMA received substantial commentary from industry in responses to the Outlook and the spectrum management principles regarding expiring spectrum licences, spectrum certainty and licence tenure; and ACMA's approaches towards the renewal or otherwise of these licences. These comments are not discussed in detail in this Outlook, since they are being considered in detail as part of a separate project dealing with expiring spectrum licences.

Table 4.1 provides a summary of the spectrum licensed bands, the year that the licences expire and the main use or intended use for the band. The table illustrates that only a small proportion of the radiofrequency spectrum is licensed using spectrum licensing. However, the sale of these licences garnered high prices, particularly the 2 GHz auction for third generation mobile services, which raised approximately $1 billion.

[14] *IFC 05/2008—Independent Review of Government Spectrum Holdings*, www.acma.gov.au.

Table 4.1: Expiry of spectrum licences

Frequency band	Year of expiry	Main/intended use
500 MHz[15] (501–505 / 511–515 MHz)	2012	Land mobile
825–845 MHz	2013	Mobile telephony
1800 MHz (1725–1785 / 1820–1880 MHz)	2013 & 2015	Mobile telephony
28 & 31 GHz (27.5–28.35 / 31–31.3 GHz)	2014	WAS
2.3–2.4 GHz	2015	WAS
3.4 GHz	2015	WAS
27 GHz (26.5–27.5 GHz)	2016	WAS
2 GHz (1900–1980 / 2110–2170 MHz)	2017	3G mobile telephony
20 & 30 GHz	2021	Defence

Under the Act, ACMA has three options for the expiring spectrum licences:

1. ACMA may re-allocate new spectrum licences in the bands under section 60 of the Act by an auction, tender, or pre-determined or negotiated price.
2. ACMA may renew licences to the same licensees without undertaking a price based allocation in certain circumstances:
   - ACMA can renew a licence that is used to provide a service that is part of a class of services for which the Minister determines renewing licences to the same licensees would be in the public interest.
   - ACMA can renew the licence if it is satisfied that special circumstances exist in which it is in the public interest for the existing licensee to continue to hold the licence.

   In either case, incumbent licensees will be charged a spectrum access charge which ACMA determines under section 294 of the Act.
3. ACMA may use a different licensing system in the band, such as apparatus licences.

Under any of these options, ACMA could vary previously established licence conditions. To date, the Minister for Broadband, Communications and the Digital Economy (the Minister) has not determined a class of services for which renewal would be in the public interest.

To derive the maximum public benefit from use of the spectrum, it is desirable to provide certainty to existing spectrum licensees about procedures to renew or re-allocate the expiring licences well before the licences expire.

[15] A small number of spectrum licences in the 500 MHz band expired on 31 May 2007. These licences were offered to market by price-based allocation for a five-year term to align their expiry with all other 15-year spectrum licences in the 500 MHz band which are due to expire in 2012.

In addressing issues related to the expiry of spectrum licences, ACMA will:

- work closely with and assist the Department of Broadband, Communications and the Digital Economy (DBCDE) to ensure all relevant issues are considered.
- examine options for pricing and licensing arrangements and allocation methodologies;
- be guided by the spectrum management principles set out in section 2.2;
- initiate timely review of each band where there are expiring spectrum licences;
- consult with a wide range of stakeholders to promote transparency and accountability of decision making;
- inform incumbent licensees of the processes and criteria well ahead of expiry of the licences; and
- take into account all relevant factors, including the approaches adopted by other leading spectrum regulators in managing expiring spectrum licences.

Digital dividend

The Minister has announced a timetable for the switch off of terrestrial analog television services, which will involve a staged process commencing with certain regional areas in 2010, and which will conclude with metropolitan areas. The switch off will be completed nationwide by the end of 2013. This will free up significant amounts of spectrum which may open up opportunities for alternative uses such as new mobile services, additional broadcasting services and wireless broadband services. Existing services may also benefit from enhanced services or coverage. The opportunity to introduce new or improved services is known as the 'digital dividend'.

Australia has yet to determine its approach to the digital dividend. Ultimately the replanning of bands currently designated as broadcasting services bands (BSB) is a decision for the Minister to make. If the spectrum vacated following the cessation of analog terrestrial broadcasting remains part of the BSBs, ACMA must continue to manage that spectrum in accordance with the *Broadcasting Services Act 1992.* ACMA will assist the Minister and his department in their consideration of the issues.

The size and nature of the dividend will depend on government decisions, including those based on:

- factors stemming from television industry demand, including additional and enhanced broadcasting services;
- whether, and if so, to what extent, digital television services are replanned so as to make available a contiguous block of spectrum (referred to as restacking); and
- the uses to which the vacated spectrum can be put.

If digital television services were restacked, then a contiguous block of spectrum could be available for alternative uses such as those mentioned above. Industry feedback has confirmed that this spectrum is sought after by a range of prospective spectrum users. The benefits of using this spectrum for other services have to be compared with the costs to broadcasters and viewers of any restacking, as well as alternative uses for the spectrum such as enhancing existing broadcasting services.

Some other countries are further advanced in developing arrangements for using digital dividend spectrum. The United Kingdom (UK) has identified a total of 112 MHz of spectrum in two separated blocks to be released after digital switchover plus additional ‘interleaved spectrum’ within the restacked bands specific to localised areas. This spectrum is in the UHF band. The spectrum will be allocated by auction before mid 2009 and will be made available on a technology neutral basis.

The United States (US) has identified and sold its digital dividend spectrum. A contiguous block of 108 MHz in the 700 MHz band was sub-divided into blocks, and blocks covering 62 MHz were allocated at an auction that was held earlier this year. The total of the provisional winning bids at that auction was close to US$20 billion.

Section 5.2 provides more information on issues relevant to broadcasting services.

5 Future spectrum needs

This chapter contains a service based analysis of issues affecting spectrum demand over the next five years, and outlines ACMA's proposed approaches for managing and addressing these issues. For each service, there is also a brief discussion about spectrum requirements that may arise beyond 2013.

5.1 Aeronautical mobile

The aeronautical mobile service[16] consists of the voice and data communications necessary to ensure the safety and efficiency of aviation, both civil and military. Due to the international nature of aeronautical operations, Australian allocations are consistent with harmonised ITU allocations to the aeronautical service, while the International Civil Aviation Organisation (ICAO) is involved in the harmonisation of equipment standards and frequency planning criteria. ICAO's Asia and Pacific Office is responsible for the development of frequency plans for civil aviation member states in this region, and for coordinating aeronautical frequency assignments across countries that could be affected by such assignments. Airservices Australia[17] is accredited by ACMA to endorse all frequency assignments in aeronautical mobile bands.

5.1.1 CURRENT SPECTRUM USE

There are several HF bands allocated to aeronautical mobile, both for the 'route' (R) service associated with air ground air communications for the safety and regularity of civil aviation, and for the 'off-route' (OR) service generally used by military aircraft.

The heaviest usage of aeronautical mobile spectrum is in the 117.975-137 MHz VHF aeronautical mobile (R) service (AM(R)S) band, mostly for air traffic control (ATC) using voice communications. Aeronautical HF spectrum is mostly used for aircraft flying in areas where VHF coverage is not available, particularly over the horizon in oceanic areas. Telemetry allows the remote monitoring of systems, with remote system control enabled by the associated telecommand; the only current non defence application is the aircraft communications addressing and reporting system (ACARS), typically operating at about 131 MHz. There are some VHF channels for coordinated search and rescue (SAR) with sea vessels, and the remaining allocations at frequencies above this are for the aeronautical mobile-satellite service.

[16] In this report, the aeronautical radionavigation service (ARNS) is included in the radiodetermination service section.
[17] Airservices Australia is a government-owned corporation providing air traffic control management and related airside services to the aviation industry.

Defence aeronautical telemetry systems operate in the band 4400–5000 MHz, designated to be used principally for defence purposes, as well as in other bands for systems including those aboard UAVs. Other aeronautical mobile systems include the air combat manoeuvring instrumentation (ACMI) and TSPI[18] at 1350–1400 MHz and airborne telemetry including flight termination systems (FTS) at 420–430 MHz.

A limited number of wideband aeronautical mobile systems are thought to currently operate in Australia by different users in a number of frequency bands, including the 915–928 MHz, 2.4 GHz and 5.8 GHz class licensed bands.[19] Current wideband aeronautical mobile systems range from amateur and hobby FM[20] video transmitters on radio controlled aircraft to high definition (HD) digital video systems onboard helicopters[21].

5.1.2 2009–2013

Issues affecting spectrum demand

VHF band congestion

Congestion in the VHF aeronautical band has been identified in some parts of the world, and it is expected to increase with the growth in aircraft traffic (expected to more than double over the next 15 years). However, the aeronautical industry is working to transform its operating practices and re-engineer its infrastructure to accommodate the additional demands within existing allocations. Changes include the use of more spectrally efficient technologies (such as migration to digital systems) and reducing channel spacing[22].

Airservices Australia is implementing a digital ATC radio network to upgrade existing VHF and HF communication systems. Such work is expected to accommodate future growth in demand for aeronautical mobile spectrum within the current allocations.

Additional allocations made at WRC-07

At the World Radiocommunication Conference 2007 (WRC-07) the bands 108–117.975 MHz, 960–1164 MHz and 5091–5150 MHz were allocated to the AM(R)S on a primary basis. Applications operating in these bands are intended to provide information related to safety, navigation and traffic management to the cockpit, and to facilitate the reduction of runway incursions. This can be achieved through the use of data links transmitting information from systems such as ATC radars, weather radars and monitoring systems.

To avoid interference with the broadcasting service operating at 85–108 MHz (VHF-FM band), the frequency range 108–112 MHz will be a guard band. Use of the guard band will be limited to those systems that support air navigation functions; namely, the broadcast of radionavigation-satellite service (RNSS) signal corrections for ground based GPS augmentation systems. The band 112–117.975 MHz is intended to provide additional radiocommunications services relating to the safety and regularity of flight.

The 960–1164 MHz band is intended for use by air-to-ground LOS applications over long distances and with moderate throughput. The only AM(R)S system allowed to operate in the band is the universal access transceiver (UAT), which is used for automatic dependant

[18] TSPI—'Time, space, position information'.
[19] Office of Legislative Drafting and Publishing, Attorney-General's Department, 2008, *Radiocommunications (Low Interference Potential Devices) Class Licence 2000*,, available at: www.comlaw.gov.au.
[20] FM stands for frequency modulation.
[21] This application uses the 2.5 GHz band used for ENG. For more information, see section 5.3.1.
[22] Channel spacing has been reduced from 50 kHz to 25 kHz channels in Australia; 8.33 kHz channels are being used in Europe.

surveillance broadcast (ADSB) in Australia. The Department of Defence (Defence) operates the joint tactical information distribution system (JTIDS)[23] in the 960–1215 MHz band on a 'no interference, no protection' basis[24].

The 5091–5150 MHz band is intended for use by airport surface applications transmitting over short distances with high throughput, and security applications employing secure and confidential transmissions used in response to interruption of aircraft operations (such as runway incursions). However, ICAO is also studying the feasibility of air-ground aviation communications at 5 GHz with a view to easing congestion in the VHF aeronautical band.

World Radiocommunication Conference 2011

Agenda item 1.4 of the World Radiocommunication Conference 2011 (WRC-11) will continue the work of WRC-07 by aiming to accommodate more aeronautical applications in light of the apparent congestion in the main VHF AM(R)S band, including the consideration of an additional AM(R)S allocation in the band 5000–5030 MHz. VHF communications are moving towards data intensive, integrated air traffic management (ATM) systems, while surface applications (generally short range communications with high throughput) will become significant in the 5 GHz range.

Agenda item 1.7 of WRC-11 will consider ITU studies on the spectrum requirements of the aeronautical mobile-satellite (route) service (AMS(R)S) and its assessment, and will assess whether the future requirements of this service can be met within current provisions of Article 5.357A of the ITU *Radio Regulations*[25]. This work is aimed at ensuring adequate long term spectrum availability and access for the AMS(R)S, and appropriate action will be taken, while leaving intact the generic allocation to the mobile-satellite service (MSS) in the bands 1525–1559 / 1626.5–1660.5 MHz.

Agenda item 1.12 is to review the results of ITU sharing studies between the aeronautical mobile service and other co-primary services[26] in the band 37–38 GHz, and consider the introduction of compatibility criteria in order to protect these other services.

Aeronautical mobile telemetry

At WRC-07, additional spectrum allocations were made for aeronautical mobile telemetry (AMT) for flight test systems in the 4400–4940 MHz and 5091–5150 MHz bands. It is expected that telemetry systems will be used by Defence, especially considering that the *Australian Radiofrequency Spectrum Plan 2009* (the Spectrum Plan) designates the 4400–4940 MHz band to be used principally for the purposes of defence. However, when there are similarities in requirements, ACMA may consider options to permit the sharing of this band with other government agencies for such uses.

Wideband aeronautical mobile systems

Recent approaches to ACMA by industry representatives indicate that the use of wideband aeronautical mobile systems is likely to grow significantly in the future. The ability of airborne platforms to provide data to ground based terminals is rapidly increasing, and increased data rates combined with a proliferation of such systems will result in increased

[23] JTIDS is an advanced information distribution system using frequency-hopping, spread spectrum technology that provides communications between fixed stations, aircraft, warships and air defence ground units, thereby providing secure integrated communications, navigation and identification capability to tactical operations.

[24] This means that the system must not cause interference to other radiocommunications services, and it will not be afforded protection against interference from other services.

[25] In the bands 1545–1555 / 1646.5–1656.5 MHz, AMS(R)S transmissions for the purposes of distress, safety and urgency communications, ensuring flight regularity or radio direction finding, have priority over other mobile-satellite service transmissions.

[26] Fixed service, mobile service, space research service (space-Earth) and fixed-satellite service (space-Earth).

demand for spectrum. Much of this demand is expected to manifest itself in mission data downlinks and high data rate payloads such as video, which are likely to require large bandwidths.

Planning arrangements for wideband aeronautical mobile systems will be required to accommodate a wide range of applications and operational requirements. Such a range of requirements may be compatible with spectrum sharing between the different applications. For example, the use of wideband AMT systems is likely to be sporadic in nature and occur in geographically isolated areas, while wideband aeronautical systems in support of emergency service applications are likely to operate more regularly and over more populated areas.

The operational characteristics of airborne platforms usually make sharing with terrestrial services problematic. There is a range of quality of service requirements for these systems, depending on the application. While communications related to air traffic or flight control require a high level of protection, the robustness of other applications such as payload downlinks is not so critical, and hence can probably be afforded less protection.

Ku-band CDL

One family of data link standards (primarily for military use) is the common data link (CDL)[27]. CDL is designed to operate over a number of different bands, including those 10 GHz bands currently designated for use for defence purposes. However, Ku-band[28] CDLs that have an uplink in the 15.15–15.35 GHz band and a downlink in the 14.40–14.83 GHz band pose significant spectrum management challenges in Australia because this spectrum is currently used extensively by terrestrial fixed P-P links and by satellite Earth-to-space links.

Defence has had preliminary discussions with ACMA seeking to establish arrangements in Australia to support Ku-band CDL operations. ACMA understands that currently the primary interest in CDL applications is from Defence to support a number of existing and planned systems, and it is apparent that there are legitimate requirements to provide an appropriate degree of support for Ku-band CDL operations in Australia. Other government agencies may seek to acquire systems using CDLs or will have a requirement to communicate with Defence systems utilising Ku-band CDLs.

Unmanned aerial vehicles

An unmanned aerial vehicle (UAV) is an unpiloted aircraft. UAVs can be controlled remotely or fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. Currently, Defence is an important user of UAVs, with control communications typically using the bands within 230–400 MHz, 2.9–3.4 GHz and 4.4–5 GHz that are designated for use principally for defence purposes in the Spectrum Plan. Defence states that these are mission critical communications that must not suffer harmful interference.

Spectrum demand for UAVs is expected to increase significantly over the next decade. UAV use in civilian applications is a developing market, and applications such as weather research, crop monitoring and coastal patrols may be introduced in Australia in the future. While some demand may be able to be accommodated in current spectrum allocations, Agenda item 1.3 of WRC-11 seeks to identify additional or modified spectrum allocations for UAVs, taking into consideration the spectrum requirements and regulatory measures

[27] The tactical common data link (TCDL) is a very similar system from a spectrum management perspective.
[28] Ku-band generally refers to the frequency range 12–18 GHz.

required to support remote flight command and control and ATC communications relay. As some UAVs will require the use of satellites for beyond-LOS communications, as well as terrestrial links for LOS operations, one area of study is the feasibility of introducing a worldwide AMS(R)S system in the band 5000–5150 MHz. This is in addition to wideband aeronautical mobile systems used for mission data downlinks, which may also be considered at WRC-11.

Use of higher frequencies

The increase in data rates (generally leading to larger system bandwidths) is a trend which, along with gradual saturation of lower bands, is leading towards the use of higher frequencies, particularly for applications that do not require long propagation distances. An example of this is the AM(R)S allocation added to the 5091–5150 MHz band at WRC-07, whereas previously aeronautical mobile allocations were mostly made in VHF spectrum.

Australian Air Traffic Management Strategic Plan

In 2007 the Australian Strategic Air Traffic Management Group (ASTRA[29]) published the third edition of the *Australian Air Traffic Management Strategic Plan*[30]. The plan sets the path for the future development of ATM in Australia from now to 2025 and beyond, and describes ASTRA's vision of ATM in the future. The 2003 version of the plan addressed more specific communication, navigation and surveillance infrastructure plans required to support future ATM systems. The plan:

- identified technologies for continued voice and increasing data link communications;
- envisioned the increased use of controller pilot data link communications[31] and pre-departure clearance[32]: and
- predicted the replacement of aeronautical telecommunications networks[33].

The 2003 plan did not specify additional spectrum requirements; its future vision of ATM was based on continued access to existing aeronautical spectrum allocations.

Safety considerations

In its published position for WRC-07[34], ICAO stressed that safety considerations dictate exclusive frequency bands must be allocated to safety critical aeronautical systems and that adequate protection against harmful interference must be ensured to permit safe and efficient operation of aircraft. There are concerns within industry regarding interference to aeronautical communications systems stemming from the susceptibility of digital systems to interference from in home cable television systems and power line transmissions, which may pose an obstruction to the migration from analog to digital aeronautical communications.

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[29] ASTRA is Australia's whole-of-industry air traffic management planning body. ASTRA includes airlines, airports, regional aviation, pilots, general aviation and various government organisations.

[30] Australian Strategic Air Traffic Management Group, 2007, *The Australian Air Traffic Management Strategic Plan*, http://astra.aero/Publications.aspx.

[31] Controller pilot data link communications (CPDLC) is the direct transmission of text-based messages from controller to pilot.

[32] Pre-departure clearance (PDC) is used to uplink the flight plan from ATC to the cockpit.

[33] The 2003 *Australian Air Traffic Management Strategic Plan* includes plans to replace the aeronautical fixed telecommunication network (AFTN, which provides communications between fixed aeronautical stations) and the future air navigation system (FANS) with the Aeronautical Message Handling System (AMHS) and a limited deployment of the aeronautical telecommunications network (ATN). The AMHS provides ground-to-ground aeronautical communications including transmission of hazard alerts, flight plans and meteorological data. The ATN is a generalised data link network that is able to support a wide variety of ground-air and ground-ground communications, including CPDLC and the AMHS.

[34] International Civil Aviation Organisation, 2007, *ICAO Position for the ITU WRC-07*, available at: http://www.icao.int/anb/panels/acp/.

Terrestrial flight telecommunications systems

Additional spectrum may be required to support terrestrial flight telecommunications systems (TFTS), including in flight telephony. In essence, TFTS provides terrestrial applications in an aeronautical environment through a ground based cellular radio system. Linking the aeronautical system to the terrestrial component can be done either via satellite or directly to the ground. Europe is focused on delivering voice and text services to passengers' mobile phones via satellite, supported by the approval of mobile phone use on aircraft by the Electronic Communications Committee (ECC). In the US, investigation towards such a decision has been halted due to interference concerns, and focus has been diverted towards in flight internet and live television services.

In Australia, ACMA has been approached by airline companies regarding the provision of GSM (Global System for Mobile communications) services onboard aircraft, and ACMA is aware of the TFTS trials being carried out in the 1.8 GHz band. Different implementations have been proposed for this purpose, and while most involve the delivery of telecommunications via satellite, one of the systems involves the use of a direct downlink to the ground.

ACMA's proposed approaches

WRC-11

The most significant changes within the 2009–2013 timeframe are expected to relate to the additional allocations made to the aeronautical mobile service at WRC-07 and potentially at WRC-11. It is possible that some VHF and L-band[35] systems in support of air navigation functions, long range communications and global navigation satellite system (GNSS) correction broadcasts, along with short range surface applications for the dissemination of systems data at 5 GHz, may be introduced within the next five years.

Measures to introduce new AM(R)S applications in allocations made at WRC-07

Following the primary allocations made to the AM(R)S in the 108–117.975 MHz, 960–1164 MHz and 5091–5150 MHz bands, ACMA will consider the impact of the introduction of aeronautical mobile systems on existing services. No compatibility criteria currently exist between AM(R)S systems and adjacent band FM radio broadcasting services in the 87.5–108 MHz band, the aeronautical radionavigation service (ARNS) in the 960–1164 MHz band, or RNSS in the adjacent 1164–1215 MHz band. The VHF-FM broadcasting band is heavily used in Australia, while in the band 960–1164 MHz, there is significant usage of aeronautical radionavigation systems (see section 5.6.1). ACMA will monitor the deployment and operation of ground based augmentation systems (GBAS and GRAS—see section 5.6.2) in the band 108–117.975 MHz to ensure that no detriment is caused to the existing services.

As an interim measure, AM(R)S systems must meet requirements of the standards and recommended practices of Annex 10 of the ICAO Convention on International Civil Aviation. By adhering to these requirements, ARNS systems are compatible with broadcasting services. However, with the exception of the UAT as mentioned earlier, AM(R)S systems may not operate in the 960–1164 MHz band until the ITU completes studies on operational and technical measures to allow sharing between the AM(R)S and the co-band ARNS and adjacent band RNSS.

[35] L-band refers to the frequency range between 1 GHz and 2 GHz.

Sharing studies are much more advanced for the 5091–5150 MHz band. In Australia, the only current use of the band is by Globalstar feeder links serving non geostationary satellites of the MSS. At WRC-07, three provisional resolutions were produced: 418, 419 and 748, which outline considerations relating to the use of airport surface applications, AMT and security transmissions, respectively. Resolutions 419 and 748 state that the ITU considers sharing between the relevant aeronautical mobile systems with the fixed-satellite service (FSS) to be feasible, provided that the aeronautical mobile systems operate in accordance with Recommendation ITU-R M.1827. Resolution 418 refers to Recommendation ITU-R M.1828, which provides technical and operational requirements for aircraft stations, and Report ITU-R M.2118, which describes methods to ensure compatibility between aircraft stations used for AMT and the FSS. The annex to Resolution 418 outlines sharing criteria, including a power flux density (pfd) limit at the FSS orbit.

The introduction of AM(R)S in these bands would typically require consideration and application of such ITU sharing studies, criteria and requirements of the Australian operating environment.

Aeronautical mobile telemetry

Before considering any options for shared use of AUS1 bands within 4.4–5 GHz, ACMA would consult with interested parties and Defence.

Wideband aeronautical mobile systems

Ku-band CDL

ACMA will continue to work with Defence, and other government users where necessary, to identify appropriate whole of government approaches to support CDL use of the 15 GHz band while maintaining the utility of the band for existing and future fixed and satellite services. As part of this, ACMA will work with Defence to explore options for customised Ku-band CDL equipment that maintains interoperability with CDL systems of other countries, but is better suited to Australian spectrum management arrangements.

UAVs

Civilian UAV applications are likely to appear within 2009–2013. In the short to medium term, ACMA will continue to investigate the demand for such applications as they arise, and will also follow closely developments related to WRC-11 Agenda item 1.3.

General considerations

ACMA may need to develop a position on the abovementioned issues in preparation for WRC-11, which would involve consultation with and advice from industry, Airservices Australia and the Civil Aviation Safety Authority (CASA).

The implementation of new developments in the aeronautical industry is typically characterised by long timeframes as changes requiring aircraft refit are likely to be associated with major overhaul timeframes (typically five to seven years). In addition, the bands used for aeronautical purposes are determined at an international level, usually after considerations that extend over one or more WRC cycles. As a result, changes to allocations for aeronautical purposes do not occur rapidly, but they still need to be included in ACMA's long term strategic planning. However, considering the roles of Airservices Australia and CASA, ACMA's role in spectrum management for the aeronautical service is more limited when compared to ACMA's responsibility in relation to other radiocommunications services. ACMA will, where necessary, work closely with these two government agencies to facilitate spectrum requirements for aeronautical operations, especially considering the safety of life aspect that they entail.

Terrestrial flight telecommunications systems

Arrangements for the use of spectrum to provide in flight GSM services would require the agreement of telecommunications carriers. In October 2008, ACMA proposed to allow TFTS—that is, the possession and installation of in flight mobile phone systems by Australian airlines for domestic and international flights[36]. Appropriate licensing arrangements would need to be made to support the introduction of TFTS.

5.1.3 BEYOND 2013

Data intensive ATM networks

Beyond 2013, aeronautical mobile communications are expected to continue to move towards harmonised ATM networks combining ground-to-ground and ground-to-air links, voice and data communications and the integration of data from a wide variety of ground based sensors.

Taking into consideration the general trend towards increasing data communications relative to voice, the addition of data services in the HF aeronautical bands is also possible within the next decade. However, a corresponding increase in the spectrum required for such purposes is not expected, as it is likely that these services will manifest in satellite communications rather than in HF terrestrial transmissions.

5.2 Broadcasting

The broadcasting service[37] involves one way radiofrequency transmissions intended for direct reception by the general public. Currently, the principal uses of the broadcasting service in Australia are in the medium frequency (MF)[38] band for AM[39] radio, in the VHF band for FM[40] radio, and in both the VHF and UHF bands for television (subscription television services are considered in the satellite section).

5.2.1 CURRENT SPECTRUM USE

MF-AM radio broadcasting

The MF-AM band (526.5–1606.5 kHz) is used for national[41], community and commercial broadcasting services, as well as high power open narrowcasting[42] (HPON) services. Coverage for these services can be wide area or local, although at MF frequencies, long range interference (which worsens with night time sky wave propagation) makes international coordination (particularly with New Zealand and Indonesia) necessary for higher power transmitters. The long distance propagation makes MF-AM radio effective in Australia's remote regions; however, it has poorer audio quality and is more prone to

[36] For more information, see the Media Release *ACMA proposes to allow in-flight mobile phone systems*, 15 October 2008, available at: www.acma.gov.au.

[37] In this report, the broadcasting-satellite service is included in the satellite service section and mobile television is included in the WAS section, due to strong technical and/or commercial synergies with these other services.

[38] MF is the frequency range 300–3000 kHz.

[39] AM stands for amplitude modulation.

[40] FM stands for frequency modulation.

[41] Australian Broadcasting Corporation (ABC), Special Broadcasting Service (SBS) and the Parliamentary and News Radio Broadcasting Service.

[42] Narrowcasting services are broadcasting services whose reception is limited due to programming of limited appeal or targeted to special interest groups, or limited to certain locations or periods of time (section 18 of the *Broadcasting Services Act 1992*).

electrical noise than VHF-FM. Some stakeholders within the industry are of the view that the MF-AM band is heavily congested. As at October 2008, there were about 300 broadcasting licences and 30 licensed HPON services in the MF-AM band.

MF and VHF narrowband area services

Narrowband area services (NAS) have mainly been licensed to operate in non broadcasting allocations in the MF frequency range 1606.5–1705 kHz immediately above the MF-AM broadcasting band; however, some licences have also been issued in the VHF range at 151–152 MHz and 173 MHz. As at October 2008, there were about 310 licensed NAS stations, of which approximately 220 are in the MF band.

NAS stations are required to obtain authorisation under the Broadcasting Services Act for the content of any broadcasting service they provide. In the case of open narrowcasting services, this is provided by a class licence. NAS station operators, or any other person using spectrum outside of the broadcasting services bands (BSB) to provide a broadcasting service, may also provide commercial broadcasting services (licensed under section 40 of the BSA); however, in the case of MF NAS licences, this right is circumscribed by a Ministerial direction and resultant apparatus licence condition. ACMA does not have 'use it or lose it' licence conditions for MF NAS licences and feedback from consultation with industry suggests that there are NAS licences that are not currently in use.

HF radio broadcasting

As at November 2008, there was very limited use of HF spectrum for domestic broadcasting within Australia; the only significant domestic usage is the ABC's HF Inland Service (some channels in the 2 to 5 MHz range), in addition to a few narrowcasting services. Only three broadcasters are currently using the HF broadcasting bands to provide international broadcasting services from Australia. ACMA has embargoed the assignment of services other than broadcasting in several HF bands to encourage the introduction of digitally modulated emissions for broadcasting services in these bands[43].

VHF-FM radio broadcasting

The VHF-FM band (VHF Band II 87.5–108 MHz) is used for national, commercial and community broadcasting services, as well as low power open narrowcasting (LPON) and HPON services. The VHF-FM band is considered by some broadcasters and ACMA to be heavily congested in major cities and nearby regional areas. This view is supported by the difficulty that ACMA has experienced in planning additional services in many regional areas. The prices obtained for VHF-FM commercial radio broadcasting licences in major metropolitan markets at the most recent auctions are evidence of demand for additional FM broadcasting channels, although the amounts paid may also reflect scarcity and the fact that no additional FM commercial licences would be planned in the short to medium term[44]. For example, in 2004 auctions, of single FM licences in Melbourne, Brisbane and Sydney attracted winning bids of 52, 80 and 106 million dollars, respectively.

[43] For more information please refer to embargo 46, contained in *Radiocommunications Assignment and Licensing Instruction MS03: Spectrum Embargoes*, available at: www.acma.gov.au.

[44] Australian Broadcasting Authority, 25 September 2003, *ABA – NR60/2003—Analog commercial radio sector*. ABA stated that from this date, it did not propose to allocate any further analog commercial radio licences within five years of the last allocation in the ongoing round at that time. The last allocation was made for Melbourne in August 2004 (see *$52 million bid for new Melbourne commercial radio licence*, ABA Update, August 2004, Australian Broadcasting Authority, pg. 7).

A significant proportion (about 30 per cent) of the approximately 2300 broadcasting[45] licences held in the 88–108 MHz frequency range is used for retransmission services. Retransmission services in this band typically serve small population centres in rural and remote areas and are fed via satellite. Despite the large number of retransmission licences, the majority of the Australian population receives VHF-FM services from a relatively small number of high power transmitting sites.

In addition to ‘mainstream’ VHF-FM radio broadcasting services (generally taken to refer to national, commercial and community broadcasting services), the 87.5–108 MHz band contains significant numbers of LPON and HPON services. Under section 34 of the BSA, three channels (87.6, 87.8 and 88.0 MHz) have been made available to accommodate LPON services until the end of 2013, when the current Determination of Spectrum under the Broadcasting Services Act expires. It is expected that ACMA will commence consultation with industry on the future of the LPON planning and regulatory arrangements in the 2011.

As at October 2008, approximately 1,870 LPON services have been licensed to operate on these channels, with about another 60 LPON services licensed to operate on frequencies above 88 MHz. Unlike licences for NAS stations, LPON licences are subject to ‘use it or lose it’ conditions. Over 200 HPON services operate in the 88–108 MHz range.

Digital radio broadcasting

Licences have been issued for terrestrial digital audio broadcasting (T-DAB) services operating in the 174–230 MHz band (VHF Band III). ACMA has also issued licences for trial systems in VHF Band III and the 1452–1492 MHz band, as well as trial systems for Digital Radio Mondiale (DRM) in the MF and MF-NAS bands and at 26 MHz (see Appendix A) to help ACMA and industry assess the performance of digital radio systems. The significance of these trials for digital radio broadcasting systems is set out in section 5.2.2.

VHF/UHF television broadcasting

In Australia, analog and digital television broadcasting services are provided in VHF and UHF bands using 7 MHz wide channels. Details of current usage are listed below:

- VHF Band I (45–52 MHz and 56–70 MHz): VHF channels 0, 1 and 2 for analog television;
- VHF Band II (85–92 MHz and 94–108 MHz): VHF channels 3, 4 and 5 for analog television (in a limited number of geographic areas; these channels are shared with extensive deployments of VHF-FM radio broadcasting services);
- Television channel 5A (137–144 MHz) for analog television;
- VHF Band III (174–230 MHz): VHF channels 6–9, 9A and 10–12 for analog and digital television services;
- UHF Bands IV and V (520–820 MHz): UHF channels 28–69 for analog and digital television services[46].

As at October 2008, approximately 4670 transmitters were licensed, comprised of about 3600 analog and 1070 digital services. In the case of analog television, the majority of

[45] Including commercial, community (both permanent and temporary community broadcast licences), national and retransmission services. Under section 212 of the BSA, in addition to the retransmission of commercial broadcasting (within the licence area), national broadcasting and National Indigenous TV Ltd programming content, commercial broadcasters are permitted to retransmit their program content outside their licence area with special written permission by ACMA.

[46] ACMA’s policy is, where practical, to avoid allocating digital services on channels 68 and 69.

television transmitter licences are for retransmission; however, the majority of Australia's population rely on 271 analog and 392 (operating or planned) digital transmitters at 52 high power 'main station' transmitting sites for delivery of their television services[47].

Australia is currently transitioning from analog to digital television, and the simultaneous transmission of both (known as 'simulcasting') is facilitated by the enhanced technical characteristics of digital television which, unlike analog television, permits interference free adjacent channel transmissions in the same location. For this and other reasons, digital television is far more spectrally efficient than analog television. Digital television allows broadcasters, subject to government policy, to transmit multiple content streams (known as multi channelling; for example, additional streams of standard definition (SD) or high definition (HD) audiovisual content, or audio only content or data) within a single 7 MHz channel with the use of a multiplexer, a feature of significant benefit to consumers. Digital television also provides a higher picture quality than analog television.

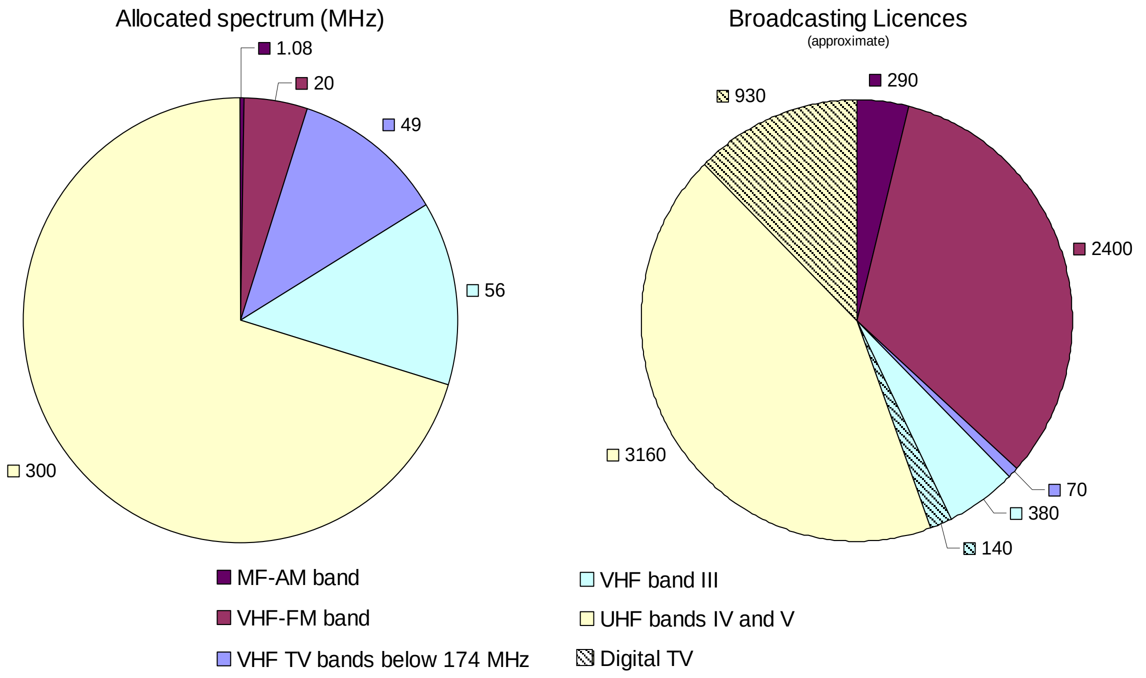
Figure 5.1 shows the proportions of allocated spectrum and licences in the BSB for the four major broadcasting services in Australia.

Services ancillary to terrestrial television broadcasting

Before television programming content is broadcast to the general public, various other radiocommunications services are utilised to relay this content. See section 5.3.1 for details of fixed services used by broadcasters (e.g. electronic news gathering, television outside broadcast, studio to transmitter links) and section 5.7 for details of satellite broadcasting and satellite links that are used to support terrestrial broadcasting services.

[47] For the purpose of this report, 'major' transmitting sites are defined as sites with one or more digital services with either VHF or UHF effective radiated power above 10 kW.

Figure 5.1: Distribution of allocated spectrum[48] and broadcasting licences in the BSB (October 2008)



5.2.2 2009–2013

Issues affecting spectrum demand

A feature of both television and radio planning for the BSB is the importance of regulation in determining spectrum requirements. The development of television and radio services in the BSB is both constrained and driven by legally imposed opportunities or constraints on the broadcasting sector. Examples are the moratoria on additional commercial radio or television services in the BSB and, on the other hand, the statutory schemes for the introduction of digital television and radio services. The highly regulated environment makes ‘demand’ per se an unreliable guide to future spectrum requirements. Put another way, future requirements for broadcasting spectrum are likely to depend critically on government decisions about the future development of the sector.

A second distinctive feature of planning for the BSB is that the Minister, rather than ACMA, is responsible for decisions to vary the BSB. This means that ACMA does not have authority to make planning decisions that involve reviewing the boundaries of the BSB, notably decisions relating to any ‘digital dividend’ resulting from the switch off of analog television.

ACMA’s observations about planning and demand issues affecting the BSB need to be read in the light of these distinctive features of broadcasting planning.

[48] In the graph of allocated spectrum, it should be noted that AM radio broadcasting services operate at a much lower frequency than television services, and that the bandwidth of a single MF-AM transmission is 0.3% that of a single television channel. Similarly, the bandwidth of a VHF-FM transmission is only about 3% that of a single television channel.

Analog radio broadcasting

Analog radio broadcasting in the MF-AM and VHF-FM bands is expected to continue well beyond the timeframe considered in this report. Both bands are extensively used and in most areas there will only be limited opportunities for the introduction of additional services.

Demand for the current domestic HF radio services is expected to remain relatively limited. There is, however, some interest in use of DRM using MF NAS licences and in the 26 MHz band for domestic HF broadcasting (see Appendix A).

Internet audio streaming is not yet perceived as a major challenge to traditional radio broadcasting, and is expected to operate more as an adjunct to main broadcasting activities rather than as direct competition. However, as broadband networks become more ubiquitous, this situation could change.

T-DAB digital radio broadcasting

The current policy for the implementation of digital radio services in Australia is based on the introduction of T-DAB digital radio services initially in the five mainland state capital cities no later than 1 July 2009[49]. The expansion of T-DAB into regional areas and the possible consideration of other digital radio technologies are matters that require further consideration by ACMA and the government more broadly.

The policy framework to guide the introduction of digital radio in Australia, released by the former government on 14 October 2005, stated:

> …the Government’s framework has been built around digital radio being a supplement to existing services in Australia rather a replacement technology, as it is in television. Therefore there will be a staged rollout of digital radio in Australia commencing in metropolitan areas as soon as practicable. The Government will urge broadcasters to commence trials of digital radio in regional areas, so technical and other issues can be resolved. The Government will then consider what financial support is necessary to expand digital radio services to rural and regional Australians[50].

While the course of T-DAB development in metropolitan areas is relatively clear, the nature, timing and spectrum requirements of any expansion into the regions will depend on government decisions that are yet to be made. There are spectrum availability challenges associated with some options and ACMA will need to work closely with government in the development of options for regional area expansion of T-DAB. In addition, demand in the period up to 2015 will be limited by the prohibition of new commercial digital radio licences for six years after the commencement of digital transmissions.

In VHF Band III, T-DAB services are required to share spectrum with digital and analog television services. While spectrum within VHF television channel 9A is, with certain caveats, available in each of the mainland state capital cities, additional spectrum within the 174–230 MHz band is not currently available. This places serious limits on the potential for expansion of VHF Band III T-DAB services into regional areas (especially those areas close to the state capital cities). Increased opportunities will occur only after the switch over to digital television is completed, depending on the nature and timing of any ‘digital

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[49] For more information, see: www.dbcde.gov.au under Media and Broadcasting and Digital Radio.

[50] Announcement by Senator the Hon. Helen Coonan, Minister for Communications, Information Technology and the Arts, 14 October 2005, *Digital Radio*, http://www.minister.dcita.gov.au/coonan/media/speeches/digital_radio_-_commercial_radio_australia_conference.

dividend'[51]. However, based on currently planned and operating digital television channel arrangements and sharing criteria, it is foreseeable that VHF Band III spectrum for T-DAB may not be available in a number of regional areas even if the anticipated dividend in VHF Band III is applied to digital radio expansion.

One potential solution to improve the coverage of T-DAB may be to use L-band frequencies (1452–1492 MHz). If used for in fill transmissions, up to three T-DAB frequency blocks (1.536 MHz wide) may be required in the L-band in each state capital city by 2014, but this will require careful engineering of single frequency networks (SFNs)[52].

A key issue with the use of L-band for digital radio is the availability of dual-band[53] T-DAB receivers that can operate across VHF Band III and L-band. Early indications are that DAB+ radios are likely to be dual-band. L-band may be required to provide both regional area coverage (for example, where VHF Band III spectrum is not available) and in fill transmissions for the main digital audio broadcasting (DAB) metropolitan transmissions where SFN transmissions are not practical. However, the radios do not seamlessly switch between bands, which could result in a short break in reception if L-band is used to in fill areas of deficient VHF coverage.

The 1452–1492 MHz band is currently used by P-P fixed links, some broadband wireless access (BWA) services in regional areas, some Defence aeronautical telemetry and, in less densely populated rural and remote areas, by Telstra's digital radio concentrator system (DRCS) and high capacity radio concentrator (HCRC) system. Planning in this band should also consider the potential for future satellite digital radio broadcasting, which could effectively provide coverage of regional areas. For example, AsiaSpace has a satellite network filing for the AUSDSB satellite at 150.5ºE, intended to provide L-band satellite digital radio coverage in Australia through a hybrid terrestrial/satellite network. Recognising the competing, and probably conflicting, demands on spectrum in this band, ACMA will rely on the assignment limitations for this band contained in the *1.5 GHz Band Plan*[54] in order to preserve planning options until the extent of requirements for T-DAB are known.

Other digital radio technologies

The implementation of T-DAB will involve multiplexes that combine a large number of different program streams. Such multiplexing is typically best suited to wide coverage area services where several licensees share a common licence area allowing them to use the same multiplex. In some situations, T-DAB may not be an optimum technical or commercial method for providing digital radio services, notably:

(i) broadcasters in small licence or coverage areas within which only one or two services are licensed to operate (examples include limited coverage community broadcasters in metropolitan or regional areas and LPON operators); and

(ii) small regional markets where there may only be a few broadcasting services in total.

[51] The 'digital dividend' is a term used to describe the benefits and opportunities that are expected to arise following the conversion of analog to digital television. The switch-off of analog television services will leave significant amounts of spectrum vacant in the VHF and UHF bands.
[52] A single-frequency network (SFN) involves multiple transmitters operating on the same frequency.
[53] Quad-band receivers would be required if MF/AM and VHF/FM functionality is included.
[54] The *1.5 GHz Band Plan* limits new assignments in the frequency range 1452–1492 MHz; however, fixed P-MP services for the delivery of telecommunications services in a rural or remote area, such as DRCS, are still permitted. The Band Plan is available at: www.comlaw.gov.au/comlaw/Legislation/LegislativeInstrument1.nsf/0/D9FD9C61C81A64F4CA256FF6001CBA62/$file/1.5bandplan.pdf.

For this reason, there is a need to continue investigation of alternative technologies. At this stage the most relevant alternatives for limited coverage community services and for covering less densely populated areas are DRM, which operates below 30 MHz, and the DRM+ system[55], which will operate in VHF Bands I or II but is yet to be standardised. To this end, in September 2006 ACMA placed an embargo[56] on new assignments in nine HF frequency bands to support domestic broadcasting services using DRM technology. Another possibility may be the introduction of DRM services in the MF band but, as mentioned earlier, given the current high utilisation of the MF band, the opportunities for doing this would appear to be limited unless a major replanning of that band was to be undertaken.

Television

From 2004 to 2006, the (then) Department of Communications, Information Technology and the Arts (DCITA) performed legislation mandated reviews on various aspects of the television broadcasting regulatory framework. All of the necessary reviews were undertaken, and discussion papers were released for public comment[57]. Limited changes were made as a result of submissions received (mostly from industry), but the information gathered was considered in the formulation of government media reforms. Some of the main outcomes of this work are outlined below.

From 2009 to 2013, arrangements for the provision of simulcast analog and digital television services are expected to be maintained in current VHF and UHF television spectrum, at least in certain areas of Australia. The Minister detailed a proposed digital switchover timetable, indicating that analog services would be switched off at different times around Australia, depending on the geographical area. Under the proposed timetable, which depends on legislative change and future Ministerial decisions, regional areas will switch over first, starting from 2010, while remote areas and state metropolitan areas will be the last to switch over, in 2013[58]. The digital switchover process will ensure that all viewers currently receiving analog free-to-air television will receive digital free-to-air television at the completion of the digital switchover. Until digital switchover is completed there will be very limited opportunities to introduce new services or add additional transmitters (beyond those planned for digital television services). Prior to digital switchover completion, the only remaining vacant television spectrum is substantially the channels currently planned to be packaged as Channel A and Channel B.

At nearly all broadcast transmitter sites around Australia, there are two planned but currently unassigned television broadcasting channels. The frequencies differ depending on the geographical location and are generally located in UHF television Bands IV or V (that is, 520–820 MHz). ACMA has been assembling national sets of these planned unassigned channels into packages to be called Channel A and Channel B in preparation for a price based allocation. Channels A and B have been planned as additional digital networks that would operate alongside the five digital networks that complement the existing five analog networks. The uses of these two channels are prescribed in legislation (Channel A is

[55] The DRM+ system is a development of the DRM system that is designed to operate in frequency bands between 30 and 108 MHz. Trials of this system commenced in Germany in November 2007.

[56] Embargo 44, contained in *Radiocommunications Assignment and Licensing Instruction MS3: Spectrum Embargoes*; available at: www.acma.gov.au.

[57] Reports on the results of the consultation process were completed for all of the reviews, except the review of the duration of the analog/digital television simulcast period.

[58] The Mildura/Sunraysia district (in Victoria) will be the first area to switch over, in the first half of 2010. This is followed by regional areas in SA (second half of 2010), Victoria (first half of 2011), Queensland (second half of 2011) and NSW (2012). Finally metropolitan areas in the states will be switched off in 2013, along with regional and remote areas of WA and NT. For more information, see *Conroy sets Digital TV switchover timetable*, Ministerial media release, 19 October 2008, www.minister.dbcde.gov.au/media/media_releases/2008/077.

authorised to provide additional fixed free-to-air television services such as narrowcasting, datacasting or community television; Channel B could be used in the same way but is also permitted to be used for a wider range of services such as mobile television). Allocation of Channels A and B is dependent on the finalisation of the government's position on relevant technical and policy settings.

Following other changes to legislation, commercial television broadcasters have commenced HDTV multi channel services, and from 1 January 2009, each commercial television broadcaster will be permitted to provide one SD multi channel (as is the case with the current SBS News and ABC2 channels). Full multi channelling (SD and HD) will be permitted after digital switchover[59].

Issues concerning re-use and/or reallocation of spectrum that may become available following the switchover to digital television (the digital dividend) are the subject of current consideration by government. However, it is clear that preparatory work will need to be conducted to ensure that the switchover to digital television proceeds smoothly and can occur on the date decided by government.

In particular, arrangements for the conversion of television retransmission facilities operated by local councils and other similar community groups will need to be decided. Various conversion options may exist. Simulcasting would provide the smoothest transition for viewers but may not be practical at all sites; digital conversion without simulcast may be forced by financial or spectrum availability issues in at least some areas. Alternatively, replacing terrestrial retransmission stations with direct to home (DTH) satellite services may also be an option to be explored. Careful consideration of the spectrum efficiency of these options is required as they may potentially erode the size of any potential digital dividend.

ACMA's proposed approaches

Analog radio broadcasting

Given the current high usage levels in both the MF-AM and VHF-FM bands, there is limited opportunity to introduce new services. ACMA will monitor technical developments and usage levels but no dramatic changes are foreseen in the 2009–2013 timeframe. The most significant development in these bands will be the introduction of digital services; ACMA will monitor such technologies (most notably DRM technologies) and will assess how and whether such technologies might be introduced. Part of that process will be continued support for trials[60].

Digital radio broadcasting

Under section 215A of the BSA, a final decision on the delivery of digital radio broadcasting services in regional areas (including those suitable for operation at MF, HF and VHF Bands I and II) will not be made until after a review on the technical and economic merits of various digital radio technologies is completed (before 2011). In the meantime, ACMA is prepared to facilitate trials for different digital radio broadcasting technologies. In relation to the apparent congestion of the MF-AM and VHF-FM bands, possible solutions may include channel replanning involving the use of narrower bandwidths (MF-AM band) and narrower channel spacing (VHF-FM band); most probably in conjunction with introduction of digital

[59] The *Broadcasting Legislation Amendment (Digital Television) Act 2006* (No. 128, 2006) inserts new sections 41B and 41C into the BSA, commencing 1 January 2009.

[60] *Digital Radio Trials using the Broadcasting Services Bands—Policy Guidelines*, available at: www.acma.gov.au/webwr/_assets/main/lib100535/dig%20radio%20trials%20pol%20march06.pdf .

services, but this is seen as a longer term possibility and in the 2009–2013 timeframe ACMA will continue to monitor the situation.

ACMA has determined legislative channel plans and issued multiplex transmitter licences in preparation for the commencement of T-DAB transmissions in capital cities in 2009. The deployment of T-DAB in regional areas is an issue that requires further consideration by ACMA and other areas of government. ACMA will also continue to facilitate licence issue for conducting digital radio broadcasting trials in non-BSB spectrum; this applies especially to the L-band. The *1.5 GHz Band Plan* will be maintained for now, but at an appropriate time it may need to be revised to permit the operation of planned T-DAB broadcasting services. Part of any such revision would need to include arrangements for the clearance of incumbent users in the L-band, particularly in major metropolitan cities and regional centres. Additional planning will also be required to determine the balance between the spectrum requirements for T-DAB services and a potential future satellite digital radio service. At this stage, allowing the issue of terrestrial or satellite digital radio licences could impede planning processes for the 1.5 GHz band.

Television

The government announced details of the timeline for digital switchover on 19 October 2008. As mentioned earlier, arrangements for the conversion of retransmission sites operated by council and community organisations will need to be determined. Where appropriate, ACMA will assist the government in its digital switchover activities.

ACMA is involved in testing digital television coverage to assess whether analog and digital services achieve the same level of coverage, as well as monitoring the nationwide roll out of digital television infrastructure.

Digital dividend spectrum will not be available before the completion of the digital switchover process. However, there are a wide range of potential (and potentially competing) demands for any spectrum that may become available. The government, with assistance from ACMA, will need to take into account the potential alternative services that may operate in the vacated spectrum and the respective costs, public benefit and commercial value resulting from their implementation. Possibilities include:

- spectrum that may be needed in a limited number of locations to resolve coverage or SFN implementation difficulties that are encountered in the implementation of digital television;
- additional television services (for example, a fourth commercial television network);
- digital radio broadcasting (T-DAB and potentially DRM+);
- additional or expanded WAS (see 5.9.2);
- public safety services (see 5.4.2);
- defence land force communications; and
- wireless microphones.

Work on the digital dividend is expected to include consultation with relevant stakeholders and the public once the work has progressed to an appropriate stage.

Allocation of Channels A and B is dependent on the finalisation of the Government’s position on relevant technical and policy settings.

5.2.3 BEYOND 2013

T-DAB digital radio broadcasting

The extension of T-DAB digital radio services into regional areas will depend on the success of T-DAB in state capital cities and the availability of suitable VHF Band III spectrum and/or adequacy of DRM or DRM+ as an alternative in regional areas. It is currently expected that digital radio will complement rather than replace existing analog services, and discontinuation of analog radio seems unlikely within the timeframe of this report. It also appears that new services are most likely to drive DAB take up rather than performance enhancements. T-DAB multiplex transmitters also enable the transmission of ‘restricted datacasting’ services, which is being promoted by Commercial Radio Australia as being useful for applications such as vehicular navigation. VHF-FM transmission is expected to continue to be an attractive option well into the future, especially considering the relatively low cost of establishment and operation of FM stations. However, some metropolitan MF-AM radio broadcasters may wish to vacate the MF band if T-DAB services are commercially successful due to the cost and inefficiency of maintaining duplicate transmissions. Such a migration would only occur if there was a high audience penetration of T-DAB digital receivers, and any audience loss was commercially insignificant.

Based on an assumed longer term growth in the number of T-DAB services, especially in major metropolitan areas, T-DAB spectrum requirements may increase beyond 2013 (see section 5.2.2). Estimates for spectrum demand suggest that by 2023, about 10 DAB blocks may be needed in VHF spectrum, and between six and 20 DAB blocks may be needed in L-band, if used for T-DAB in fill transmissions. The digital dividend in VHF Band III after switch-off is the preferred spectrum to accommodate additional VHF T-DAB demand, while making L-band spectrum available would require a strategy to clear incumbent services.

Other radio broadcasting technologies and planning issues

Demand for spectrum for alternative digital radio technologies beyond 2013 will require ACMA to keep under review and potentially consider its policies on:

(i) the availability of HF broadcasting spectrum;

(ii) potential for replanning the MF-AM band should incumbent broadcasters wish to vacate the band or adopt narrower bandwidth transmissions; and

(iii) the future use of vacated VHF Band I and II television spectrum should the DRM+ technology become available.

Some alleviation of VHF-FM band congestion may be possible after digital television switchover in areas that are currently covered by analog VHF Band II television services. Areas where significant Band II analog television services currently operate are:

- Renmark/Loxton and Spencer Gulf North (about 200 km ENE and north of Adelaide, respectively);
- Bunbury (150 km south of Perth);
- Townsville; and
- Wollongong and Newcastle.

Digital television and planning issues

As mentioned earlier, analog television transmissions are scheduled to cease nationwide by the end of 2013. This will release the channel capacity currently occupied by analog services in each area, typically two national services and up to three commercial services at each location and sometimes up to eight television services in areas (such as the Gold Coast and the Central Coast region of NSW) where commercial television licence areas overlap. Under current law, decisions about the longer term requirements of digital television in the BSB and the size and location of any digital dividend are for the Minister and not ACMA to make. Television industry demand is expected to be a factor in Ministerial consideration of the size of any dividend. At a minimum, there will be ongoing demand for the amount of spectrum required by current digital television services. Following analog switch off, there should be no further demand for spectrum in VHF Bands I and II for television services. In relation to VHF Band III and the UHF part of the BSB, any demand additional to spectrum already in use for digital television will depend on government decisions; for example:

- in relation to the number of commercial television services;
- on Channels A and B;
- on community self help services;
- on approaches to television ‘black spots’;
- in relation to community television broadcasting; and
- in relation to the programming requirements of existing broadcasters themselves.

These decisions will permit determination of how large a part of the remainder of VHF Band III and the UHF portion of the BSB will be required by television services.

Further into the future, consideration may be given to emerging television broadcasting technological advancements, such as second generation digital television, more advanced coding schemes and U-HDTV. Such developments and the associated spectrum requirements will be monitored by ACMA, but the potential implementation of these would need to be considered in light of their merit relative to other competing uses of the spectrum.

5.3 Fixed

The fixed service[61] is a radiocommunications service between a fixed transmitter and one or more fixed receivers (P-P or P-MP). Fixed links are a fundamental communications delivery technology for numerous spectrum users (including government networks, emergency services, utilities and mining operators), and act as a backhaul enabler for other radiocommunications networks (including mobile telephony and satellite).

5.3.1 CURRENT SPECTRUM USE

The fixed service has allocations across the entire radiofrequency spectrum, from very low frequency (VLF)[62] to extremely high frequency (EHF)[63]. The usage considered in this section of the report is at UHF (400 MHz and 900 MHz bands) and the bands from 1.5 GHz to 58 GHz (often referred to as the microwave bands). Another band including noteworthy use is VHF high band for fixed telephony services to remote homesteads. In addition, a primary band for Defence operations is the 230–399.9 MHz band, which is used, among other services, for tactical radio relay systems.

The fixed service in the UHF bands is predominantly used by narrowband applications that link land mobile base stations (P-P) and perform telecommand and telemetry functions (often P-MP). Wideband fixed services at 403–420 MHz (P-P) and 500–520 MHz (P-MP) are used, among other purposes, in rural areas by Telstra to provide universal service obligation (USO) telecommunications services. The 900 MHz band is also used for some studio to transmitter links (STLs) for the broadcasting service.

At 400 MHz and 900 MHz the P-MP systems are typically digital or analog systems in which a single central master station communicates with a number of outlying remote fixed stations. The predominant use of these systems is for data transmission; typical applications include telemetry, supervisory control and data acquisition (SCADA) systems, computer networking and alarm systems. Specific segments have been set aside in band plans[64] for these systems, but there are now limited opportunities for new frequency assignments; in recent times provision was made for these systems to access 400 MHz band spectrum allocated for the land mobile service. Demand for spectrum for P-MP systems appears strong in the 400 MHz and 900 MHz bands.

The microwave fixed bands that are used in Australia are specified in ACMA's *Radiocommunications Assignment and Licensing Instruction (RALI) FX 3—Microwave Fixed Services Frequency Coordination*. These bands can be classified into four major categories of use:

1. low capacity long haul links—1.5, 1.8, 2.1 and 2.2 GHz bands;
2. high capacity long haul links—3.8, 6, 6.7 and 8 GHz bands;
3. medium capacity medium haul links—7.5, 10, and 13 GHz bands; and
4. backhaul and urban networks—15, 18, 22, 38, 50 and 58 GHz bands.

[61] In this report, the fixed-satellite service is included in the satellite service section, and FWA is included in the WAS section.
[62] VLF is the frequency range 3–30 kHz.
[63] EHF is the frequency range 30–300 GHz.
[64] The administrative band plan *RALI MS 22—400 MHz Plan* is available at: http://www.acma.gov.au/WEB/STANDARD..PC/pc=PC_2571, while the legislative *Radiocommunications 900 MHz Band Plan 1992*, www.comlaw.gov.au/comlaw/Legislation/LegislativeInstrument1.nsf/0/9D52513538D665BACA256FF000063209?OpenDocument

In rural and remote areas, the 1.5 GHz band is used for DRCS/HCRC, which provides telephone services to these areas, as well as for the provision of BWA. The 1.5 GHz band is also used for non-DRCS/HCRC P-P links across Australia, for which it is heavily used in metropolitan areas. The *1.5 GHz Band Plan* prohibits new assignments in the frequency ranges 1452–1492 MHz and 1525–1530 MHz; however, fixed P-MP services for the delivery of telecommunications services in a rural or remote area are still permitted[65]. This constraint was made in order to preserve options in the 1452–1492 MHz band for the deployment of T-DAB transmitters in and around metropolitan areas (see section 5.2.2) and in the 1525–1530 MHz band for the MSS (see section 5.7.2).

Other microwave bands not listed above are used for television outside broadcast (TOB)[66] services (2.5, 7.2 and 8.3 GHz) or temporary links (49 GHz), or are spectrum licensed (3.4 and 31 GHz). The 3.4 GHz band (outside spectrum licensed areas) also provides rural communities with fixed telephony and data communications services. The 2.5 GHz band is also used for electronic news gathering (ENG—see Appendix A), which involves the use of terrestrial portable radio equipment by services ancillary to broadcasting. Typical ENG use includes the transmission of video from a remote unit at a sporting or news event. Some channels in the 13 and 22 GHz bands are also designated for TOB services. The 5 GHz band (4400–5000 MHz) is Defence's main band for microwave fixed services, although it is also used for other services. Defence uses this band for tropospheric scatter systems and microwave fixed P-P links.

5.3.2 2009–2013

Issues affecting spectrum demand

Drivers

Based on industry consultation and international trends, variations in spectrum requirements are envisioned in the future; for example, a move towards HD television and IP-based[67] applications would drive increased capacity requirements (though an increase in the spectral efficiency of technology may offset this to some degree). ACMA expects growth in the fixed service to be driven mainly by the backhaul needed to support the creation and expansion of mobile carrier networks during the transition from second generation (2G) to 3G and other International Mobile Telecommunications (IMT)[68] technologies. The demand for broadband communications services in rural and remote areas is likely to have a consequent implication for backhaul spectrum in the low capacity bands to support fixed wireless broadband services. As such, and following international trends, the use of high capacity radio technologies is expected to increase in microwave bands below 15 GHz. Other factors that may affect future spectrum demand (such as the possible replacement of high capacity, long haul trunks with optical fibre) are discussed in the following subsections.

400 and 900 MHz bands

High demand for narrowband fixed links in the 400 MHz band has exceeded the available spectrum in certain areas, both metropolitan and regional. Parts of the 900 MHz band are also heavily used, and there is increasing difficulty in finding available spectrum for P-MP

65 *1.5 GHz Band Plan*; available at: http://www.comlaw.gov.au/comlaw/Legislation/LegislativeInstrument1.nsf/0/D9FD9C61C81A64F4CA256FF6001CBA62/$file/1.5bandplan.pdf.

66 TOB involves the use of temporary fixed links for broadcast coverage of an event remotely located from the broadcasting studio.

67 IP stands for internet protocol.

68 IMT is an ITU-approved global standard for 3G and 4G (fourth generation) wireless communications which includes the WiMAX technology.

links in particular. Industry has requested that ACMA provide additional opportunities to operate in these bands, particularly for telecommand and telemetry applications and STLs.

Figures 5.2 and 5.3 show the distribution of fixed P-P links and fixed P-MP transmitters in the 400 MHz and 900 MHz bands respectively.

Figure 5.2: Distribution of fixed P-P links (blue lines) and fixed point-to-multipoint transmitters (red dots) in the 400 MHz band (January 2008)

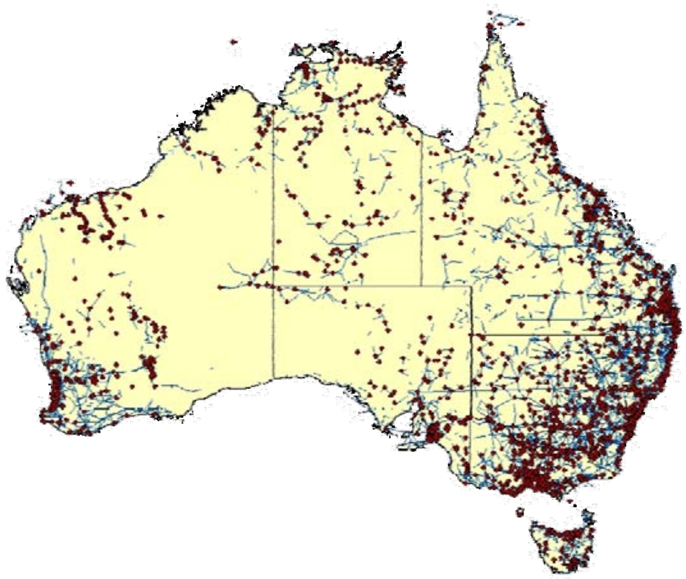
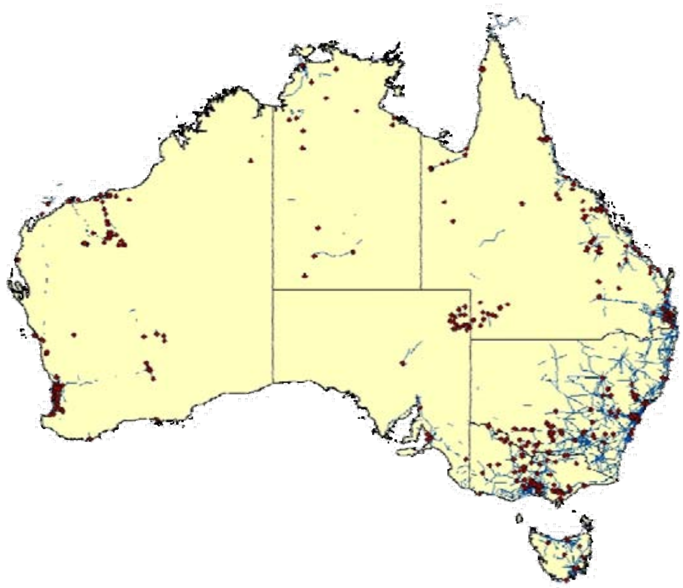


Figure 5.3: Distribution of fixed P-P links (blue lines) and fixed P-MP transmitters (red dots) in the 900 MHz band (January 2008)



There is currently considerable discussion among power utilities and radiocommunications industry regarding technology options to introduce the smart grid concept to their power networks. This involves power networks doubling as data networks for remote grid management, automated meter reading and the provision of enhanced power consumption and cost information to consumers (known as 'smart metering'). Trials of smart grids are already underway in Australia. Fixed links operating in spectrum below 1 GHz may be suitable for the implementation of smart grids, though it is not yet known whether wireless communications will play a part in the network design.

Low capacity, long haul links

Most of the 1.8 GHz band is spectrum licensed in major city areas and typically used for third generation (3G) mobile telephony services and GSM-1800[69], and portions of the band are spectrum licensed in regional areas also. In addition to this, part of the 1.8 GHz band is embargoed to support possible future replanning for WAS (see section 5.9.1). Most of the 2.1 and 2.2 GHz bands in low, medium and high density areas are either spectrum licensed or embargoed to facilitate the introduction of the MSS[70] or to preserve options for future planning[71]. Apparatus licences issued in these, and several other bands, are subject to apparatus licence advisory note BL, which states:

> This frequency band is currently under review to accommodate changes in technology. This review may lead to a requirement to change frequency or cease transmissions.

In this case, the bands are under review for the possible accommodation of WAS.

In recent years, there has been a decline in the number of low capacity long haul links, which could be due to parts of the 1.8, 2.1 and 2.2 GHz bands being embargoed, and the spectrum licensing of large portions of the bands in populated areas. These bands are under increasing pressure from other services to share or release their spectrum, which could result in operators being reluctant to roll out links in these bands due to the uncertainty surrounding their future. However, rural and remote, along with some regional areas are available for apparatus licensing, and these bands continue to be available for the provision of fixed backhaul in rural and remote areas.

High capacity, long haul links

There is an international trend to identify spectrum below about 3 GHz (and more recently 6 GHz) for WAS. Decreased opportunity for new fixed service assignments in these lower bands has resulted in a shift of links from the 1.8, 2.1, 2.2 and 3.8 GHz band to the 6, 6.7, 7.5 and 8 GHz bands. The latter group of bands are mostly used along trunk routes that link major towns and cities across Australia, and spectrum is highly utilised along these major routes. Considering the cost of installing new trunk routes and the increased capacity that alternatives such as fibre offer, ACMA expects that use of these bands will increase slightly over the next few years, but does not anticipate that additional spectrum will be required.

Figure 5.4 shows the distribution of low capacity and high capacity long haul fixed links across Australia.

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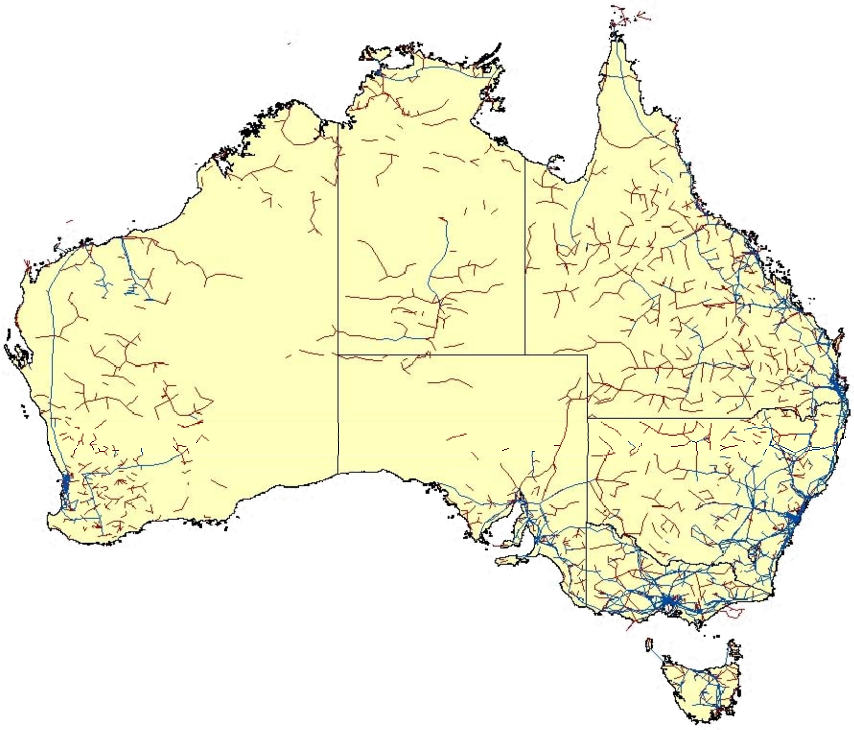
[69] GSM (Global System for Mobile communications) services operating in the 1800 MHz band.
[70] Embargo 23, contained in RALI MS3, http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712.
[71] Spectrum Management Agency, 1996, *1.9 GHz Band Plan*, www.comlaw.gov.au/ComLaw/legislation/LegislativeInstrument1.nsf/0/4B5FF06D93A21416CA256FEB00083741?OpenDocument prohibits new fixed point-to-point services in 1880–1900 MHz, while Embargo 23 (see above) applies to 2025–2110/2200–2300 MHz.

Figure 5.4: Distribution of low capacity (red lines) and high capacity (blue lines) long haul links (January 2008)



Bands above 7 GHz

ACMA expects usage to increase in all fixed service bands above 7 GHz. These bands are moderately utilised at present, and a projection of recent frequency assignment growth rates indicates that there is sufficient spectrum to accommodate demand from 2009–2013 (for example, see Figure 5.5). However, the deployment of future technologies may impact on spectrum requirements; for example, future growth in the bands above 15 GHz in urban areas is expected to be driven by the expansion of mobile operator networks and in particular, the deployment of IMT technologies.

Figure 5.5: Linear regression of utilisation figures of the 7 MHz channels in the 22 GHz band (based on channel loading studies). The 22 GHz band is among the most highly utilised of the microwave fixed link bands.

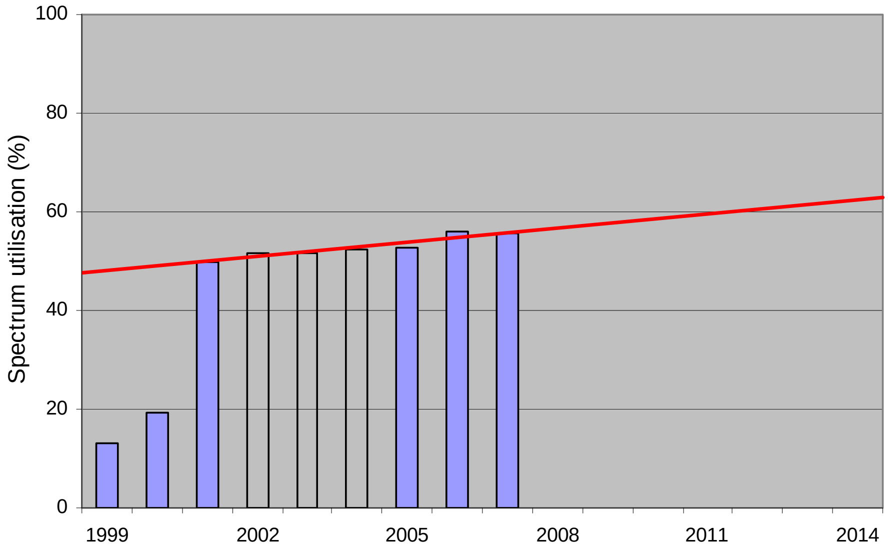
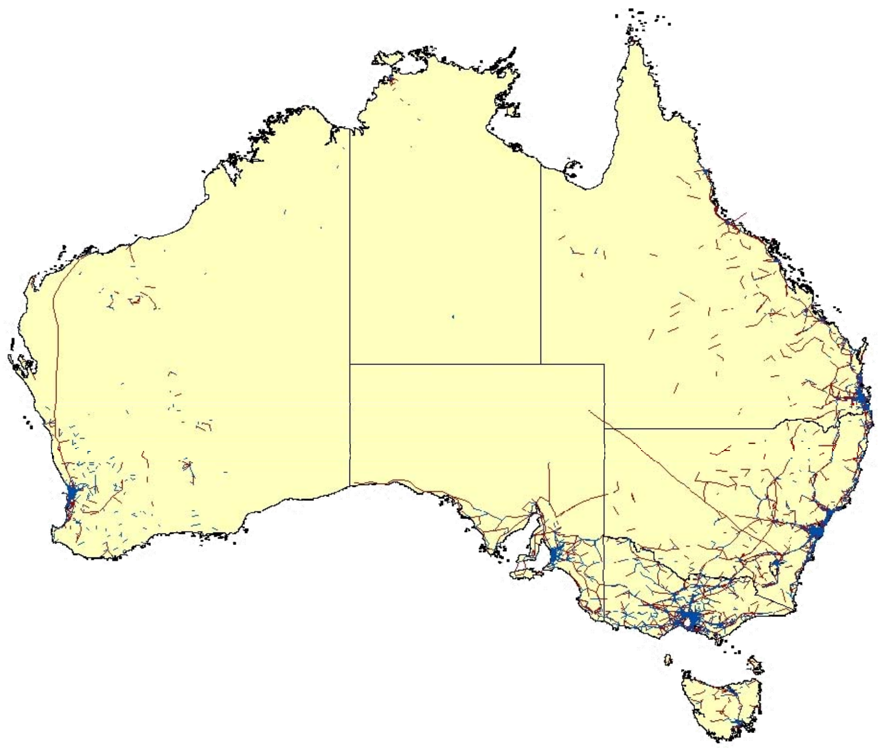


Figure 5.6: Distribution of medium capacity medium haul links (red lines) and backhaul and urban networks (blue lines)[72] (January 2008)



The 50 and 58 GHz bands were made available for fixed services relatively recently, and due to slow take up within industry they are currently very lightly utilised. A self coordinated

[72] The backhaul links (blue lines) reaching out from cities to regional areas are mainly in the 15 GHz band, as the vast majority of links in the 18 GHz band and above are concentrated in metropolitan areas (particularly visible in the state capital cities).

apparatus licence is currently available to authorise the use of fixed P-P links in the 58 GHz band, with the licensing process guided by *RALI FX20—Millimetre Wave Point-To-Point (Self Coordinated) Stations*[73]. Based on international trends, ACMA believes that these bands may see a large increase in use in the future if envisioned technological improvements and increased affordability are realised. However, due to the relatively small re-use distance of the bands, ACMA expects that additional spectrum requirements for fixed services operating in these bands are unlikely during the next 15 years.

The broadband wireless technology known variously as millimetre-wave, pencil beam or gigabit wireless spectrum is designed to operate in the 71–76 GHz and 81–86 GHz bands. As for the 58 GHz band, self coordinated apparatus licences may authorise the use of millimetre wave systems in the 71–76 and 81–86 GHz bands.

Transmissions at these frequencies allow communication paths of up to three kilometres, and with this technology, full duplex data rates of up to 10 gigabits per second can be reached[74]. At these frequencies, antennas can have much narrower beamwidths than antennas at lower frequencies. This means that millimetre-wave technology has a relatively low potential to cause interference to other nearby links, and can provide a high level frequency reuse. Therefore, ACMA does not expect spectrum shortage in these bands within the next five years, despite the expectation that the use of this technology will become more widespread.

The viable use of increasingly higher frequencies is a common trend in radiocommunications that is facilitated by technological advancements. The use of active services (services that generate their own electromagnetic emissions for the purposes of radiocommunications) is expected to continue above 71 GHz, and for this reason, WRC-11 Agenda item 1.8 is to consider the results of ITU studies into sharing arrangements between passive and active services (Resolution 731), and between multiple different co-primary active services (Resolution 732).

Spectrum management issues

A number of issues possibly affecting the fixed service will require consideration over the next five years. In particular, consideration of sharing issues between the fixed service and other services as a result of decisions made at WRC-07 will need to be considered. At WRC-07, the parts of the 790–806 MHz band allocated to the mobile service on a primary basis were identified for use by administrations wishing to implement IMT; in addition to the existing IMT identification in the frequency range 806–960 MHz. This latter range includes the entire 900 MHz fixed service band. Considering the aforementioned spectral congestion, the introduction of WAS applications to the band may further compound the problem.

The limited availability of spectrum in the 1.5 GHz band is due in part to the existing heavy use of some channels, and in part to the restrictions imposed by the *1.5 GHz Band Plan* to facilitate the introduction of other services. In the case of T-DAB being introduced in the 1.5 GHz band, the relevant band plan would need to be revised, and include arrangements for the clearance of incumbent fixed links. The identification of the 1518–1525 GHz MSS allocation (the ‘extension band’) for the satellite component of IMT at WRC-07 (see section 5.7.2) may place additional pressure on the fixed service in the 1.5 GHz band in the future.

Sharing issues with other services in certain bands may also affect future growth in that band or other bands. For example, technical arrangements for the 10 GHz band may be changed to

[73] RALI FX20 is available at: http://www.acma.gov.au/webwr/radcomm/frequency_planning/frequency_assignment/docs/ralifx20_millimetre_wave_point.pdf.
[74] With four-level frequency shift keying (FSK) modulation.

protect passive sensing operations of the Earth exploration-satellite service (EESS—see section 5.8.2). This could also indirectly affect spectrum demand in, for example, the 11 GHz band, which is currently relatively lightly utilised, but already growing rapidly. The 50 MHz channels of the 22 GHz band may be reviewed with a view to accommodating the potential future satellite broadcast of high definition television (HDTV) in the 21.4–22 GHz band (see section 5.7.2). These channels of the 22 GHz band are relatively lightly utilised by fixed P-P links.

WRC-11 Agenda item 1.5 is to consider the worldwide/regional harmonisation of spectrum for ENG. Consultation with the relevant stakeholders is essential for the formulation of a national position on the matter. Future spectrum usage for ENG in Australia may also be affected by the outcome of ACMA's review of arrangements for the 2.5 GHz band and the associated development of long term spectrum arrangements for ENG (see Appendix A).

High altitude platform stations

High altitude platform stations (HAPS) are fitted to aircraft or airships intended for the wireless transmission of both narrowband and broadband telecommunications services over a wide area.

There are currently two sets of paired bands, 47.2–47.5 / 47.9–48.2 GHz, allowing the use of HAPS in Australia. Although HAPS are not currently used in Australia, there are other services in and near these bands. At WRC-07, pfd limits were determined to protect fixed services, separation distances were defined to protect adjacent band radio astronomy stations, and equivalent isotropically radiated power (EIRP) and antenna beam pattern constraints were applied to facilitate sharing with the FSS[75].

At WRC-07 the 27.5–28.5 GHz (28 GHz) and 31–31.3 GHz (31 GHz) bands identified for HAPS[76] were further clarified. In the 28 GHz band, the HAPS downlink segment was reduced to 27.9–28.2 GHz band. For both the 28 GHz and 31 GHz HAPS bands, it was determined that interference mitigation techniques and protection criteria would need to be determined to minimise interference to the terrestrial fixed and mobile services. Both the 28 GHz and 31 GHz bands are spectrum licensed and lightly used in Australia; these were intended for systems optimised for BWA.

WRC-11 Agenda item 1.20 is to identify spectrum for gateway links for HAPS in the range 5850–7075 MHz for systems in support of fixed and mobile services. Such links could, for example, support the provision of broadband services to rural areas.

[75] Provisional Final Acts of WRC-07, Resolution 122 – *Use of the bands 47.2–47.5 GHz and 47.9–48.2 GHz by high altitude platform stations in the fixed service and by other services*.
[76] These provisions for HAPS were made at WRC-03.

ACMA's proposed approaches

High capacity, long haul links

ACMA will monitor utilisation levels in these bands. If it appears they are becoming congested, ACMA will investigate mitigation strategies such as facilitating the use of more spectrally efficient technology (for example, XPIC technology[77]) or increasing the use of unpaired spectrum[78].

Spectrum users may also consider the use of new trunk routes or the use of optical fibre if the bands become congested, though these options would have a significant financial burden.

Low capacity, long haul links

ACMA has commissioned a consultancy into the long term aspirations of microwave fixed P-P users in microwave bands below about 5 GHz. The subsequent consultation period sought to receive comments from stakeholders regarding their spectrum requirements and possible future band planning arrangements. Based on this consultation, ACMA expects to release a public discussion paper in early 2009, including proposals for changes to assignment arrangements in *RALI FX 3* (see Appendix A).

Spectrum management issues

Whenever possible, ACMA will attempt to follow international practice when considering arrangements for use of the fixed service bands. ACMA plans to maintain a high level of support for P-P links and does not intend to make major changes to fixed service band usage without extensive consultation. One such potential change may be that related to the possible introduction of the satellite broadcast of HDTV in the band 21.4–22 GHz (see section 5.7.2). Generally, incremental improvements to planning arrangements will be made, and measures such as incentive pricing may be utilised to encourage the use of less congested bands and the relinquishment of unused licences.

ACMA periodically conducts trending studies of fixed service licensing and makes adjustments to the licensing framework as appropriate. A review of protection criteria and planning arrangements for microwave services is planned within the next five years, which may lead to a consequential update of *RALI FX3*. Consideration of changes to arrangements in the 10 GHz band for the protection of the EESS (see section 5.8.2) may be undertaken as part of a general review or as a separate project. In order to protect future options for the use of the 11 GHz band by the fixed service and other terrestrial services, ACMA policy does not support the ubiquitous, uncoordinated deployment of Earth station receivers in the 10.7–11.7 GHz band (see section 5.7.2).

ACMA is encouraging the development of standardised geoclimatic and rainfall statistical information for Australian microclimates, in conjunction with ARSG 3, to help remove uncertainties associated with planning fixed services above 10 GHz and allow for more efficient use of these bands.

400 and 900 MHz bands

ACMA is currently examining the overall use of the 400 MHz band to find ways of increasing access to it (see Appendix A). This will hopefully lead to improved access for the fixed service (mainly P-MP) in the medium term; ACMA has received feedback from

[77] XPIC (cross-polarisation interference cancellation) is a technology that allows use of the same frequency over the same path on the opposite polarisation.

[78] Unpaired spectrum means that a communications link only uses one frequency channel, and bidirectional links can be achieved with unpaired spectrum using time division duplex (TDD) technologies.

several stakeholders seeking continued access to 25 kHz channels for fixed P-P services in the 400 MHz band. Increased size of and interoperability in land mobile networks, as sought by government organisations (see 5.4.2), would correspondingly require an increase in base station backhaul.

In the 1990s, spectrum in the 900 MHz band was allocated for cordless telecommunications services (CTS) known as CT2, CT3 and digital short range radio (DSRR). These services did not gain wide acceptance in the Australian market (or internationally) and the spectrum is thought to be poorly utilised. ACMA has not yet made a decision about the long term use of this spectrum, and has put in place Embargo 34[79] to support possible replanning or spectrum licensing of this band. The embargo prevents new fixed or mobile assignments being made in this spectrum. In any case, replanning of the 900 MHz band would not commence until after replanning of the 400 MHz band is well underway.

Currently ACMA is applying annual licence tax increases (in accordance with opportunity cost pricing) to fixed services operating in bands below 960 MHz, in order to ease congestion and bring licence fees closer to market valuations. This is planned to continue until 2009, when fee equivalence with land mobile services will be achieved.

High altitude platform stations

ACMA supports the future deployment of HAPS on the proviso that work, including detailed sharing studies, is undertaken to ensure the successful cohabitation of HAPS with other systems. ACMA is currently monitoring HAPS developments, and will use the information obtained with a view to forming a position in relation to Agenda item 1.20 of WRC-11.

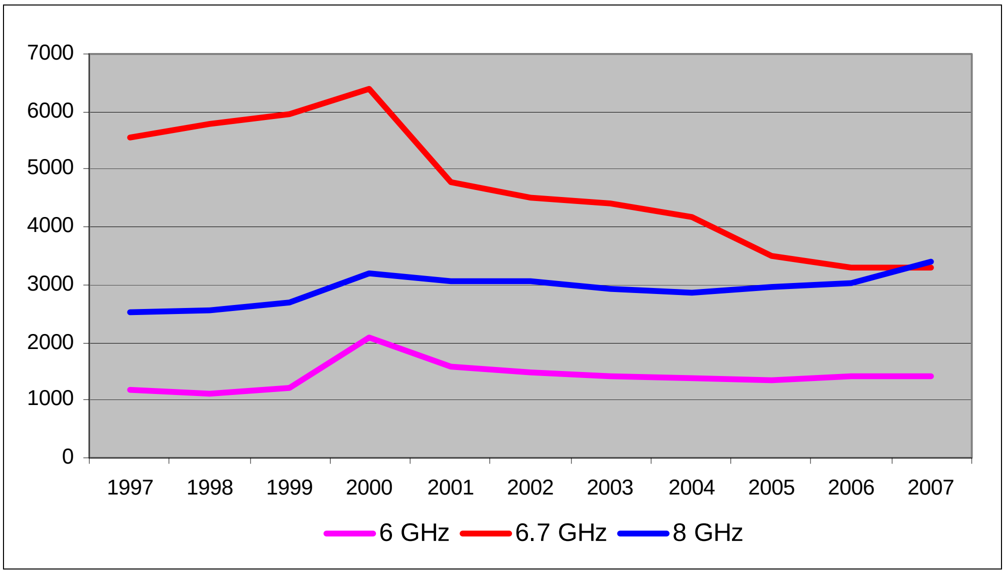
[79] Embargo 34, contained in RALI MS3, http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712.

5.3.3 BEYOND 2013

High capacity, long haul links

Based on current frequency assignment growth rates (Figure 5.7), the 8 GHz band may experience more growth than the other high capacity long haul bands beyond 2013. Despite the international trend towards the replacement of high capacity long haul radio links with optical fibre systems, the feasibility of this in Australia is somewhat limited by rough terrain, a small dispersed population, large distances between population centres and higher costs. Consequently, the high utilisation of these bands is expected to continue.

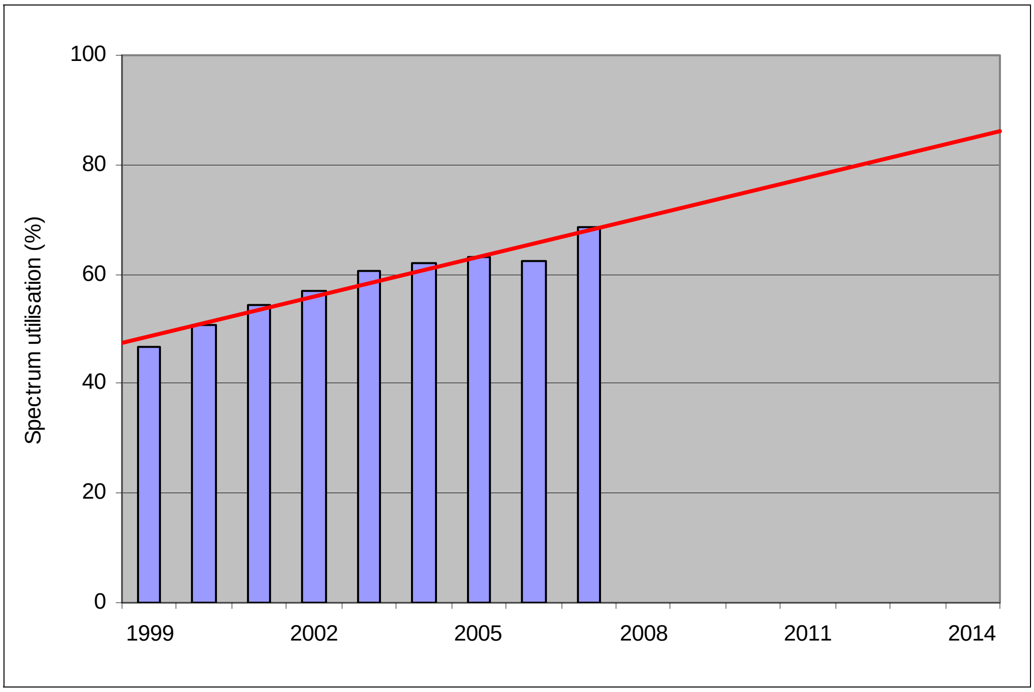
Figure 5.7: Licence trends for the high capacity long haul bands of the fixed service



Bands above 7 GHz

Growth is expected to continue for all the microwave fixed service bands above and including 13 GHz. Due to moderate utilisation levels at present and predicted continued growth, ACMA considers it a possibility that demand in the 7.5 GHz band may exceed current allocated spectrum by 2023 (Figure 5.8). Other bands that may become congested within the next 10 years in very high density areas are the 13, 15 and 22 GHz bands. ACMA will monitor utilisation levels in these bands. If it is evident that the bands are becoming congested, ACMA may consider replanning these bands to ease the congestion.

Figure 5.8: Linear regression of the spectrum utilisation (%) of the 7.5 GHz band within the low density area[80] of Australia's east coast



If growth increases in the bands above 13 GHz to the extent that there may be unmet demand, ACMA may consider making available alternative bands to relieve the pressure. For example, the 25 GHz band (24.5–26.5 GHz) has been embargoed[81] for potential future use by the fixed service and other bands, including the 32 GHz band (31.8–33.4 GHz), have been identified by the ITU[82] for high density applications in the fixed service.

It is also expected that fixed service usage will extend up to frequencies above 100 GHz within the next 15 years. The use of such high frequencies is likely to be impacted by the possible results of Agenda item 1.8 at WRC-11, particularly if inter-service sharing criteria are determined.

[80] High, medium and low density areas are defined in ACMA's *Apparatus Licence Fee Schedule*, http://www.acma.gov.au/WEB/STANDARD/pc=PC_1614. This particular low density area extends along Australia's east coast from Port Douglas to Melbourne, and covers almost all of Victoria and to the west past Adelaide and up to Whyalla. This area (known as the 'J-curve') contains the medium density areas of Adelaide and Newcastle, and the high density areas of Brisbane and the Gold Coast, Sydney and Wollongong, and Melbourne and Geelong. These higher density areas were included in the data for Figure 3.9.
[81] Embargo 24, contained in RALI MS3, http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712.
[82] See Article 5.547 in the ITU *Radio Regulations*.

5.4 Land mobile

The land mobile service is a terrestrial service that provides radiocommunications between base stations and land mobile stations, or directly between land mobile stations. Land mobile stations typically provide one to many or one to one communication services to law enforcement, defence, security and emergency services organisations, public works including transportation, rail and utilities industry sectors, private companies with large vehicle fleets and field staff, and others from industry sectors including agriculture, construction, hospitality, mining, manufacturing, tourism and telecommunications services providers.

This report considers the land mobile service as comprising the following land mobile licensing options:

- land mobile systems;
- ambulatory stations;
- citizen band radio service (CBRS) repeaters; and
- paging systems.

Land mobile systems usually comprise a fixed base station communicating with one or more mobile units, which can either be handheld or vehicle mounted. Coverage is typically metropolitan in scale.

Ambulatory stations are similar to land mobile systems, but they do not have base stations. Communication is between handheld units, which typically have a lower power than land mobile systems and therefore a comparatively smaller coverage area.

The CBRS is a two way, short distance voice communications service that can be used by any person in Australia. A CBRS repeater is established at a fixed location for the reception and automatic retransmission of radio signals from citizen band (CB) stations.

Paging systems comprise a base station and portable receiving devices used to contact, or convey messages to, individuals. Paging systems can be used in either indoor or outdoor applications.

5.4.1 CURRENT SPECTRUM USE

There are six frequency bands generally used for the land mobile service:

- HF band (3–30 MHz);
- VHF low band (29.7–45 MHz);
- VHF mid band (70–87.5 MHz);
- VHF high band (148–174 MHz);
- 400 MHz UHF band (403–430 MHz and 450–520 MHz); and
- 900 MHz UHF band (820–825 MHz and 865–870 MHz).

In addition to some of these bands, Defence deploys land mobile systems in other parts of the spectrum, in particular 230–399.9 MHz. Defence has specified its use of HF for long distance communications and VHF low band for land force communications, including for joint and allied interoperable communications.

This document focuses on the 400 MHz and 900 MHz bands, as these are the prime land mobile bands for non defence users. However, ACMA does not ignore the value of lower frequency bands for land mobile radio users, and the superior coverage of these bands makes them useful for communications in regional and remote areas. For example, in the VHF high band, the Victorian Government uses the StateNet Mobile Radio (SMR) network and Telstra operates its commercial Fleetcoms trunked land mobile network, while the Queensland Government uses VHF mid band for emergency services communications.

400 MHz band

The 400 MHz band caters for land mobile and fixed services with a mix of 12.5 and 25 kHz channelling. Both single and two frequency operation is supported, as well as trunked land mobile services. The *400 MHz Plan*[83] details planning arrangements for the 400 MHz band. Industry feedback indicates that users of the 400 MHz band agree that current spectrum arrangements, technology availability and frequency characteristics make 400 MHz the ideal band for wide area land mobile radiocommunications. VHF is suitable for regional areas but requires larger antennas and is more susceptible to man made noise. On the other hand, 900 MHz is optimal for urban areas, but lesser coverage makes infrastructure rollout to regional areas very expensive.

900 MHz band

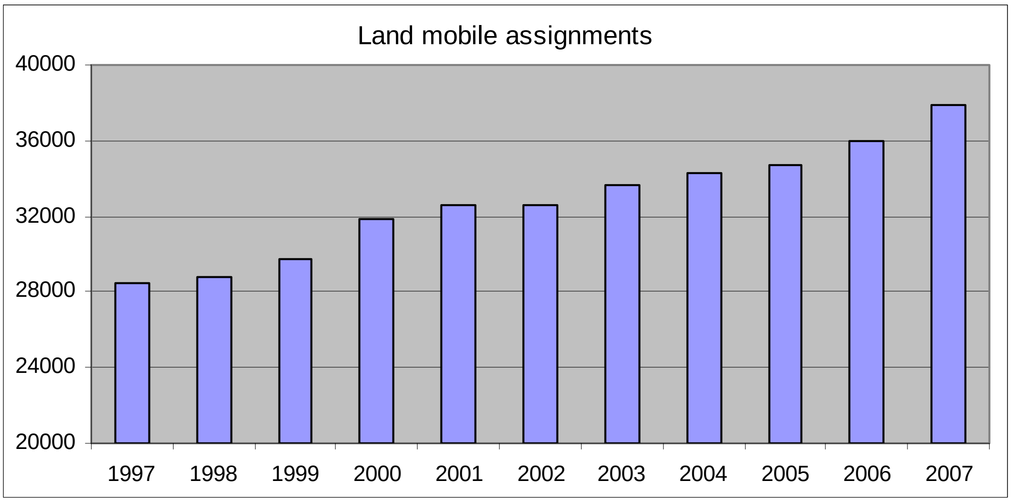
The majority of this band is used for 2nd and 3rd generation public mobile telecommunications services using GSM and wideband CDMA[84] (WCDMA) technologies. Land mobile services in this band are for trunked systems restricted to one paired segment: 820–825 MHz (base receive) / 865–870 MHz (base transmit). All land mobile assignments in this paired segment authorise 25 kHz systems. The *900 MHz Band Plan*[85] details planning arrangements for the 900 MHz band.

Trends

Analysis shows steady growth in the number of land mobile assignments over the past several years. Apparatus licence data only gives an indication of the growth of base station or repeater station numbers, but not on the actual number or growth of mobile stations. Motorola has advised ACMA[86] of studies estimating that there were approximately 800,000 two way radios in use in 2003, utilised by around 180,000 different organisations, and that annual shipments of two way radios had grown by 30 per cent since then. However, there is anecdotal evidence to suggest that growth has been tempered by congestion in some metropolitan areas. In congested areas new systems are often accommodated by splitting 25 kHz channels into 12.5 kHz channels or by deploying low power systems. The growth of land mobile assignments in the 400 MHz and 900 MHz bands is charted in Figure 5.9. Traditionally mostly used for voice communications, the use of land mobile radio for data services is increasing rapidly and becoming very important to users.

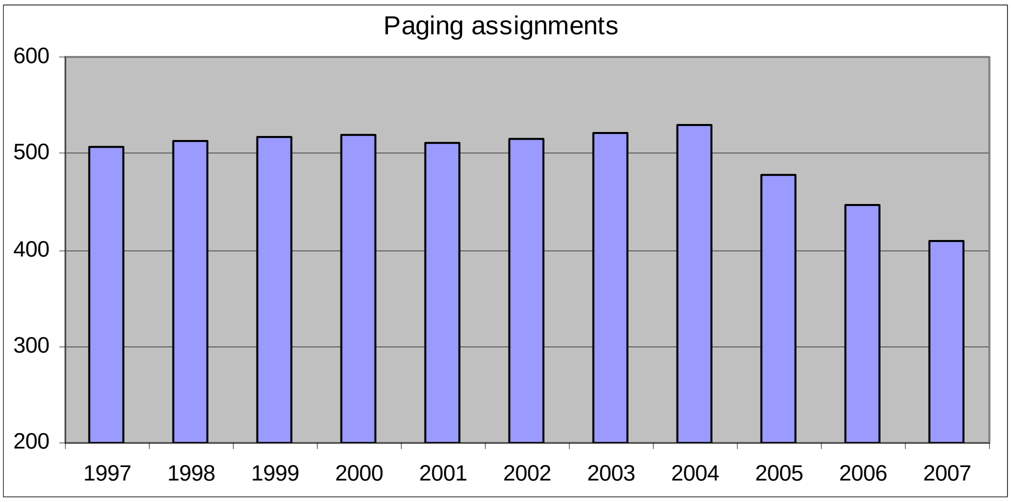
[83] The *400 MHz Plan* ; available at: http://www.acma.gov.au/WEB/STANDARD/pc=PC_2571.
[84] Code division multiple access.
[85] The *900 MHz Band Plan* ; available at: http://legislation.gov.au/comlaw/Legislation/LegislativeInstrumentCompilation1.nsf/0/FFAC85B8A5C4FB5FCA25703B0015B33F?OpenDocument.
[86] Motorola Australia Pty Ltd Response to the draft *Five-year Spectrum Outlook 2009–2013*, http://www.acma.gov.au/webwr/_assets/main/lib310714/motorola.pdf.

Figure 5.9 Total land mobile assignments in Australia in the 400 MHz and 900 MHz bands



There has been a gradual decline in the number of paging assignments over the past four years, which is largely attributable to the growth of the short message service (SMS), provided by digital cellular mobile telephony services. This decline can be seen in Figure 5.10.

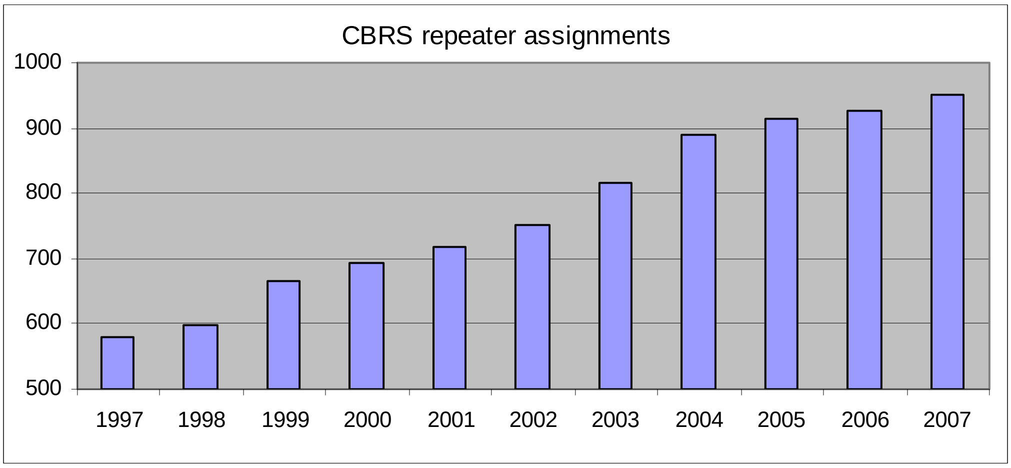
Figure 5.10: Paging assignments



The operation of CB radios is authorised under a class licence[87], which means that stations are not recorded individually. Growth in the use of the CBRS can be inferred from the growth in CBRS repeater assignments over the last decade, as shown in Figure 5.11. This shows steady growth over the past 10 years.

[87] Australian Communications Authority, 2002, *Radiocommunications (Citizen Band Radio Stations) Class Licence 2002*, http://www.comlaw.gov.au/ComLaw/legislation/LegislativeInstrument1.nsf/0/9C9C576BDCCEBF70CA256F8C007DAC72?OpenDocument.

Figure 5.11: CBRS repeater assignments



5.4.2 2009–2013

Issues affecting spectrum demand

Congestion and the availability of spectrum to facilitate new technologies are key issues for the land mobile service. Industry has expressed the view that land mobile radio services provide essential features that in most cases cannot be provided by other services such as public mobile telephony and satellite, including group calling, one to many communications, accessibility and reliability. Such features render land mobile radio a continuing requirement for a variety of commercial and government users.

Fragmented government land mobile spectrum holdings

To date, spectrum used by government agencies, including those involved in law enforcement, defence, security and emergency services, is fragmented across various segments of the 400 MHz band[88]. Federal and state/territory governments are developing strategies for their use of 400 MHz band spectrum for land mobile systems, including whole or most of government networks, which could exploit trunking efficiencies and potentially use less spectrum. The various government jurisdictions are working towards a national strategy for the consolidation of government land mobile spectrum holdings to achieve inter-jurisdictional interoperability through the use of common frequencies and technologies.

The rail industry is also an important user of the 400 MHz band, especially in particular channels widely used by government rail authorities. Land mobile systems used by the rail industry include train protection, command and control systems such as Queensland Rail's shunt radio, train control radio (TCR), maintenance supervisory radio (MSR) and automatic train protection (ATP), together with several other systems, providing communications for voice and monitoring data. Such use is another example of fragmented government spectrum

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[88] 403–420 MHz—used by the state of SA, as well as the NSW Government for its government radio network (GRN). 420–430 MHz—Victorian metropolitan mobile radio (MMR) and NSW mobile data radio service (MDRS) networks used by police and emergency services; NT has expressed interest in moving its trunked radio network to this band. 458.3375–459.9375 / 467.8375–469.4375 MHz—law enforcement and public safety (LEPS) spectrum—used by most jurisdictions (principally police) for voice communications; this band has some capacity for cross-jurisdictional operations and interoperability. 470–490 MHz—used by law enforcement and security agencies for radiocommunications in counter-terrorism operations. 500–520 MHz—includes systems deployed by Motorola: trunked radio network for Western Australian police and the mobile data network (MDN) and the Victorian MMR network.

holdings to be considered, albeit in a different manner. ACMA acknowledges that radiocommunications are essential in the safe and efficient operation of Australia's railways.

Of course, the requirements of the commercial sector must also be accommodated, and some industry commentary has argued that the level of interoperability, and consequently contiguous, common spectrum, being sought by government agencies is excessive. ACMA is aware of and will take into consideration the costs incurred by the private sector as a result of any potential changes to spectrum arrangements, especially companies with large mobile fleets and small businesses.

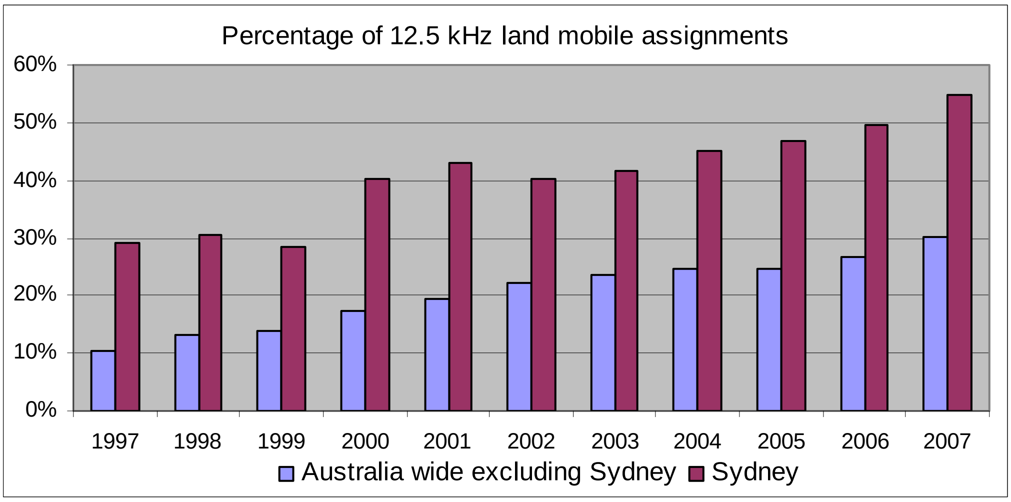
Congestion

Congestion, especially in high demand markets such as Sydney and Melbourne, is currently the most significant issue affecting the land mobile service. Survey results from frequency assigners indicate that in high demand markets it is almost impossible to find available 25 kHz channels. Consequently, frequency assigners have resorted to splitting 25 kHz channels in Sydney and using low power assignments in Melbourne to meet demand for land mobile assignments.

Figure 5.12 shows the percentage of 12.5 kHz land mobile assignments in Sydney and for the rest of Australia. It indicates that Sydney, over the past 10 years, has had a higher proportion of 12.5 kHz assignments than has the rest of Australia. The difference between the 12.5 kHz assignment proportions of Sydney and Australia has grown over the last decade to the extent that nearly 55 per cent of land mobile assignments in Sydney are now 12.5 kHz, in comparison to the national ratio of 30 per cent.

Industry feedback reveals that digital radio technologies employing 6.25 kHz channel bandwidths are readily available, and some suggest that spectrum planning should be focused on a future of 6.25 kHz channel widths to support the use of even more spectrally efficient technologies.

Figure 5.12: Percentage of 12.5 kHz land mobile assignments in Sydney compared with the rest of Australia



Under utilisation of channels

There is evidence to suggest that the abovementioned ‘congestion’ is better described as a lack of channel availability. Assignments in a number of channels in the 400 MHz band are lightly used; that is to say, at any given time of the day, there is a high probability that the channel will not be in use. Spectrum monitoring by ACMA indicates that there is a significant quantity of spectrum occupied by such assignments. There may be a number of reasons why the assignments are not used or only lightly used, and this situation could be further examined with a view to using these channels more productively.

ACMA notes that government agencies involved in law enforcement, defence, national security and emergency services, along with the rail industry, have expressed that their communications cannot be subject to unacceptable delay or interference due to the preservation of public safety involved in their operations. As such, they are strongly opposed to the principle of sharing their land mobile channels. Emergency services acknowledge the low average temporal utilisation of their radiocommunications networks, but are adamant that network capacity must be capable of supporting the simultaneous peak demand of all law enforcement, defence, security and emergency services agencies in the case of major events and emergencies.

Support for new technologies

New technologies employing digital modulation schemes, particularly those employing trunking techniques, can improve the spectral efficiency and quality of land mobile services. For example, the Terrestrial Trunked Radio (TETRA)[89] system enables four time divided communications channels in 25 kHz of bandwidth, while the Association of Public Safety Communications Officials (APCO) Project 25 (P25) system supports time division multiple access (TDMA) on both 12.5 kHz and 6.25 kHz bandwidths[90]. Both systems were designed to support the operations of government agencies. To maximise options for the introduction of such new technologies, flexible arrangements would be required, and would necessitate changes to band arrangements (for example, compatible, contiguous blocks of spectrum and compatible frequency splits)[91]. Despite the large amount of work required by both ACMA and radiocommunications users, industry feedback suggests that users are supportive of changes to spectrum arrangements within the 400 MHz band that would enhance the efficiency of spectrum use, including reduced bandwidths and trunked radio technologies. However, trunked systems are not optimised for some services, such as those delivering communications to rural areas, and use of conventional land mobile radio systems is expected to continue in the foreseeable future.

Future developments

The United States of America, as part of the planning process for digital dividend spectrum (see section 5.2.2), has set aside the paired bands 763–775 MHz and 793–805 MHz to support the deployment of a nationwide broadband ‘public safety’ network enabling interoperability between different law enforcement, defence, security agencies and emergency services. While the lower half of the ‘700 MHz public safety band’ is for broadband communications, the upper band pair (769–775 MHz and 799–805 MHz) is intended to accommodate existing narrowband (6.25 kHz channel widths) land mobile services. Various Australian defence and security agencies and organisations involved in law

[89] For further information on TETRA see: http://www.etsi.org/website/technologies/tetra.aspx.
[90] For further information on APCO P25, see: www.apcointl.org/frequency/project25/information.html#documents.
[91] Paired spectrum blocks of 5 MHz each, with 10 MHz splits, are sought by law enforcement, security and emergency services agencies.

enforcement and emergency services have expressed interest in accessing parts of the 700 MHz band for medium speed broadband data communications.

A similar development to meet the increasing need of such government agencies for broadband data communications was the identification of the band 4940–4990 MHz for use by ‘public protection and disaster relief’ (PPDR) organisations (at WRC-03). Various Australian organisations involved in PPDR type operations have expressed interest in using the 4.9 GHz band for deployable high speed data systems (see Appendix A).

Railway operators and authorities have acquired spectrum licences for disaggregated spectrum in metropolitan areas in the 1.8 GHz band. This spectrum was purchased with a view to implement high speed data communications for modern train protection systems, for which the prime candidate technology is GSM-R. This spectrum could also provide additional capacity for other applications, including those facilitating counter terrorism and security operations, and passenger information dissemination.

At WRC-07, the band 450–470 MHz was identified for administrations wishing to implement IMT (see 5.9.2). The initial focus for this band was on the implementation of IMT systems in developing countries where the use of lower frequencies can significantly reduce infrastructure costs. A primary candidate technology for WAS in this band is CDMA450, which, due to favourable propagation characteristics of the band, combined with broadband communications capability, is seen by some elements of industry as an effective potential solution for the provision of wireless access in rural areas. While Australia supported this allocation at WRC-07, the feasibility of using this band for WAS in Australia will need to be considered as part of the 400 MHz band review process.

ACMA’s proposed approach

400 MHz band

ACMA released a public discussion paper in April 2008 about issues facing spectrum in the 403–520 MHz frequency range. The paper sought information and comments on the following broad areas:

- Improvements to the technical efficiency in use of the spectrum (for example, by reducing channel bandwidths, reviewing preferred transmit/receive splits, increasing the use of digital technologies and trunking systems, and exploring opportunities for channel loading and time sharing).
- Consideration of the licensing and pricing mechanisms used in the band with the goal of improving the allocative efficiency in the band. This includes the possibility of increased use of public park (class licensing) or private spectrum rights (spectrum licensing) arrangements in various parts of the band, as well as fee incentives to encourage sharing. Regional variations in licensing and pricing are also considered.
- Options for new technologies and uses of the band, including the introduction of WAS in 450–470 MHz.
- Opportunities for consolidating spectrum use by certain government agencies; options include the band 403–420 MHz and possibly 420–430 MHz (which is already dedicated to government mobile radio networks).

Comments to the paper will assist ACMA in developing short, medium and long term usage strategies for this spectrum. Industry feedback has indicated that the costs incurred by users of the 400 MHz band as a result of changes to spectrum arrangements is a cause for concern, albeit to varying degrees. ACMA notes that industry is undivided in its desire for sufficient time to be allowed for the planning and implementation of any changes. Timeframes provided to and costs incurred by radiocommunications users will be major factors considered in ACMA's review of the 400 MHz band.

Data communications requirements

For ACMA's intended actions relating to digital dividend spectrum, see sections 5.2.2 and Appendix A (under 520–820 MHz).

ACMA will undertake a consultation process to assist in developing appropriate spectrum management processes to support use of the 4.9 GHz band by PPDR applications, and will involve liaison with Defence and various other government agencies. Any future spectrum arrangements should provide flexibility and interoperability between PPDR organisations. As with the 400 MHz and 700 MHz band, the identification and specification of which organisations and agencies will have access to this band will be crucial.

With respect to the possible future use of the 1.8 GHz band for modern train protection systems, ACMA is currently investigating spectrum requirements for GSM-R.

5.4.3 BEYOND 2013

Currently, small land mobile radio networks serve client groups. Based on an international trend towards larger, more integrated networks, it is expected in the future that land mobile radio networks in Australia will also expand in size. This will allow for the wider use of trunking and thereby improve spectrum usage; these networks will therefore ideally reside in contiguous blocks of spectrum.

As mentioned earlier, the US has set aside blocks of spectrum within the 700–800 MHz range for land mobile services, and interest for similar public safety networks in Australia has been expressed, with consideration of the advantage of equipment manufactured overseas. However, this spectrum will not be available in Australia at least until after the switch off of analog television, and decisions on the final use of the digital dividend are unlikely to be made within the next five years (see section 5.2.2 and Appendix A).

5.5 Maritime

The maritime mobile service[92] comprises an important part of Australia's radiocommunications, with a wide range of users including the Royal Australian Navy; life saving, search and rescue (SAR) and coastal patrol organisations; competing commercial entities, and the authorities and corporations that manage their maritime activity; as well as those from the recreational and fishing industries.

In addition to its usual roles of spectrum management and interference investigation, ACMA also assists Australian Search and Rescue (AusSAR) in locating emergency position indicating radio beacons (EPIRBs).

Just as for the aeronautical service, the international nature of maritime operations means that Australian allocations are consistent with harmonised ITU allocations to the maritime mobile service, with much of the planning work being driven and overseen by the

[92] In this document, the maritime mobile-satellite service is included in the satellite service section, and the maritime radionavigation service is included in the radiodetermination service section.

International Maritime Organisation (IMO). The IMO is responsible for ensuring the safety and security of shipping activities.

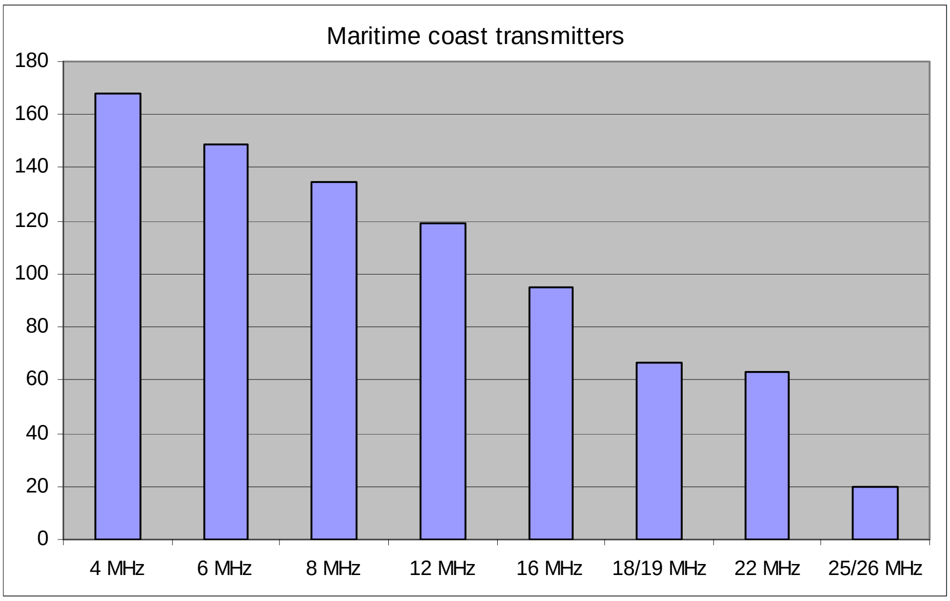
5.5.1 CURRENT SPECTRUM USE

The majority of spectrum usage in the maritime mobile service occurs in the HF and VHF maritime mobile bands. Above these bands there is only one maritime mobile allocation (457–467 MHz), which is used for on board communications. There are also several maritime mobile bands throughout VLF to MF, but the most significant of these are MF bands 415–526.5 kHz and 2000–2495 kHz. Especially important are the 490 and 518 kHz channels for maritime safety information (MSI) and the 2174.5, 2182 and 2187.5 kHz channels for distress, urgency and safety communications.

HF maritime mobile bands

Appendix 17 of the ITU *Radio Regulations* specifies the frequencies allocated to the maritime mobile service in the HF bands. There are eight HF maritime mobile bands, ranging from 4 MHz to 26 MHz, along with significant class licensed and apparatus licensed usage of the 27.5–28 MHz band. Figure 5.13 shows the number of licensed maritime coast transmitters per band in the HF maritime mobile bands.

Figure 5.13: Number of licensed maritime coast transmitters per band in the HF maritime mobile bands



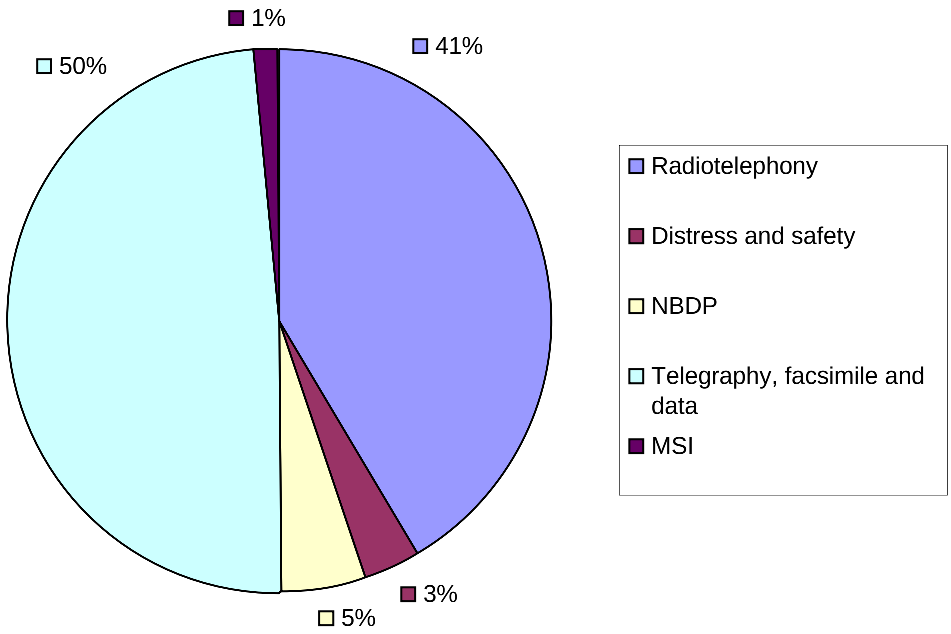
Appendix 17 allocates channels in the HF bands for transmissions using:

- radiotelephony (voice communications);
- Morse telegraphy;
- Narrow band direct printing (NBDP);
- wide band and direct printing telegraphy, facsimile and data transmission;
- facsimile; and
- digital selective calling (DSC).

Radiotelephony, NBDP and DSC can all be used in distress situations, on designated channels specified in Appendix 15, and a few radiotelephony and NBDP channels are designated for the transmission of MSI. In Australia, the state and territory governments operate a safety communications service, including watch on 4, 6 and 8 MHz distress frequencies, as well as the broadcast of maritime safety information (MSI) on 8176 kHz. Radiotelephony and NBDP channels can also be used for public correspondence in Australia. The telegraphy and data channels are mainly used by Defence in Australia; for both command and control via formal messaging, and for data tactical beyond LOS communications. Telegraphy involves the transmission of low rate data and text messages for both distress situations and working for commercial and non-commercial operations. Morse telegraphy is no longer an important part of maritime mobile communications; it is not included in the Global Maritime Distress and Safety System (GMDSS), and many governments have phased out Morse code listening services. This was also reflected at WRC-07, where 500 kHz ceased to be the international distress and calling frequency for Morse telegraphy.

Figure 5.14 provides a breakdown of the proportion of maritime coast frequency assignments used for each of these purposes.

Figure 5.14: Percentage of maritime coast frequency assignments used for each purpose[93]



VHF maritime mobile band

Appendix 18 of the ITU *Radio Regulations* specifies the frequencies of the VHF maritime mobile band (59 channels in the range 156–162 MHz). Two channels in this band (161.975 MHz and 162.025 MHz) are reserved for use by the automatic identification system (AIS), which is required by the IMO to be fitted on all cargo ships over 300 gross tonnage (GT) on international voyages, cargo ships of over 500 GT not on international voyages and all passenger vessels. The National Marine Safety Committee (NMSC) is currently finalising Australian AIS carriage requirements for commercial vessels, and it is expected that AIS may become a requirement aboard most passenger vessels and vessels operating outside sheltered or restricted offshore waters, less than 35 m in length. AIS provides information about the ship (including identity, type, position, course and speed) to other ships and coastal authorities, thereby facilitating tracking operations for purposes including pollution prevention and border security.

The *Radiocommunications Licence Conditions (Maritime Coast Licence) Determination 2002*[94] and *Radiocommunications Licence Conditions (Maritime Ship Licence) Determination 2002*[95] specify the permitted uses for VHF maritime mobile spectrum in Australia, which include distress, urgency and safety communications, and calling and working for commercial, non-commercial, professional fishing and port operations. VHF maritime mobile communications generally use radiotelephony, with the exception of VHF Channel 70 designated for distress calls using DSC. At WRC-07, regulations were changed

[93] The majority of assignments in the frequencies assignable to coast stations for wideband and Morse telegraphy, facsimile, special and data transmissions systems and direct-printing telegraphy are held by Defence.

[94] *Radiocommunications Licence Conditions (Maritime Coast Licence) Determination 2002*, http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrumentCompilation1.nsf/all/search/6F188ABFCE7A90A1CA2575390022BE89.

[95] *Radiocommunications Licence Conditions (Maritime Ship Licence) Determination 2002*, http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrumentCompilation1.nsf/all/search/B456B37B6531036ECA25753D00067FF5.

so that distress, urgency and safety calls and announcements must be made using DSC on VHF Channel 70, if equipped to do so.

In addition, the *Radiocommunications (Maritime Ship Station—27 MHz and VHF) Class Licence 2001* specifies the conditions under which users can operate Australian maritime ship stations in the 27 MHz and VHF maritime mobile bands.

Figure 5.15 shows the percentage of maritime coast frequency assignments used for different purposes in the 27 MHz and VHF maritime mobile bands. Apparatus licence information does not reveal information about the large number of ship stations that are class licensed in the 27 MHz and VHF maritime mobile bands, or those licensed by foreign governments.

Figure 5.15: Percentage of maritime coast frequency assignments used for each purpose in the 27 MHz and VHF maritime mobile bands

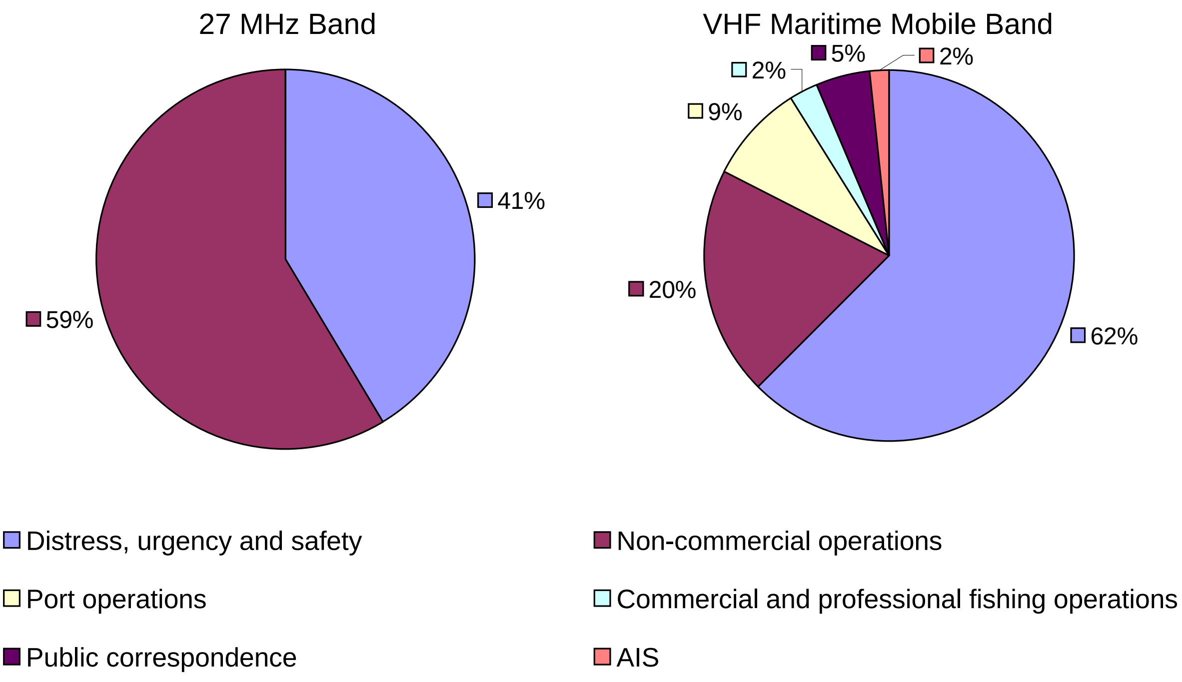
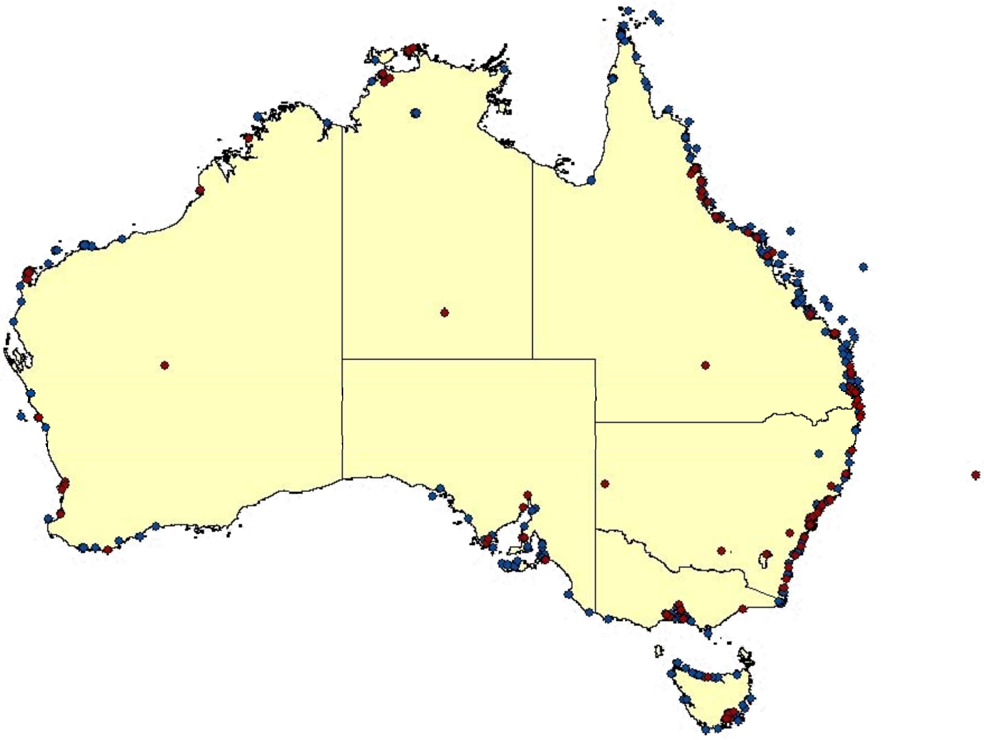


Figure 5.16 shows the distribution of HF and VHF maritime coast stations across Australia.

Figure 5.16: Distribution of HF (red dots) and VHF (blue dots) maritime coast stations[96] (January 2008)



Global Maritime Distress and Safety System requirements

It is a requirement of the International Convention of Safety of Life at Sea (SOLAS) that all SOLAS passenger vessels and ships of 300 GT and over on international voyages be fitted for the GMDSS. Commercial vessels under 300 GT, or on domestic voyages, are subject to the requirements of their Flag State. The GMDSS became mandatory for SOLAS vessels (and signatory countries' shore facilities) from 1 February 1999, after a 7 year phase in period. The GMDSS is an international system using radiocommunications equipment on ships, land and satellites to achieve the rapid and automated alerting of coastal authorities and nearby ships of another ship in distress (see Figure 5.17). The GMDSS consists of equipment for:

- distress, urgency and safety communications to ship and coast stations using radiotelephony, NBDP and DSC at MF, HF and VHF;
- the coordination of SAR operations involving ship, aircraft and coast stations using aeronautical frequencies at HF and VHF[97];
- the reception of MSI via NBDP at MF and HF; and

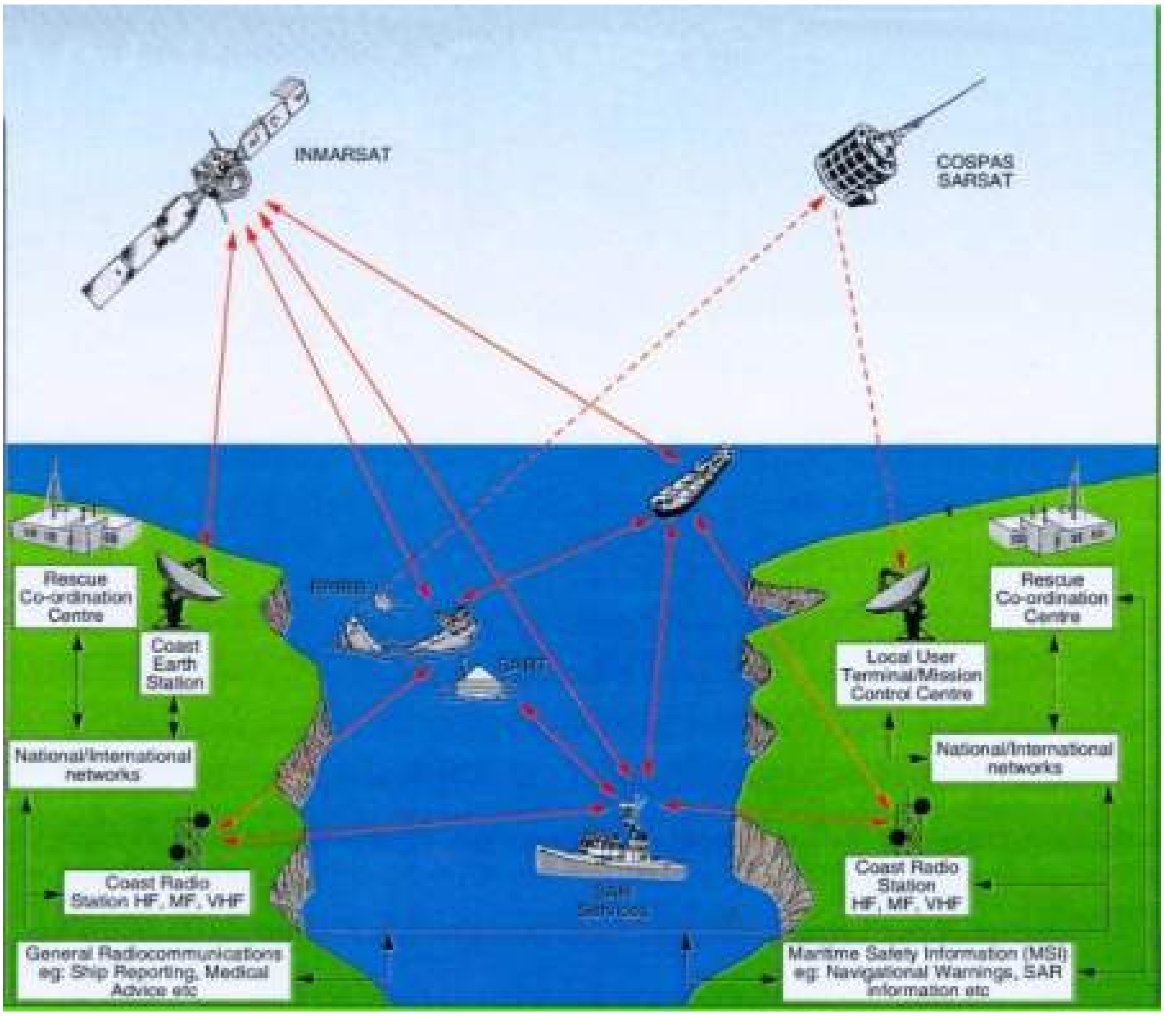
[96] The two HF stations in the centres of Western Australia and Queensland are located at Wiluna and Charleville, respectively. These stations broadcast marine weather warnings from BoM, and comprise AMSA's Safety Offshore System (based on GMDSS), monitored from the Rescue Coordination Centre in Canberra.

[97] 3023, 4125 and 5680 kHz at HF; 121.5, 123.1 and 156.3 MHz at VHF.

- 406 MHz EPIRBs, X-band[98] SARTs, and L-band satellite communication equipment to relay distress alerts and EPIRB emissions.

The Australian Maritime Safety Authority (AMSA) requires[99] all ships to be equipped with the above equipment, except for ships normally engaged in harbour duties, which only require fitting with VHF radio and 406 MHz EPIRB. For emergencies requiring ship evacuation, vessels are required to carry handheld VHF radiotelephone apparatuses able to communicate on VHF channels 6 (for coordinated SAR purposes), 13 (for ship to ship navigation safety communications), 16 and 67. In addition, all seagoing vessels are required to maintain a continuous watch on VHF distress channels 70 (automatic watch using DSC) and 16 (listening watch using radiotelephony). The government operated safety communications service mentioned earlier maintains watch on VHF Channels 16 (156.8 MHz) and 67 (156.375 MHz).

Figure 5.17: The GMDSS concept[100]



[98] X-band refers to the microwave frequency range between 8 GHz and 12 GHz.
[99] Australian Marine Safety Authority, 2006, *Marine Orders, Part 27—Radio Equipment, Issue 3*, http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/0/6637919175A029C6CA25717E0001540B?OpenDocument.
[100] ICS Electronics, *The Global Maritime Distress and Safety System (GMDSS)*, http://www.icselectronics.co.uk/GMDSS.php.

5.5.2 2009–2013

Issues affecting spectrum demand

Consultation with AMSA has indicated that current maritime spectrum arrangements are largely sufficient to meet the requirements of existing applications and technologies. There appears to be no shortage of spectrum for distress communications, and provisions for NBDP are adequate.

Interference

Interference poses a threat to all radiocommunications services, but it is particularly troublesome at HF because propagation characteristics allow interference to originate overseas[101] from a number of sources, including malicious and illegal operations, and poor radio equipment. In addition, aural telephony distress alerts are being replaced with automated DSC alerts. Undecoded interference may go unnoticed and has the potential to prevent the reception of distress alerts. There are similar service degradation concerns for the VHF maritime mobile bands, especially inappropriate use of the international distress, safety and calling channel 16. The quality of the band may degrade further in the future due to the low cost and class licensing of VHF equipment, which could make detecting the source of misuse difficult.

GMDSS

The safety of life nature of maritime mobile communications makes it important to have numerous communications technologies providing redundancy in the case of emergencies. This is why a single global interoperable system such as GMDSS is required to ensure that any ship in distress will be able to alert a relevant authority of its situation. The transition of vessels to the GMDSS has been a major focus of the ITU and IMO for many years, but so far the process has been very slow. In Australia, AMSA has ensured this transition through the requirement of GMDSS equipment carriage in its Marine Orders, to which all ships registered in Australia and foreign non-SOLAS ships navigating in Australian waters are subject. However, a major consideration is to maintain a communications environment that will continue to accommodate non-SOLAS vessels and support interoperability with SOLAS vessels. This was an important part of the discussions on WRC-07 Agenda Item 1.14.

Digital technologies

The ITU has specified[102] the need to enhance spectrum efficiency with the use of new digital technology in order for both the HF and VHF maritime mobile bands to better respond to future spectrum demand. Digital HF technologies have already been developed and are in use, and digital communications such as DSC will also relieve the burdens of aural watch keeping[103].

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[101] This is because HF signals travel long distances both along the surface of the Earth and in sky-wave mode (by reflecting off the ionosphere).

[102] ITU *Radio Regulations*, Resolutions 342 and 351.

[103] The obligation for coast stations to maintain listening watch on the 2182 kHz international calling channel was removed by the IMO in 1999.

It is likely that in the long term, NBDP may be replaced by more advanced digital HF data exchange technologies, for which the IMO[104] and the US[105] consider it important to identify additional spectrum allocations for the future (particularly in the range 9–18 MHz).

It is also likely that changes will be made to Appendix 17 at WRC-11; Agenda item 1.9 is to revise the frequencies and channelling arrangements of Appendix 17 to accommodate new digital technologies for the maritime mobile service. Several administrations have proposed using channels allocated to NBDP transmission to accommodate digital data systems, but some NBDP allocations (at least those for MSI, and distress and safety communications) may need to be preserved globally for some years due to the unavailability of satellite based alternatives in polar regions.

While digital HF data transfer protocols using 3 kHz channel widths have been proposed, additional spectrum may be required if the potential advent of higher speed services (akin to email) are implemented. However, the use of commercial and personal HF data services may be declining (certainly those using NBDP) due to an increasing preference for satellite based solutions.

Growth in spectrum usage

In Australia, trends in maritime coast frequency assignments over the past eight years indicate that the NBDP channels in the 8 MHz band may become congested within the next five years if the current growth rate was maintained. However, considering that this growth is attributed to a single licensee, along with the other aforementioned decline in commercial HF data services, ACMA does not anticipate that additional spectrum will be required for NBDP within the next five years.

Security, safety, tracking and surveillance

The increasing need for systems enhancing ship and cargo identification, tracking and surveillance, as well as ship and port security and safety, is an issue to be addressed under Agenda item 1.10 at WRC-11. A resolution[106] to review provisions and consider additional allocations for such systems was made at WRC-07, which considers the use of long range HF data systems for the transmission of security alerts[107], safety information, and information from the long range identification and tracking (LRIT) system. The LRIT system is a satellite based tracking system that is similar to AIS in the information it provides, but is intended only for recipients authorised to access such information (mainly coastal authorities).

At WRC-07, additional provisions were made for use of the two AIS channels by AIS search and rescue transponders (AIS-SARTs), for use by aircraft stations for search and rescue operations and for reception by the MSS. Correspondingly, ACMA has proposed to make variations to class licences to allow for the above uses. Maritime authorities expect to use AIS base stations to transmit information relating to safety and aids-to-navigation (AtoN), and as repeater stations to extend AIS network range, especially considering the expected

[104] International Maritime Organisation, 2006, *IMO position on WRC-07 agenda items concerning matters relating to maritime services,* www.mincomunicaciones.gov.co/mincom/src/user_docs/Internacional/INTERCMR/R07-CPM-C-0005.pdf. [104] The US's National Telecommunications and Information Administration (NTIA), 2006, *United States of America - Draft Proposal for the work of the Conference;* available at: http://www.ntia.doc.gov/osmhome/wrc/documents/CoordLetter_xf_AI_7_2.doc.

[105] The US's National Telecommunications and Information Administration (NTIA), 2006, *United States of America - Draft Proposal for the work of the Conference;* available at: http://www.ntia.doc.gov/osmhome/wrc/documents/CoordLetter_xf_AI_7_2.doc.

[106] Resolution 357–*Consideration of regulatory provisions and spectrum allocations for use by enhanced maritime safety systems for ships and ports*. This resolution is in the Provisional Final Acts of WRC-07, and its name will be changed upon publication of the Final Acts.

[107] As is done with ship security alert systems, which are a SOLAS requirement.

increase in the use of AIS and AIS-SARTs. Variations have also been proposed to licence conditions determinations to allow for the licensing of AIS base stations, including those used for AtoNs. AMSA has indicated that it has experienced difficulties in coordinating AIS stations with adjacent band land mobile services at some locations.

VHF communications

Agenda item 1.14 of WRC-07 considered two proposals for changes to the VHF band to allow for more efficient use. The first was a proposal initiated by the US to convert more channels to simplex and to move from 25 kHz to 12.5 kHz channelling. The second proposal, initiated by Europe, was to use the public correspondence channels to introduce new digital, spectrally efficient systems. Both proposals received support at WRC-07.

In addition, similar channel spacing reductions have occurred for the aeronautical mobile service overseas and are likely in the land mobile service in Australia. As such, a reduction in channel spacing in the VHF maritime mobile band from 25 kHz to 12.5 kHz is possible.

The possible reduction in channel spacing, combined with the overall reduction of Australian maritime coast stations over the past eight years, suggests that spectrum demand will not exceed current VHF maritime mobile allocations in the 2009–2013 timeframe.

ACMA is considering the future use of the VHF channels intended for public correspondence (about 500 kHz of spectrum formerly used for Telstra’s VHF Seaphone service); as such, no assignments can currently be made to them. Some search and rescue organisations have shown interest in using them for calling and working communications.

ACMA’s proposed approaches

Digital technologies

ACMA plans to investigate the use of HF data transfer technologies and their spectrum requirements. Because allocations for digital technologies are likely to be made in Appendix 17 at WRC-11, an Australian position may need to be developed on which frequencies would be suitable for use; or conversely, which frequencies would be undesirable for Australian users. HF spectrum requirements for e-Navigation (see 5.5.3) and characteristics for HF digital data and email radio systems have not yet been finalised, and may be an important consideration in forming any changes to Appendix 17 frequency allocations. Consultation with existing NBDP users may also be an important part of forming such a position.

VHF communications

ACMA may perform some preliminary research into VHF radiotelephony technologies using 12.5 kHz channel widths, and subsequently reassess the possibility of changing technical requirements of equipment. This would have the benefit of preparing Australian ships for changes to radiocommunications equipment in advance. However, such work would be of low priority considering that the use of interleaved channels will not be possible until international changes are made by the ITU, and especially considering that the issue will not be on the WRC agenda for at least another four years.

ACMA is currently investigating the future use of the channels formerly used for Telstra’s VHF Seaphone network; the outcomes of WRC-07 Agenda item 1.14 will be considered in the investigation.

5.5.3 BEYOND 2013

Growth in spectrum usage

While ACMA expects no additional spectrum requirements for the maritime mobile service from 2009–2013, current growth in the number of apparatus licensed coast stations operating in the HF channels for NBDP suggests that additional spectrum may be required in the 4, 6, 8, 12 and 18/19 MHz bands by 2023. The 8 and 18/19 MHz bands have the highest growth rates, and as such, congestion seems likely within the next 10 years. The 8 MHz band may require an additional 3 kHz channel by 2018, with a further 3 to 40 kHz needed by 2023, depending on service growth. The 18/19 MHz band may require between two and six additional 3 kHz channels by 2023.

Digital technologies

As mentioned earlier, the introduction of a new digital HF data exchange technology will increase spectrum efficiency. However, it may also present an opportunity to implement higher data rate services, which could require additional spectrum. On the other hand, channels for NBDP are not heavily utilised at present (supported by discussions at WRC-03 and WRC-07), and HF data services for commercial and personal purposes are becoming less attractive in comparison to satellite based solutions. ACMA will continue to monitor the progress of HF data services and relevant technology developments, and will assess options for planning arrangements when more is known about the spectrum requirements.

e-Navigation

Additional spectrum may be needed for a proposed network known as e-Navigation. Current maritime mobile bands, especially the HF and VHF bands and UHF satellite frequencies, are expected to play a major part in e-Navigation. It is intended to provide a globally harmonised navigation system using a wide variety of current technologies, enabling the transmission, processing and display of navigational information to increase the level of safety and efficiency of maritime voyages. e-Navigation will supplement GNSS with terrestrial on-board positioning systems to generate up to date electronic navigational charts, complemented by route information and meteorological and oceanographic data. This information will be transmitted to and from coast stations and to other ships for efficient vessel tracking and management.

e-Navigation is envisioned to provide global broadband communications via satellite and terrestrial networks. Based on those of similar broadband navigation systems and systems recognised for high bandwidth use of the VHF maritime mobile band, its VHF spectrum requirements could be in the vicinity of 2 MHz.

However, the system architecture, including communications requirements, are not expected to be finalised before 2010. A strategic framework for e-Navigation has been proposed by the IMO which outlines a proposed timeline for an implementation plan that should be developed by 2012. This means that the use of e-Navigation may not be realised within the next five years[108]. ACMA will continue to monitor the development of e-Navigation and revisit the issue when more information is available.

[108] Sub-Committee on Safety on Navigation (NAV), 54th session: 30 June-4 July 2008, see: http://www.imo.org/Newsroom/mainframe.asp?topic_id=112&doc_id=8876.

5.6 Radiodetermination

Radiodetermination[109] is the use of the propagation properties of radio waves to determine the position, velocity or other characteristics of an object, or to obtain information relating to these parameters.

5.6.1 CURRENT SPECTRUM USE

There is some spectrum usage by the radiodetermination service in the frequency bands below 300 MHz, most notably for non-directional beacons (NDBs) at low frequency (LF) and MF, and the instrument landing system (ILS) and VHF omnidirectional range (VOR) system at VHF, all of which are used for civil air navigation. However, most of the usage is spread across the UHF and microwave frequency bands, and is dominated by a few licensees.

About half of all radionavigation and radiolocation allocations are designated in the Spectrum Plan to be used principally for defence purposes; primarily for military radars for surveillance and tracking of both aircraft and ships.

Defence uses HF spectrum for the operation of the Jindalee Operational Radar Network (JORN), which consists of two over the horizon radars for air and surface object detection using sky waves. 960–1164 MHz is used for military radar systems like identity friend or foe (IFF—included as part of the JTIDS platform) and tactical air navigation (TACAN). 1240–1400 MHz is a core band for Defence, in which future L-band radar is expected to be concentrated. Uses of 1350–1400 MHz include airborne early warning and control (AEW&C) surveillance radar, airfield radar and ground based air defence radars. This part of the band may experience pressure, especially with the introduction of ACMI and TSPI (see section 5.1.1). Defence also uses a variety of X-band radars in the frequency range 8.5–10.55 GHz.

Apart from this, the main non-Defence uses of spectrum for the radiodetermination service are listed in Table 5.1.

Table 5.1: Main uses of spectrum for the radiodetermination service

Frequency band	Use
328.6–335.4 MHz	ILS (Airservices Australia)
400.15–403 MHz	Weather monitoring using radiosondes (meteorological sensors on weather balloons) (BoM)
420–430 MHz	Vehicular tracking and monitoring (QuikTrak)
915–928 MHz	Automatic identification systems (Australian Rail Track Corporation (ARTC), RailCorp NSW and Pacific National)
960–1215 MHz	Distance measuring equipment, secondary surveillance radar (SSR), airborne collision avoidance system, ADS-B for air traffic control purposes and landing approach guidance (Airservices Australia)
1164–1350 MHz and 1559–1610 MHz	Allocations to the radionavigation satellite service (RNSS)—currently used by the US's Global Positioning System (GPS) and the Russian Federation's GLONASS.
1270–1295 MHz	Wind profiler radar
2700–2900 MHz	Primary surveillance radar (PSR) (Airservices Australia) S-band[110] weather radars (BoM)

[109] The radiodetermination service includes the radionavigation, radionavigation-satellite, radiolocation and radiolocation-satellite services.
[110] S-band refers to the microwave frequency range between 2 GHz and 4 GHz.

2900–3100 MHz	Maritime radar beacons (AMSA) and associated shipborne S-band radars
5010–5030 MHz	RNSS allocation (Galileo)
5600–5650 MHz	C-band[111] weather radars (BoM)
9200–9500 MHz	Maritime radar beacons (AMSA) and associated shipborne radars, harbour surveillance radar, SARTs, airport surface movement radar and airborne weather radars
9500–9800 MHz	Slope stability radar (GroundProbe)
22–26.5 GHz	UWB short range vehicle radar
24.05–24.25 GHz & 34.7–35.2 GHz	Traffic speed radar (police)

The number of frequency assignments authorising most of the uses in this table has been steady or has slightly increased over the past decade. The most significant growth in assignments has occurred for automatic dependent surveillance-broadcast (ADS-B), C-band weather radars, radar beacons and 35 GHz police traffic speed radars. Growth has also occurred in the use of S- and X-band[112] maritime radar and SARTs, as well as airborne class licensed devices such as radio altimeters (4200–4400 MHz), weather radars (5350–5470 MHz and 9300–9500 MHz) and Doppler radars (8750–8850 MHz and 13.25–13.4 GHz) [113].

The global navigation satellite systems (GNSS) currently in use, GPS and GLONASS, enable aeronautical, seaborne and terrestrial receivers to calculate their own position on the Earth by performing multilateration on time signals received from a number of satellites belonging to the GPS or GLONASS constellation.

5.6.2 2009–2013

Issues affecting spectrum demand

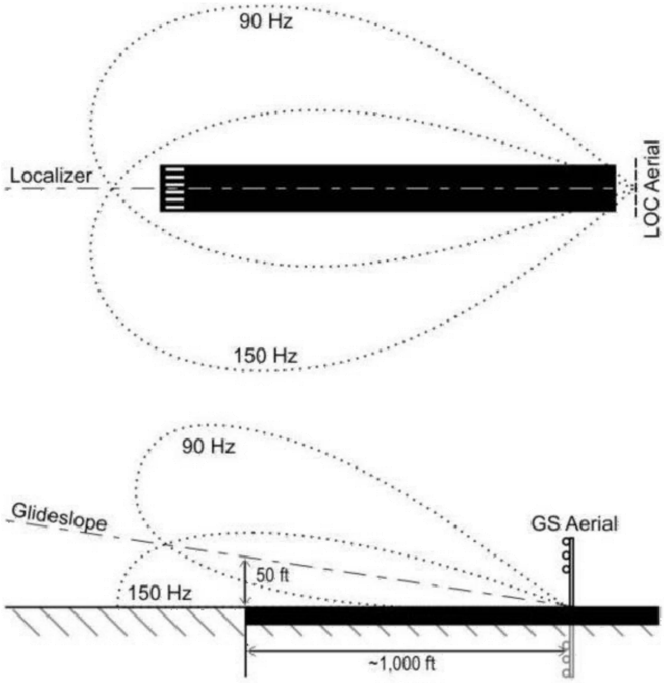
Civil air navigation, surveillance and landing systems

The future of navigation and landing systems is very much being directed towards GNSS augmentation systems over terrestrial based navigation systems. However, the use of ILS and distance measuring equipment in particular is expected to remain important in the foreseeable future (though their role may be reduced), especially considering that GPS presents a single point of failure unacceptable for the safety of life nature of the aeronautical radionavigation service (ARNS). ILS facilities in Australia are currently being upgraded by Airservices Australia, and the installation of new sites is also possible.

Figure 5.18 depicts the concept behind the operation of ILS.

[111] C-band refers to the microwave frequency range between 4 GHz and 8 GHz.
[112] X-band refers to the microwave frequency range between 8 GHz and 12 GHz.
[113] Australian Communications and Media Authority, 2006, *Radiocommunications (Aircraft and Aeronautical Mobile Stations) Class Licence 2006*, http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/0/A46873B7EB7B69D6CA2571DF00046478?OpenDocument.

Figure 5.18: Concept of the operation of ILS (the aircraft is in line for a safe landing when the signal strengths from the 90 Hz and 150 Hz signals are equal)[114]



The microwave landing system (MLS) is not currently used in Australia and, despite its planned phase down in the US, spectrum in the 5030–5091 MHz MLS band is not likely to become available in the near future considering increased implementation in Europe and the UK, and a strong position from ICAO to protect the spectrum. This position was upheld at WRC-07, with no additional allocations made in the band despite the need for additional spectrum in the 5 GHz range for airport surface applications in the aeronautical mobile service.

Australia's surveillance infrastructure has until recently been dependent primarily on PSR and SSR, but this is expected to change with the current deployment of the Australia wide ADS-B network. ADS-B and GNSS-based navigation, surveillance and landing systems are expected to expand and possibly replace some ground based surveillance systems within the next decade. The primary objective of the proposed wider application of ADS-B for air traffic surveillance and GNSS-based navigation for aircraft navigation is to enhance safety and increase efficiency of air traffic management.

The use of class licensed airborne radars is expected to increase proportionally to the increase in aircraft traffic, which is expected to at least double over the next 15 years.

GNSS

Satellite based positioning systems are different to other radionavigation services because they are used by many different platforms, industries and end users. Currently only the GPS and GLONASS systems are operational; the US is modernising GPS with the introduction of new signals (L5 in 2009, L1M, L2M and L1C in 2013) and the launch of new satellites (Block IIR and IIF over the next seven years, Block III from 2013). The Russian Federation is also committed to the maintenance, development and deployment of a fully restored GLONASS until 2011.

[114] Wikipedia, *ILS illustration*, available at: http://en.wikipedia.org/wiki/Image:ILS_illustration.jpg.

Systems under development for future deployment include the European Union's Galileo positioning system and Japan's Quasi-Zenith Satellite System (QZSS), which uses GPS frequencies. There are proposals to extend channels for Galileo up to 5150 MHz. China is also developing a GNSS system known as Compass (or Beidou-2); currently there are four Beidou-1 satellites offering limited coverage and application. Initially intended to be used for military purposes, 'open' services to China and Asia are expected to commence in 2008. Both Compass and the Indian Regional Navigation Satellite System (IRNSS)[115] plan to use the S-band radiodetermination-satellite allocation at 2483.5–2500 MHz. Although it is a primary allocation only in Region 2 (and some Region 1[116] countries), Agenda item 1.18 of WRC-11 is to consider making this a global primary allocation, taking into account ITU-R studies analysing the compatibility of GNSS with existing services.

GNSS ground based augmentation systems (GBAS) and space based augmentation systems combine received GPS signals and the surveyed positions of ground stations to compute corrections for signal errors (for example, timing and ionospheric delay). This achieves far greater positioning accuracy than stand alone GPS. One of the earliest and most significant expected applications of GPS augmentation is for aeronautical navigation, surveillance and landing guidance, which is exemplified by the US's space based wide area augmentation system (WAAS). Differential GPS (DGPS) is a terrestrial GPS augmentation system currently used in Australia to facilitate coastal marine navigation (at LF and MF), as well as in land surveying and navigation (typically VHF high band and UHF).

The means for providing augmentation for GPS signals for aviation applications in Australia has not yet been decided. However, GBAS has already been introduced at Sydney Airport by Airservices Australia. The ground based regional augmentation system (GRAS) may be selected for en-route and regional approach navigation. In both cases, GPS signal corrections are broadcast to aircraft at VHF in the 108–117.975 MHz band.

Industry has expressed some concern about the potential for interference to Galileo L-band systems (to be introduced after 2010) operating at 1164–1350 MHz and 1559–1591 MHz by Defence's JTIDS and airborne warning and control systems (AWACS). AWACS are aircraft that use radar technology and can be used to collect intelligence, coordinate Defence activities and communicate instructions. Current co-channel operation between GPS, GLONASS and Defence radar in the L-band seems to suggest that no significant problems will be encountered in the future. However, further encroachment on L-band GNSS frequencies by other services has been identified as a major concern. This is because the operations of the current GNSS elements are entirely based on the availability of the 1559–1610 MHz band. Several regulatory and representative bodies (including ACMA) and industry continue to hold the position that the use of this spectrum by GNSS should not be constrained by other services.

UHF radar

Defence considers the 430–450 MHz band critical to its operations due to its suitability for long range air surveillance radars and foliage penetration radar (under development).

[115] The first satellite of the IRNSS constellation will be launched in 2009, with full operation expected in about 2012. However, this is a regional positioning system and will not serve Australia.

[116] Region 1 includes Europe (including the entire Russian Federation and the former Soviet Socialist Republics), Africa, the Middle-East (excluding Iran and Afghanistan) and Mongolia.

S-band radar

The primary users of the 2700–2900 MHz band are Defence, Airservices Australia and the Bureau of Meteorology (BoM), which operate a number of fixed and mobile radar systems. As seen in Table 5.1, Airservices Australia operates PSR and BoM operates part of its S-band 'Weather Watch' system and wind finding radars in the band. Recent and planned procurement programs by existing radar system operators in this band have identified a number of assignment coordination difficulties. While in the short term these difficulties have been resolved by discussions between operators, it is possible that additional radar deployments in the band will result in further coordination difficulties.

New Defence radar systems, such as advanced phased array 3D radars for air and missile defence systems (particularly aboard naval vessels), are currently under development. These technologies are designed for the band 2900–3400 MHz.

C-band weather radars and RLANs

C-band weather radars are widely deployed and critical to BoM's operations. The BoM has indicated that additional spectrum is a possible future requirement, depending on the extent to which BoM introduces rural area weather radar coverage. In addition, BoM has indicated that it is concerned about the introduction of class licensed radio local area networks (RLANs) in the band 5600–5650 MHz.

The frequency range 5600–5650 MHz, used by C-band weather radars in Australia, is currently excluded from Australian class licensing arrangements for 5 GHz RLANs. Sharing arrangements for the compatible operation of RLANs and weather radars in this band and the wider 5470–5725 MHz frequency range have been defined in ITU Recommendation ITU-R M.1652. RLANs and C-band weather radars currently operate in this shared spectrum in Canada, the US and Europe. ACMA is unaware of interference issues between RLANs and weather radars in the US; in Europe, arrangements and standards for RLANs have been modified to include extended monitoring periods for dynamic frequency selection, previously not implemented. In addition, ETSI is reviewing its standard for 5 GHz RLANs (ETSI EN 301 893) to incorporate enhanced RLAN receiver capabilities to detect narrower radar pulses.

Airport surface detection equipment

Advanced surface movement guidance and control systems (A-SMGCS) utilising surface movement radar will commence operation in Australia from 2008 in the 9.0–9.2 GHz band. Airport surface detection equipment (ASDE) performs a very similar role to A-SMGCS, providing surface movement tracking and control of aircraft and vehicles. ASDE systems[117] are currently used overseas at smaller airports in the 9.0–9.2 GHz band. ASDE[118] is also used overseas at larger airports in the 15.7–16.6 GHz radiolocation band, and replacement of ASDE systems operating at 23.6–24.4 GHz with those operating at 16 GHz is underway in the US. For this reason, a potential increase in spectrum demand has been identified for ASDE in the 15.7–16.6 GHz frequency range, due to increasing traffic densities at airports and the need to reduce runway incursions by personnel, vehicles, aircraft and debris.

[117] ASDE-X is used in the 9.0–9.2 GHz band, and utilises two to four frequencies.
[118] ASDE-3 is used in the 15.7–16.2 GHz band, and has a 16-frequency hopset, with two assignable hopping patterns.

While ASDE is not currently planned for Australia, any future introduction of ASDE would need to be made in consultation with Defence because spectrum in this range is designated to be used principally for the purposes of defence[119].

Automotive radar systems

The operation of two different automotive radar systems is currently authorised by the *Radiocommunications (Low Interference Potential Devices) Class Licence 2000* (LIPD class licence)[120] in the 22–26.5 GHz (24 GHz band) and 76–77 GHz frequency ranges. The 24 GHz short range radar (SRR) technology is used for low power collision avoidance applications (at the front, back and sides of the vehicle), while the 76–77 GHz long range radar technology is used for higher power intelligent cruise control applications (observing traffic on the road ahead of the vehicle).

The use of these systems is expected to increase in the future, as it is likely that automotive radar systems will not be limited to luxury cars but will become a baseline safety system in many vehicles. It is expected that new collision avoidance radars operating in the 77–81 GHz band (79 GHz band) will eventually replace those at 24 GHz. The European Commission (EC) decided that 24 GHz ultra wideband (UWB) SRRs were only a temporary solution for anti-collision automotive radar, and that new systems would be installed only until June 2013, after which new systems would be limited to 79 GHz radars (currently considered too expensive for a feasible market)[121].

The likely future proliferation of automotive radar could increase the potential for interference to the RAS within the 24 GHz, 76–77 GHz and 79 GHz bands. However, adequate protection is generally provided by separation distances and terrain shielding, which is greatly assisted by carefully planning the location of radio astronomy facilities.

Members of the scientific community have expressed additional concerns that harmful interference may be caused by 24 GHz UWB SRR to the EESS (see section 5.8). Compatibility analyses performed by ACMA[122] show that for UWB SRRs to cause harmful interference to EESS passive sensors operating in the 23.6–24 GHz band, a large number of vehicles would have to be equipped with SRR within the coverage area of the sensors. Such interference scenarios could only occur in the most densely populated areas in Australia, and would require the use of 24 GHz UWB SRRs well into the future. The expected gradual migration to 79 GHz radars would reduce the likelihood of sufficient 24 GHz UWB SRR densities to cause interference to EESS passive sensors.

WRC-11 radiolocation allocations

The radiolocation service currently has no global primary allocation in the frequency range 3–300 MHz (HF and VHF).

HF radars are generally capable of useful over the horizon operation, and the ITU has recognised the need for oceanographic HF radars for the measurement of coastal sea surface conditions in support of a range of operations. ACMA has been approached to facilitate the trialling of HF surface wave radars, and temporary arrangements have been developed to

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[119] As per footnote AUS1 of the Spectrum Plan.
[120] Available at: http://www.comlaw.gov.au/.
[121] European Commission, 2005, *Commission Decision on the harmonisation of the 24 GHz range radio spectrum band for the time-limited use by automotive short-range radar equipment in the Community*, http://eur-lex.europa.eu/LexUriServ/site/en/oj/2005/l_021/l_02120050125en00150020.pdf.
[122] Australian Communications and Media Authority, 2005, *Ultra-wideband short-range radars for automotive applications*, Radiofrequency Planning Branch, Australian Communications and Media Authority, Canberra, http://www.acma.gov.au/webwr/radcomm/frequency_planning/spps/0502spp.pdf.

support these trials. Defence has also indicated its involvement in research into HF surface wave radar also. The large distances over which HF signals propagate mean that the interference potential of a HF signal is high, so the operation of HF radar requires careful coordination with existing services. With this in mind, spectrum would ideally be set aside for this application, in which case existing services may need to migrate to other bands. Agenda item 1.15 of WRC-11 is to consider possible allocations to the radiolocation service in the range 3–50 MHz for oceanographic radar applications.

In addition, Agenda item 1.14 of WRC-11 is to consider primary allocations to the radiolocation service in the HF and VHF bands for space detection applications including space sensing and asteroid detection.

The 15.4–15.7 GHz band is also being considered for a primary radiolocation allocation under Agenda item 1.21 of WRC-11, which is relevant to the current use in the 15.7–17.3 GHz frequency range (for example, ASDE) and the trend towards increasing bandwidths. Currently allocated to the aeronautical radionavigation service, Defence has expressed interest in this band for use of new airborne weather radar technology under development.

As mentioned in section 5.1.2, Agenda item 1.3 of WRC-11 is to seek to identify additional or modified spectrum allocations for communications in support of UAV operations. In addition to the mobile communications mentioned in that section, the safe operation of a UAV will require technologies enabling the detection and tracking of other aircraft, terrain and obstacles, for which spectrum requirements also need to be considered.

ACMA’s proposed approaches

Civil air navigation, surveillance and landing systems

ACMA will continue to monitor developments in spectrum requirements for navigation, surveillance and landing systems. In particular, it will liaise with Airservices Australia, an organisation that specialises in the planning, development and operation of these systems. Airservices Australia has indicated that additional spectrum requirements for aeronautical radionavigation are unlikely to arise within 2009–2013.

GNSS

International GNSS systems operate on frequencies allocated by the ITU, and the introduction of new GNSS constellations, satellites and signals generally has little impact on ACMA’s spectrum management activities. Despite this, ACMA monitors international policy and technological developments, and will continue to do so.

As mentioned earlier, there are concerns that JTIDS and AWACS may cause interference to Galileo L-band systems. ACMA is aware of technical specifications associated with Galileo, and is working to facilitate communications between Defence and the EC to resolve potential interference issues.

Considering the obvious future public benefits of GNSS, ACMA will aim to accommodate GNSS advances within an increasingly complex regulatory environment. ACMA supports and encourages industry involvement in services associated with GNSS by facilitating access to spectrum for GNSS, including the proposed introduction of Galileo and the QZSS. ACMA also assists in matters related to GNSS through its involvement with the Galileo Inter-Departmental Committee and the Australian Government Space Forum.

UHF radar

430–450 MHz is part of the 400 MHz band, which is under review by ACMA (see Appendix A).

S-band radar

Given the importance of the services provided by Defence, Airservices Australia and BoM in the 2700–2900 MHz band, ACMA believes that it is in the overall public benefit that all stakeholders in the band continue to cooperate so that all critical uses of the spectrum have adequate access. ACMA will work with these stakeholders to establish spectrum sharing agreements in this band. ACMA will also investigate the need to develop further spectrum planning guidance on future use of the band by radar systems.

C-band weather radars and RLANs

ACMA will monitor the outcomes of sharing between weather radars and RLANs in the 5470–5725 MHz band overseas. ACMA believes that sharing based on international arrangements set out in the Recommendations and Annex of ITU-R M.1652 is possible. ACMA will proceed carefully in the implementation of RLANs sharing the 5600–5650 MHz and will aim to align such developments with the finalisation of the relevant ETSI standard, which is currently being reviewed to address sharing concerns overseas.

ASDE

ACMA will continue to monitor ASDE developments and its possible future introduction in Australia.

Automotive radar systems

In order to protect the RAS from harmful interference caused by 24 GHz UWB SRRs, these devices are prohibited by the LIPD class licence from operating within 10 km of the Parkes and Narrabri observatories and the Western Australia Radio Astronomy Park, and within three kilometres of the Canberra Deep Space Communication Complex.

ACMA believes that the density of operational UWB SRRs required to cause harmful interference to satellites of the EESS will not be realised in the short to medium term. In Europe, 24 GHz UWB SRRs are considered to be only a temporary solution for automotive radar systems and, given that European cars constitute a significant proportion of the automobile market (especially among luxury cars with the most advanced features), it seems likely that phase out of 24 GHz UWB SRRs may commence within the next 10 years. ACMA will monitor developments in existing automotive radar systems, particularly 79 GHz UWB SRRs, through consultation with peak groups such as the Federal Chamber of Automotive Industries, and liaise with potentially affected users as appropriate. Should new systems be proposed in additional frequency bands, ACMA will conduct sharing studies to determine the potential effect of their introduction on incumbent users, and to determine appropriate licensing regimes and interference mitigation strategies.

WRC-11 radiolocation allocations

ACMA will continue to facilitate the use of HF surface wave radars through temporary arrangements; the development of permanent arrangements depends on the outcome of WRC-11.

ACMA will monitor demand for and developments of the other agenda items for VHF space detection applications, the 15.4–15.7 GHz radiolocation allocation and any future allocations in support of UAV operations.

5.6.3 BEYOND 2013

Civil air navigation, surveillance and landing systems

As mentioned earlier, aeronautical navigation and landing systems are evolving towards GNSS-based systems. For this reason, the use of some current systems is planned to decline within the next five years following the implementation of GPS-based navigation and landing systems on aircraft. In the US, the phase down of NDB, VOR and MLS to a Minimum Operational Network is planned to commence as early as 2010, based on projected satellite navigation program milestones[123]. No spectrum is expected to become available from such activity within the near future. Some interest has been expressed by the telecommunication industry in the 2700–2900 MHz band for regional broadband services, although it is important to note the continued requirement of the band for weather and Defence radars.

Airborne weather radars are under development in the 15.4–16.6 GHz band; they are currently very lightly utilised, but there is interest in use for defence purposes.

Wind profiler radar

Wind profiler radars that operate in 448–450 MHz are currently not used in Australia, but BoM does use wind profiler radars that operate in other bands. BoM expects its use of wind profiler radars to increase generally, and may commence using 450 MHz wind profiler radars. As such, BoM anticipates a consequential increase in the need for 450 MHz spectrum allocations at some locations, currently limited to 448–450 MHz. ACMA will liaise with BoM on future requirements for wind profiler radars.

GNSS

The passive reception of GPS is expected to increase, but this should not impact on spectrum demand in the next 10 years. ACMA will instead focus on adjacent band issues to ensure the functionality of GPS.

Spectrum demand will most likely increase for terrestrial augmentation systems. The use of VHF spectrum for the broadcast of GPS corrections indicates that other future systems may also require additional spectrum allocations, but at this time there is insufficient information to quantify such demand. Spectrum requirements for GNSS (in particular GPS) augmentation systems will more likely be quantifiable after terrestrial tracking applications are more widely introduced in Australia. ACMA will continue to observe the deployment of GNSS augmentation systems over the next five years.

Shipborne maritime radar

The use of S- and X-band maritime radars has increased over the past decade, and is expected to increase well into the future. Spectrum demand for these radars may therefore increase, but a spectrum shortage is not anticipated in the near future. ACMA will continue to monitor the deployment of S- and X-band maritime radars, and reassess whether additional spectrum may be needed if there are indications of growing spectrum usage.

Maritime radar beacons (racons) are widely used. Their increasing use over the past decade should continue in the future. However, consultation with AMSA has revealed concerns that new technology non-magnetron radar may not be compatible with existing racons. In addition, there is the possibility that they will not be replaceable at the end of their lifetimes,

[123] US Department of Defense, Department of Homeland Security, Department of Transportation, 2005 Federal Radionavigation Plan, http://www.navcen.uscg.gov/pubs/frp2005/2005%20FRP%20WEB.pdf.

and alternative technologies with different spectrum requirements may be introduced after 10 years. ACMA will monitor the developments of non-magnetron radars and consult with AMSA regarding the continuation of S- and X-band racons after 2013.

Automatic rail identification systems

The rapidly increasing general use of RFID systems worldwide suggests that the use of rail identification systems will also increase. Despite the limited deployment and growth of this application to rail networks in Australia, increased use for suburban rail transport routes may be a possibility. However, international developments indicate that tracking systems for terrestrial transport may instead use GNSS augmentation systems. ACMA will continue to monitor the use of the 915–928 MHz band for rail identification systems, but at this stage does not anticipate additional spectrum requirements for this purpose.

Radiodetermination in support of UAVs

As mentioned in section 5.6.2, WRC-11 may consider the spectrum requirements and identify additional spectrum allocations for radiodetermination applications to enable a UAV to operate safely through an awareness of its position relative to other aircraft, terrain and obstacles. This work may not be completed at the next Conference, and the preliminary agenda for the World Radiocommunication Conference 2015 includes an item that will focus specifically on the radiodetermination requirements of UAV operation.

5.7 Satellite

Satellite communications have enabled applications requiring international communications or very large coverage areas, and are a very important component of the telecommunications industry. In particular, satellite communications are often the preferred or only solution for the provision of communications to remote and rural areas, especially in developing countries. It also provides an important backup for undersea cables vulnerable to cuts due to geological movements. The main categories of satellite communications[124] are as follows:

- fixed-satellite service (FSS)—satellites communicating with Earth stations located at fixed, specified locations on the Earth;
- mobile-satellite service (MSS)—satellites communicating with Earth stations that move across the Earth’s surface; and
- broadcasting-satellite service (BSS)—satellites transmitting signals intended for direct reception by the general public.

Satellite systems have ‘footprints’ (coverage areas) that can cover up to one third of the Earth so they usually cannot be considered solely on a national basis. For this reason, the ITU provides a process for the coordination of satellite systems that is outlined in the ITU *Radio Regulations*.

5.7.1 CURRENT SPECTRUM USE

Long term forecasts for satellite spectrum demand in the 1990s never materialised, leading to an oversupply of capacity across the industry. However, use of satellite spectrum has grown in the past decade.

[124] In this report, the radiodetermination-satellite service and the RNSS are included in the radiodetermination service section, and the meteorological-satellite and Earth exploration-satellite services are included in the space science services section. The space operations service is also included in the space science services section, since it is concerned with the operation of spacecraft and not limited to the tracking, telemetry and control of satellites.

Internationally, the major satellite operators of the FSS and BSS are Intelsat, SES Global and Eutelsat, which operate primarily in the C-, Ku- and Ka- bands[125]. Most Australian coverage comes from footprints of geostationary satellites serving the Asia-Pacific region operated by Intelsat/PanAmSat and Optus, and, to a lesser extent, others including ASIASAT, APT Group and SES New Skies. In the FSS and BSS markets, television distribution and broadcasting is the dominant service; much of the recent growth in satellite usage can be attributed to the development of digital television. Broadcasting to the public generally uses Ku-band spectrum, with utilisation of C- and Ku-band for contribution feeds. C-band satellite communications currently facilitate important applications including distance learning, telemedicine, universal access and disaster recovery. C-band is also used for feeder links for the MSS. The Ku-band is also used heavily for very small aperture terminal (VSAT) applications and some satellite news gathering (SNG) and digital terrestrial television broadcasting (DTTB) distribution.

The paired FSS allocations 7250–7750 MHz and 7900–8400 MHz are designated to be used principally for the purposes of defence, and Defence holds space licences in these bands.

The MSS is more of a niche market based on the needs of specific communities (for example, maritime, aeronautical and transport industries) that require services in regions without alternative infrastructure. The major satellite operators of the MSS in Australia are Inmarsat, Iridium, Globalstar, Orbcomm, Optus and Thuraya. The Thuraya 3 satellite was launched recently, and Thuraya is expected to commence operations in the near future. These services primarily use L- and S-band spectrum. Table 5.2 shows the main bands used to provide satellite services in Australia:

[125] When discussing satellite services, these band names generally refer to different frequency ranges than those for other services. For the frequency ranges of satellite services corresponding to these band names, refer to Table 5.2.

Table 5.2: Main satellite spectrum usage in Australia

Band	Service	Comments	
< 1 GHz	MSS	Shared with RNSS and science services; the only exclusive MSS band is for the use of EPIRBs. Generally used for low data rate and messaging requirements (e.g. Orbcomm at 137–138 MHz / 148–150.05 MHz and 400.075–400.125 MHz, and Defence at 312–315 MHz / 387–390 MHz for Allied satellite comms).	
L-band (1–1.98 GHz)	MSS	1525–1559 MHz (downlink) and 1610–1660.5 MHz (uplink) (1626.5–1660.5 MHz is paired with 1.5 GHz, 1610–1626.5 MHz paired with 2.5 GHz)—Global or near global coverage by Inmarsat, Iridium, Thuraya and Globalstar (uplink) services (such as voice, data, fax, paging and digital messaging). Earth stations are class licensed[126] in these bands where the space object apparatus is otherwise licensed. The 1525–1530 MHz and 1660–1660.5 MHz bands are shared with the fixed and radio astronomy services, respectively. Inmarsat commenced operation of its aeronautical Broadband Global Area Network (BGAN) service in 2007. Optus MobileSat (1545–1559 MHz (downlink) / 1646.5–1660.5 MHz (uplink) on B-series Optus satellites) provides mobile phone coverage for voice, fax and data across Australia and 200 km out to sea. No new fixed assignments are permitted in the 1525–1530 MHz band to preserve options for the MSS[127]. In Australia, Earth receive licences are held by the Australian Defence Force Academy, NewSat Networks and Telstra.	
	BSS	1452–1492 MHz[128]—shared with broadcasting, mobile and fixed services (DRCS/HCRC). No new assignments are permitted[127] in order to preserve options for government policy on the introduction of DAB.	
S-band (1.98–3.4 GHz)	MSS	1980–2010 MHz (uplink) / 2170–2200 MHz (downlink) — clearance of these bands to facilitate introduction of the MSS[129], which have also been identified for the satellite component of IMT). Iridium operates in these bands, although Earth stations can operate under class licence[126]. Few fixed P-P links still operating. 2483.5–2500 MHz (downlink paired with 1610–1626.5 MHz)—used, for example, by Globalstar service downlinks. Earth receivers are authorised to operate under class licence[126] where the space object apparatus is otherwise licensed.	2500–2690 MHz identified for terrestrial and satellite components of IMT. Shared with ENG at 2.5 GHz.

[126] *Radiocommunications (Communication with Space Object) Class Licence 1998*, Available: <http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/0/F19B53DD2D4DA6F8CA256FD9000555FA?OpenDocument>

[127] This is specified in the *1.5 GHz Band Plan;* however, fixed P-MP services for the delivery of telecommunications services in rural or remote areas (such as DRCS) are still permitted.

[128] Under Resolution 528, new BSS systems may only be introduced in the upper 25 MHz of the band (i.e. 1467–1492 MHz).

[129] *Mobile-Satellite Service (2 GHz) Frequency Band Plan 2002.*

Band	Service	Comments
C-band (3.4–7.25 GHz)	FSS	C-band was the first band to be used for commercial satellite communications, and there are many extant legacy systems. C-band also has the largest number of satellites. Currently shared with the terrestrial fixed service, use of C-band is authorised by apparatus licences in Australia. 3400–4200 MHz (downlink) / 5850–6725 MHz (uplink)—about 200 frequency assignments held by several licensees. Foxtel and Austar are users of this band (supplied by Intelsat or AsiaSat satellites) for contribution feeds to receive channel content from suppliers. Government organisations such as Airservices, Defence, Dept. of Foreign Affairs and Trade and the Australian Federal Police also use C-band for critical communications in neighbouring countries and with international deployments of officers/troops. The principal usage is in 'standard' C-band (3700–4200 / 5925–6425 MHz), although some satellite services, including Inmarsat feeder links, also use parts of 'extended' C-band (3550–3700 / 5850–5925 and/or 6425–6725 MHz). 5091–5250 MHz (uplink) / 6700–7075 MHz (downlink) bands—limited to feeder links for non-geostationary satellite systems of the MSS, such as Globalstar feeder links.
X-band	FSS	6725–7075 MHz (uplink)—used by AsiaSpace for TCR to ASIABSS satellites; also licensed to SKY Channel and Lockheed Martin. 7250–7750 (uplink) / 7900–8400 (downlink)—satellite bands used by Defence—communication with AUSSAT C 156E GOV satellite is class licensed[130].
Ku-band (10.7–18.4 GHz)	FSS	This band is experiencing the fastest present growth in satellite communications. 10.7–11.7 GHz (downlink)—used by iPSTAR in Australia for the provision of broadband connectivity in regional areas, and LBF Australia (French digital TV). Several Earth receive assignments held by NewSat Networks, as well as Lockheed Martin, Pacific Teleports and Soul Pattinson Telecommunications. 12.2–12.75 GHz (downlink) / 14–14.5 GHz (uplink)—Earth stations are class licensed[126] in these bands where the space object is apparatus licensed. These bands are used for direct to home (DTH) television services (including Foxtel services on the Optus C1 satellite), SNG, VSAT services including IP broadband and private networks, DTTB distribution and international teleport services. The bands are used by all six Optus satellites. There are many Earth receive/space assignments, held by several licensees including Defence, iPSTAR, Lockheed Martin, NewSat Networks, Optus and Telstra. 13.75–14 GHz (uplink)—apparatus licensed due to sharing requirements with radiolocation and space sciences services. Only a few satellites serve Australia using this band. Optus D-series use the upper portion of the band for TT&C. 17.3–18.4 GHz (uplink)—use by geostationary satellites is limited to feeder links for the BSS. Australian fixed Earth assignments are held by Xantic BV, Lockheed Martin and Optus for TT&C operations for BSS satellites.
	BSS	11.7–12.2 GHz—no Australian usage.

[130] *Radiocommunications (Communication with AUSSAT C 156E GOV Satellite Network) Class Licence 2005*, available: www.comlaw.gov.au/ComLaw/legislation/LegislativeInstrument1.nsf/0/3AA5BADC5AF7B80DCA25709A000AEEC3?OpenDocument.

Band	Service	Comments
Ka-band (17.7–37.5 GHz)	FSS	Increasingly being used internationally for national and regional broadband connections. 17.7–21.2 GHz (downlink) / 27–31 GHz (uplink)—only the 19.7–20.2 GHz and 29.5–31 MHz bands are not shared with fixed and mobile services, even though Earth stations are class licensed[126] in the 18.8–19.3 GHz / 28.6–29.1 GHz bands and there are also MSS allocations. Iridium feeder links use a portion of these bands, Thaicom (formerly Shin Satellite),also operates in these bands under a 27 GHz spectrum licence. Defence has exclusive access to spectrum licensed bands 20.2–21.2 GHz / 30–31 GHz, which is part of the Optus C1 satellite payload. 24.75–25.25 GHz (uplink) —shared with the fixed and mobile services, but currently preserved under Embargo 24[131] pending further planning and satellite service developments.
	BSS	21.4–22 GHz—not considered compatible with existing terrestrial fixed links[132].

5.7.2 2009–2013

Issues affecting spectrum demand

Factors that are expected to drive demand for satellite spectrum include:

- increasing consumer demand;
- increasing government demand and investment in technology; and
- return of financial market interest and investment.

The growth that the satellite communications industry has experienced over the past decade (for example, a 38 per cent increase in revenue from 2000 to 2005) is expected to continue for at least the next decade. Satellite communications involves a 15 year investment cycle, meaning that long term strategic planning is necessary so industry can respond to spectrum allocation changes.

MSS in the L- and S-bands

The MSS sector is growing rapidly, and strong revenue growth is expected for the future. Globalstar and Iridium are undertaking satellite constellation replenishments, and the MSS services they provide to Australia are expected to continue, as are Inmarsat and Thuraya services. While for now MSS usage is primarily in L- and S-bands, WRC-11 Agenda item 1.25 is to consider possible additional MSS allocations, principally in the range 4 to 16 GHz. This is unlikely to have a significant effect on the Australian radiocommunications environment within the next five years.

Potential future S-band MSS systems in Australia

In the US, Terrestar's integrated S-band 4G[133] mobile satellite and terrestrial communications network and ICO's MSS/ATC (ancillary terrestrial component) system will

[131] Australian Communications and Media Authority, 2007, RALI MS03—Embargo 24, www.acma.gov.au/WEB/STANDARD/pc=PC_2712.
[132] This portion of the 22 GHz band is occupied by a relatively low number of microwave fixed links. Licences in this band are subject to advisory note BL, which states that the band is currently under review to accommodate changes in technology, which may lead to a requirement to change frequency or to cease transmission.
[133] Fourth generation mobile telephone services.

be introduced in 2008 in the 2000–2020 MHz and 2180–2200 MHz frequency ranges. The MSS/ATC system is designed to provide wireless voice, data, video and internet services throughout the US on mobile and portable devices[134]. Internationally, there has also been discussion about MSS/ATC use in the MSS bands 1610–1626.5 MHz and 2483.5–2500 MHz. These MSS systems, along with the introduction of next generation broadband platforms, satellite digital multimedia broadcasting services (particularly for handheld units), and network solutions for communications in support of aeronautical, maritime and rail operations, are expected to drive sector revenue.

Since the ECC adopted decisions in 2006 on the harmonised use of the 1980–2010 MHz and 2170–2200 MHz bands for MSS purposes, Europe has undertaken public consultation on a proposed framework for selection of MSS systems to be assigned spectrum in this band. To date, 12 to 13 systems have been proposed to use this band[135].

Interest in MSS/ATC systems may increase in Australia over coming years, especially considering the competition for suitable spectrum for terrestrial mobile communications. This could create a need for an MSS providing seamless handover in areas without terrestrial network coverage. In contrast, some industry commentators consider Australia's population without mobile service access too small to justify introducing MSS/ATC. In addition, if GNSS systems employ the 2483.5–2500 MHz band (see section 5.6.2) it may restrict additional widespread MSS usage in the band. Another mobile service for which demand may arise within the next decade is satellite delivery of mobile television in the S-band (1980–2010 MHz and 2170–2200 MHz).

L-band congestion and sharing issues

Existing MSS allocations in the L-band, which is the band primarily used by the MSS, are congested and required a memorandum of understanding between satellite operators to satisfy the short term spectrum requirements of operators, many of which are looking to replenish or update existing constellations. Additional MSS allocations were made at WRC-03 (1518–1525 MHz downlink and 1668–1675 MHz uplink) and identified for use by the satellite component of IMT at WRC-07. For example, Inmarsat is developing a new satellite to operate in these WRC-03 'extension bands', planning to begin providing services to Europe and Africa in 2012. In Australia, the aforementioned congestion issues are intensified by sharing issues with other services, which may hinder the use of WRC-03 extension bands.

Australia currently protects DRCS/HCRC in 1518–1525 MHz band from proposed MSS services by implementing a pfd limit of –124 dBW/MHz/m^2. Protection of the passive space research service (SRS) in the 1668–1668.4 MHz band is facilitated by a new resolution drafted by the ITU at WRC-07[136] specifying conditions for coordination with the SRS's SPECTR-R system. Any introduction of MSS in the 1668–1675 MHz band in Australia would also require protection of the radio astronomy sites at Parkes and Narrabri, which operate between 1660 and 1670 MHz. Future MSS growth is likely to rely on spectrum allocations in the S-band (essentially unused in Australia) and the WRC-03 extension bands.

There appears to be little scope for the future expansion of existing networks or the introduction of new networks within existing L-band allocations. Despite the possible

[134] ICO Global Communications, *Overview*, http://www.ico.com/%5Fabout/.

[135] Electronic Communications Committee (ECC), July 2006, CEPT Report 013, Report to the European Commission (EC): *Harmonised technical conditions for the use of the 2 GHz bands for Mobile Satellite Services in the European Union.*

[136] Resolution 904 of the ITU *Radio Regulations* resolves that MSS systems exceeding the coordination threshold of Appendix 5 of the ITU *Radio Regulations* will be coordinated with the SPECTR-R system operating in the SRS (passive). Along with the Appendix 5 pfd coordination threshold, ITU-R Report M.2124 provides a basis for undertaking a sharing analysis.

introduction of mobile television within the next five to 10 years, along with increased MSS subscriber numbers, additional spectrum requirements for the MSS are not expected within the 2009–2013 timeframe.

FSS and BSS in the C-band and higher frequencies

With the MSS spectrum congestion and the identification of the 2500–2690 MHz[137] band for the possible future terrestrial IMT use, the FSS and BSS are expected, for the most part, to continue to be limited to frequencies above 3 GHz. An exception is the possible broadcasting of satellite digital radio in the L-band, and the proposed launch of AsiaSpace's AUSDSB satellite at 150.5ºE, which is intended to provide Australian digital radio broadcast coverage.

C-band

Moderate growth of C-band usage is expected to continue in international markets. Current worldwide transponder utilisation is estimated to be about 65 per cent and moderate growth should be accommodated within this capacity for the next decade. In the longer term, satellite capacity issues may place some pressure on certain heavily utilised orbital locations over the US, Europe and Asia. Orbital locations for C-band satellites are less heavily congested over Australian skies, which may be suitable to continue to serve the Asia-Pacific region.

The continued improvement in satellite beam forming technologies would be expected to result in a gradual migration of some C-band services to Ku-band in the longer term. However, the significant investments tied up in existing terrestrial C-band Earth station infrastructure would likely limit the rate of any such migration. This, combined with certain satellite applications and service areas requiring high levels of service availability[138] offered by C-band, mean that the band is expected to continue to play an ongoing role in intercontinental communications, including Australia. Furthermore, C-band provides the only means of international communications for several developing countries; particularly important to the Australian context are neighbouring Pacific island territories. Australia hosts several teleport Earth stations providing feeder links to major Earth stations on these islands.

There are an unknown number of unlicensed C-band satellite receivers, operated by ethnic communities, hotels and educational institutions as well as radio and television stations. Much of this use involves unlicensed, fortuitous reception from satellites whose major intended audience is in other countries. ACMA does not support the ubiquitous, uncoordinated deployment of Earth station receivers in bands shared with terrestrial services, nor does it support use of the spectrum not authorised under current licensing regimes.

There is industry concern about the possibility of interference from future use of the C-band downlink for IMT, particularly WiMAX[139], and the constraint on future FSS deployments that could result. Part of the 'extended' C-band (3400–3600 MHz) has been identified for use by IMT in many countries and at WRC-07. While the list of countries does not include Australia or the US, part of the band has been proposed for the introduction of WAS in Australia (3575–3700 MHz—see Appendix A). In addition, parts of the extended C-band are

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[137] S-band FSS (2500–2535 / 2655–2690 MHz) and BSS (2520–2670 MHz) allocations are not used in Australia, and satellite applications are not considered feasible here.

[138] C-band is the only FSS band commonly used for commercial (non-government/military) purposes below 10 GHz. Above 10 GHz, rain attenuation becomes significant. This makes C-band critical for communications in tropical areas.

[139] WiMAX stands for worldwide interoperability for microwave access.

already used for WAS under apparatus and spectrum licences[140]. Industry has also indicated the interference potential of WAS to the adjacent ‘standard’ C-band (3700–4200 MHz).

X-band

Defence expects its use of this band to increase with its involvement in the Wideband Global System satellite communications program. Defence has identified in its response to the draft Outlook, a concern over the interference potential of current sharing arrangements between satellite and terrestrial fixed services in the band; it seeks long term protection for anchor stations and training areas in particular, and possible future protection in areas of higher density use.

Ku- and Ka-bands

The Ku-band is currently experiencing the fastest growth in satellite communications, and this is expected to continue well into the future. The widespread use of several communications solutions is expected in the Ku-band, including:

- television distribution and broadcasting;
- SNG;
- broadband;
- VSAT data communications (including IP broadband and private networks, and international teleport services); and
- mobile television (satellite downlinks are being considered in both the S- and Ku-bands, and terrestrial retransmission in the S-band).

Television distribution and broadcasting is the dominant service in the FSS and BSS. Considering that the Asia-Pacific region has over half the world’s population and a number of developed and developing countries, high growth of the BSS market is expected in the region, with increasing numbers of both users and television channels. Such growth is also expected for Australia. The expansion of the Optus satellite network (D2 launched in 2007 and D3 to be launched in 2009), intended to support Foxtel’s HDTV, is an example of capacity that is being planned to address the expected growth in demand. The D3 satellite will use 11.7–12.2 GHz for television broadcasts, and 17.3–17.8 GHz for BSS feeder links. Like the latter band, the 14.5–14.8 GHz is also limited to feeder links for the BSS, but since the band is designated to be used principally for defence purposes, it is complicated to introduce satellite services within it.

Footnotes 5.502 and 5.503 of the ITU *Radio Regulations* outline sharing criteria between FSS Earth station transmitters and radiolocation/space research services in the band 13.75–14.0 GHz. Currently, Earth stations must be individually apparatus licensed to facilitate coordination. Industry feedback indicates that, due to congestion of 14.0–14.5 GHz and the ability of new Ku-band satellites to serve Australia, there is some interest in a simplified licensing approach which still satisfies the international sharing arrangements adopted.

Internationally, there is an increasing level of interest in satellite broadcasting at Ka-band frequencies. Agenda item 1.13 of WRC-11 is to decide on the future spectrum usage of the band 21.4–22 GHz for HDTV in the BSS and associated feeder link bands; based on technical and regulatory studies on the harmonisation of spectrum usage and BSS technologies. Currently, such BSS usage of the band is not considered compatible with

[140] Since 2000, the bands 3425–3492.5 MHz and 3542.5–3575 MHz have been allocated for spectrum licensing. Seven entities currently hold licences in different geographical areas around Australia.

existing fixed P-P links in the 22 GHz band. Sixty fixed links overlap with the 21.4–22 GHz range, and arrangements in RALI FX3 specify that apparatus licences issued in the 22 GHz band for fixed link assignments shall be subject to advisory note BL, which states:

> This frequency band is currently under review to accommodate changes in technology. This review may lead to a requirement to change frequency or to cease transmission.

From 1995 to 2005, the spectrum efficiency of satellite communications technologies tripled, and it is expected to double again over the next 10 years. Technologies that can enhance the efficiency of spectrum include video encoding and modulation standards such as:

- MPEG 4, a video compression format standardised by the Moving Picture Experts Group;
- digital video broadcasting-satellite-second generation (DVB-S2), a forward error coding and modulation standard that has enhanced performance over the digital video broadcasting-satellite (DVB-S) standard; and
- digital video broadcasting return channel via satellite (DVB RCS), which provides a return channel to enable internet access and other data services over satellite.

Others include phased array antennas, spot beam forming technologies, multi-band antennas and adaptive array antennas.

Spectrum demands

The highest levels of growth within the satellite industry are expected for handheld and mobile multimedia applications (for the MSS), along with television distribution and broadcasting, and the VSAT market (for the FSS and BSS). Despite these drivers, there are no expected requirements for additional MSS, FSS or BSS allocations or additional class licensing arrangements within the next five years. There is a general agreement by industry that service providers can continue operations within existing spectrum allocations.

Earth station siting

Due to competing demands between satellite and terrestrial radiocommunications services (such as those in the 3.4–4.2 GHz and 10.7–11.7 GHz bands), ACMA has identified a need to review the spectrum management issues associated with the siting of some satellite Earth stations operating in certain bands shared with terrestrial services in areas of high spectrum demand (such as urban areas). While it is acknowledged that some satellite Earth stations need to operate in urban areas, in at least some cases there are satellite dependent services that can be successfully provided by Earth stations located in less populated areas where spectrum demand is low. Encouraging the siting of Earth stations in less populated areas could make spectrum available in urban areas from which it would otherwise be denied.

ACMA’s proposed approaches

MSS in the L- and S-bands

Within the 2009–2013 timeframe, ACMA expects to maintain current L-band and S-band class licensing arrangements for MSS services. ACMA will also monitor any MSS requirements for WRC-03 extension band applications in Australia, including class licensing arrangements for these bands, and will consider sharing arrangements between MSS and fixed DRCS/HCRC services. ACMA is unaware of any current plans for the use of MSS systems in these bands in Australia. However, increasing pressures on existing L-band resources, combined with EIRP limits published at WRC-07 to limit the interference potential of transportable radio-relay systems operating in the L-band extension band for the uplink, may result in the commencement of international use of this band. It is possible that the coverage of such international services may extend to Australia.

ACMA will continue to protect DRCS/HCRC in the 1518–1525 MHz band by imposing pfd thresholds on the MSS in this band. Though the current limit was negotiated to ensure that MSS development would not be severely constrained, future sharing arrangements for the potential introduction of MSS services in this extension band may lead to a need to reconsider the pfd limit in more depth.

There are currently no MSS systems operating in the 1668–1675 MHz band in Australia. Potential future use of the band for the MSS may require a study into the feasibility of sharing with RAS facilities at Parkes and Narrabri. In particular, consideration will need to be given to protection of RAS stations at 1660–1670 MHz. This may require the use of separation distances and mobile Earth station output power limits for co-band 1668–1670 MHz MSS[141] systems and adjacent band 1670–1675 MHz MSS systems.

ICO is introducing its MSS/ATC system (and Terrestar is introducing a similar network) in the 1980–2010 MHz and 2170–2200 MHz MSS allocations. Should these networks prove successful, it may drive interest in an Australian market. If there is an interest in the deployment of Australian MSS/ATC systems, consideration will need to be given to the effects of such a system on co- and adjacent band services. ACMA would need to undertake a review of spectrum management arrangements, as MSS/ATC was not considered when existing arrangements were developed.

FSS and BSS in the C-band and higher frequencies

For ACMA’s proposed approaches to L-band BSS, see section 5.2.2.

From 2009 to 2013, ACMA’s apparatus licensing arrangements will maintain current access arrangements to the C-band for satellite Earth stations. In addition, ACMA expects to maintain its policy not to support the ubiquitous, uncoordinated deployment of Earth station receivers in bands shared with terrestrial services; particularly the 3.4–4.2 GHz frequency range (standard and extended C-band) and the 10.7–11.7 GHz band.

ACMA will continue to work with Defence in order to balance their operational requirements in X-band with those of the broader community and radiocommunications industry.

ACMA will maintain Ku-band class licensing arrangements in the 11.7–12.75 GHz and 14.0–14.5 GHz bands, as strong continued growth is expected in the Ku-band for DTH broadcasting and VSAT applications. Current class licensing arrangements in the Ku-band are expected to be sufficient to support satellite applications, including HDTV, within the 2009–2013 time frame. However, ACMA notes some industry interest in revised licensing arrangements in the 13.75–14.0 GHz band. Any consideration of such a revision would require consultation with interested and affected stakeholders in the band.

ACMA will monitor any international technological and regulatory developments for HDTV services broadcast at 21.4–22.0 GHz. ACMA will also monitor demands for HDTV BSS systems in Australia, which may involve public and industry consultation.

Australia has yet to develop a formal position on WRC-11 Agenda item 1.13. However, Australia’s position on this issue at the time it was being considered as a potential Agenda

[141] As specified in Article 5.379C of the ITU *Radio Regulations*.

item for WRC-11 was that while any technical or regulatory changes to improve access to this spectrum for BSS usage could be supported, Australia did not support the development of a formal *a priori* 'BSS Plan' for the 21.4–22 GHz BSS band.

Ka-band class licensing arrangements in the 18.8–19.3 GHz and 28.6–29.1 GHz bands will also be maintained, with the expectation that demand for Ka-band DTH broadband applications may arise within the 2009–2013 timeframe. Industry requirements for arrangements for class licensing of ubiquitous Earth stations in the 19.7–20.2 GHz and 29.5–30.0 GHz bands will also be examined.

As mentioned in section 5.1.2, at WRC-07 the 5091–5150 MHz band was allocated to the AM(R)S on a primary basis, and is intended for use by airport surface applications, security transmissions and wideband AMT. ACMA will need to consider the impact of the introduction of such systems on existing Globalstar feeder links serving non-geostationary satellites of the MSS, which are licensed for the ground transmit segment only.

Earth station siting

At this time, ACMA favours reviewing spectrum management arrangements to limit the deployment of satellite Earth stations in metropolitan areas, where spectrum demand for terrestrial services is highest. However, ACMA recognises that it must balance the costs to Earth station operators of locating their station in these areas with the benefits of making spectrum available for services to the community in these areas. This is a complex issue and will require extensive consultation with stakeholders. Through submissions to the draft Outlook, the satellite industry has expressed opposition to such a policy being implemented, which according to this sector may result in substantial costs associated with relocating equipment and infrastructure, and establishing and maintaining backhaul communications, along with logistical considerations.

5.7.3 BEYOND 2013

Bridging the 'digital divide'

The expected increase in usage of satellite broadband is supported by a key initiative of the International Telecommunications Satellite Organisation. The Global Broadband Satellite Infrastructure (GBSI) initiative aims to develop and strengthen broadband satellite provision in areas without terrestrial infrastructure. The goal of the GBSI initiative is to bridge the 'digital divide' between developed and developing countries (and urban and rural/remote areas) by providing broadband internet access on a global and non-discriminatory basis and at an affordable cost. Current technology, spectrum and deployed satellites could form such a global infrastructure, but international technical standards for and reduced cost of terrestrial user terminals and harmonised spectrum are required[142].

Potential future deployments and spectrum demand pressures in Australia

If both mobile television and a system similar to MSS/ATC are deployed in Australia, and if MSS subscriber numbers continue to increase exponentially, then there may be insufficient spectrum under 3 GHz for MSS; additional L- and S-band spectrum may be required by about 2018. In addition, the introduction of a system similar to MSS/ATC operating at 1.6 GHz and 2.5 GHz would require the consideration of the RAS at 1610–1613.5 MHz, and ENG services and possible future WAS applications within the 2500–2690 MHz frequency

[142] Ahmed Toumi, Director General and CEO of the International Telecommunications Satellite Organisation, presentation at the Baku Global ICT Conference 2004, *Global Broadband Satellite Infrastructure (GBSI) Initiative*, http://global-ict.mincom.gov.az/presentations/2.ppt.

range. There is concern within industry that WAS may also impact on satellite usage in the standard C-band (3700–4200 MHz) (see Appendix A). This concern has been intensified by the proposed use of the band for IMT by some administrations prior to WRC-07, and the implementation of BWA systems in the 3400–3800 MHz band in Europe. However, ACMA is unaware of any interest within Australia for use of standard C-band for WAS.

Ku-band growth

Growth in the number of satellite television channels will increase spectrum demand, as will the increased proportion of HD transmissions and the expected growth of VSAT deployment numbers and data rates. There is a possibility that this may lead to congestion of Ku-band spectrum allocated to the FSS within the next 10 years, despite considerable portions of unencumbered spectrum. While it is likely that Ku-band FSS spectrum demand will exceed current satellite capacity within the next 15 years, there are several vacant orbital locations over Australia that could satisfy the estimated demand within current spectrum allocations. Spectrum demand for the BSS is not expected to exceed current spectrum allocations.

Growth in higher frequency bands

There has been slow commercial deployment and usage within Ka-band because the relative immaturity of technology and severe rain fade (mainly a concern in tropical and sub-tropical areas) poses limitations to satellite service usage at such high frequencies. However, the use of Ka-band does permit more complex satellite antennas which allows for a cellular approach to spectrum reuse, which increases throughput through a satellite. Industry feedback indicates that Ka-band satellite communications may be considered as a means of extending broadband to regional and remote areas. This is already being used in the US and may be relevant to Australia in the future.

V- and W-band satellite technology (50–75 GHz and 75–110 GHz) is currently immature and significant utilisation of this spectrum is not expected to materialise within the next 15 years.

5.8 Space science services

The space science services consist of the:

- radio astronomy service (RAS);
- Earth exploration-satellite service (EESS);
- space research service (SRS);
- meteorological-satellite service (MetSat); and
- meteorological aids service (MetAids).

EESS and SRS can be further classified into passive and active services. Passive services involve the reception of naturally occurring electromagnetic radiation (emitted at fixed frequencies depending on the molecule). Active services measure reflected or back scattered radiation from a transmitter in the system (for example, radar). EESS sensors observe phenomena on the Earth’s surface, while SRS sensors normally look away from the Earth, into space.

The space operations service (SOS) is also included in this section of the report because it is associated with manned space operations for scientific purposes. The SOS is concerned with tracking, telemetry and control (TT&C) of spacecraft, normally during the launch and early orbit phase (LEOP) and in emergency situations.

These services also have communications components. Frequency allocations for these six services are made on a global basis due to their use of space and, in some cases, their dependence on naturally occurring emissions.

5.8.1 CURRENT SPECTRUM USE

RAS involves the study of celestial bodies by way of the reception of radio waves of cosmic origin at a terrestrial station. The SRS is similar, but with the reception of cosmic radio waves by spacecraft borne instruments. The EESS on the other hand, involves the reception of the radio waves originating on or reflected from the Earth. The measurements of interest are made on airborne, terrestrial or satellite based platforms, and are processed to obtain information relating to the characteristics of the Earth and its natural phenomena (for example, soil moisture, sea surface temperature, snow cover, rainfall and atmospheric temperature, and water vapour content). Both the EESS and SRS have communications components connecting the Earth and space stations that comprise these services.

MetSat is a subset of the EESS specifically for meteorological purposes, and MetAids involves the transmission of meteorological information from airborne or terrestrial sensor platforms to ground stations. The environmental and cosmic parameters determined through MetAids and the EESS are characterised by the strength and frequency of signals received by the passive and active sensors employed. Since the naturally emitted or reflected electromagnetic signals with characteristics fundamental to these space science services have fixed frequencies (apart from some shifting due to anomalous phenomena), their protection is crucial to the operation of these services.

There is a significant radio astronomy presence in Australia, with RAS facilities at:

- Narrabri, Parkes and Mopra, operated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- Mt Pleasant and Ceduna, operated by the University of Tasmania; and
- the Canberra Deep Space Communication Complex (CDSCC), which is part of the National Aeronautics and Space Administration (NASA) Deep Space Network.

However, Australia does not operate its own satellites under the other space science services. Instead, Australia has Earth stations that receive environmental and scientific data from sensing instruments aboard foreign satellites, and provide TT&C to others. Most of the Earth stations are operated by the Bureau of Meteorology (BoM), CSIRO (including the CDSCC), Xantic BV (acquired by Stratos Global in 2006) and Geoscience Australia (GA).

Table 5.3 lists the main frequency bands used by space science services relevant to the Australian scientific community (this is not a comprehensive list):

Table 5.3: Main frequency bands used by space science services

Frequency band	Service	Main Australian licensee	Usage
VHF	MetSat (d*)	BoM	137–138 MHz—meteorological image downlink from polar-orbiting satellites (NOAA POES[143] and FengYun-1).
UHF	MetAids	BoM	400.15–401 MHz—radiosonde[144] data downlink.
	MetSat (d/u**)	AAD[145] AMSA	401–403 MHz—uplink for meteorological data sensed at data collection platforms. 460–470 MHz—interrogation downlink for data collection platforms.
		GA	401.25 MHz—ionospheric correction signal for the DORIS[146] system for position tracking.
L-band	EESS (a†)	-	1215–1300 MHz—L-band synthetic aperture radars (SAR) on Japan's ALOS and Argentina's SAOCOM satellites.
	RAS	CSIRO	1400–1427 MHz & 1610.6–1613.8 MHz—Parkes and Narrabri stations.
	MetSat (d)	BoM GA CSIRO	1670–1710 MHz—meteorological satellite data downlink (NOAA POES, FengYun, GOES, Meteosat and MTSAT and OrbView-2 satellites).
S-band	EESS (u/d) SRS (u/d) SOS (u/d)	2025–2110 / 2200–2290 MHz—primary TT&C uplink/downlink, used by almost all satellites in the EESS and SRS.	
		Xantic BV	European Space Agency's (ESA's) ESTRACK stations support: Perth—XMM-Newton and Cluster II missions New Norcia – Mars Express, Rosetta and Venus Express Both stations—LEOP support for several ESA missions.
		CSIRO	Deep space stations at CDSCC, which communicate with many spacecraft in the SRS and EESS
		USN	Provides TT&C from Yatharagga, WA under PrioraNet network (various clients).
		GA	2036.25 MHz—main Doppler signal for DORIS.
	SRS (deep space) (u/d)	Xantic BV CSIRO	2110–2120 / 2290–2300 MHz—deep space uplink/downlinks to the tracking stations at New Norcia, Perth and Canberra.
S-band	RAS	CSIRO	2690–2700 MHz—Parkes and Narrabri stations.
	EESS (aS††)		3100–3300 MHz—Envisat's Radar Altimeter (RA-2).
C-band			4033–4042 MHz—meteorological data dissemination service (GEONetCast)
	RAS	CSIRO	4800–5000 MHz—Parkes and Narrabri stations.
	EESS (a)		5250–5570 MHz—radar altimeters, SARs and scatterometers for the determination of wind speed.
	EESS (p‡)		6700–7075 MHz—advanced microwave scanning radiometer (AMSR) and the Windsat radiometer.

[143] Polar Operational Environmental Satellites (POES) of the US's National Oceanic and Atmospheric Administration (NOAA).
[144] Radiosondes are meteorological sensors mounted on weather balloons.
[145] Australian Antarctic Division.
[146] Doppler Orbitography and Radiopositioning Integrated by Satellite, used by Jason-2, SPOT-2 and Envisat.

X-band	EESS (u) SRS (u)	Xantic BV CSIRO	7145–7235 MHz—X-band command uplinks from tracking stations at Perth, New Norcia and Canberra. Deep space missions in the 7145–7190 MHz band.
	MetSat (d)		7450–7550 and 7750–7850 MHz—limited current use.
	EESS (d)	GA USN	8025–8400 MHz—primary data downlink for EESS satellites (data from Terra, Aqua, Landsat-5 and -7, ALOS, EO-1, Radarsat-1, Resourcesat-1 and ERS-1 and -2 are received in Australia).
	SRS (d)	Xantic BV CSIRO	8400–8500 MHz—primary SRS data downlink, used by Perth, New Norcia and Canberra tracking stations. Deep space missions in the 8400–8450 MHz band.
	EESS (a)		9500–9800 MHz—SAR on TerraSAR-X.
	EESS (p)		10.6–10.7 GHz—AMSR, the Tropical Rainfall Measuring Mission (TRMM) microwave imager (TMI) and the Windsat radiometer.
Ku-band	EESS (a)		13.25–14.3 & 17.2–17.3 GHz—radar altimeters, the SeaWinds scatterometer, the TRMM precipitation radar and the Jason Microwave Radiometer.
	SRS (d/u)	CSIRO	13.75–15.35 GHz—spacecraft tracking from Perth and Canberra.
Ka-band	MetSat (d)		18.1–18.4 GHz—MTSAT Ka downlink (not in Australia).
	EESS (d/u) SRS (d/u)	Xantic BV CSIRO	25.5–27 GHz—Ka-band downlink—at Canberra and New Norcia. 28.5–30 GHz—MTSAT Ka uplink (not in Australia).
	SRS (d/u)	CSIRO	31.8–32.3 GHz / 34.2–34.7 GHz—communications to/from Canberra deep space station.
	SRS (d/u)		37–38 / 40–40.5 GHz—planned links to/from Canberra and New Norcia.
	EESS (p)		Various bands between 18.6 and 24 GHz, and 36–40 GHz—AMSR, TMI, advanced microwave sounding unit (AMSU), special sensor microwave imager (SSM/I), and other microwave radiometers.
> 50 GHz	EESS (p)		50.2–59.3 GHz and 86–92 GHz—AMSU, TMI, SSM/I and AMSR. > 100 GHz—AMSU.
	EESS (a)		94–94.1 GHz—cloud profiling radar (Cloudsat).

KEY:
* d—downlink
** u—uplink
† a—active
†† S—secondary allocation
‡ p—passive

5.8.2 2009–2013

Issues affecting spectrum demand

The general issues of most concern for the space science services are:

- the protection of sensors operating at naturally emitted/reflected frequencies for Earth, atmosphere and space observations from harmful interference; and
- the future increase in bandwidth requirements; in particular, for mission data downlinks.

Passive services

For passive reception in the RAS, EESS and SRS, the extremely weak nature of the wanted signals—and hence the high sensitivity of receivers—makes these services particularly susceptible to harmful interference. This is compounded by the fact that because passive services do not transmit radiocommunications signals, techniques like dynamic frequency selection cannot be used for detection and avoidance of passive services, along with other radiocommunications receivers. This is a major challenge in implementing dynamic spectrum access (see section 5.9.3). Protection of passive services has up to now relied on regulatory measures such as separate frequency allocations or exclusion zones, requiring prior knowledge of fixed passive stations by potential interferers. While some of these are protected by Article 5.340 of the ITU *Radio Regulations*[147], other space science allocations are not. Various members of the scientific community, including BoM, have expressed concerns about reported interference to passive satellite measurements from fixed P-P links in the 10.6–10.68 GHz band. This issue has also been identified at an international level, and was addressed by Agenda item 1.2 at WRC-07. As a result, a resolution was created to specify new sharing criteria[148] between passive sensors in the EESS and fixed P-P links. In order to be able to present an Australian position on Agenda item 1.2, ACMA engaged in an initial consultation process before the conference to arrive at a compromise agreement between stakeholders of the EESS and fixed service. It was agreed that:

- there would be no further fixed P-MP or mobile use of the band; and
- new fixed P-P links would be restricted to:
  - a maximum transmit power of –15 dBW or, in the case where automatic transmitter power control (ATPC) is used, the power limit can be increased by a value corresponding to the ATPC range, up to a maximum of –3 dBW; and
  - a maximum elevation angle of 15º.

At WRC-07, the sharing criteria were developed in line with the same Conference Preparatory Meeting[149] method that was identified in the Australian proposal for the conference; the only difference was a lower maximum elevation angle in the Australian proposal.

The scientific community has also expressed concern about potential interference in the 23.6–24 GHz passive band[150] due to the class licensing of automotive UWB SRR at 22–26.5 GHz, particularly for the EESS and RAS (see section 5.6.2).

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[147] All emissions are prohibited in the bands specified in Article 5.340 of the ITU *Radio Regulations*.

[148] Resolutions 751 (10.6–10.68 GHz) and 752 (36–37 GHz) of the ITU *Radio Regulations* outline sharing criteria specifying incidence angle, spatial resolution and main-beam efficiency limits for passive sensors in the EESS, and elevation angle and transmit power limits for point-to-point and P-MP links in the fixed service.

[149] The Conference Preparatory Meeting (or CPM) prepares a consolidated report which is used as the basis for the work of the Conference.

[150] ITU *Radio Regulations* Article 5.340.

Recognition of space science services

There is concern within the space science sector that because scientific usage of the spectrum generates benefits that are generally difficult to gauge financially, such usage is particularly likely to experience pressure from commercial users. For example, ACMA recognises that the communications components of space science services involve very sensitive reception, which in some cases within the SRS, extend to distances exceeding 14 billion kilometres. Therefore, it is desirable that incompatible services do not operate in close proximity to highly sensitive RAS and SRS facilities. To reduce the consequent spectrum denial as much as possible, ACMA has actively encouraged the location of such stations, along with EESS and meteorological satellite Earth stations, to be in areas where spectrum demand is likely to be low. This may impose additional costs on the operator of the Earth station, including very large capital investments that may reduce the operator's ability to provide scientific services that could be of great value to the community. Feedback from such operators highlights claims that the costs of relocating equipment, establishing and maintaining high speed data communications from and power supply to remote locations may be prohibitive. However, ACMA must balance these costs with the benefits of making spectrum available for services to the community in the areas where demand is likely to be strongest, in addition to meeting its obligations to protect existing services operating under co-primary allocations.

Space science services received much attention at WRC-07, where prior resolutions to determine sharing criteria between passive space science services and active terrestrial and satellite services were addressed. In their general positions, administrations sought to protect passive services, while not causing undue constraint to active services. Mandatory sharing criteria[148] were determined for the 36–37 GHz band, while limits and recommended maximum levels of unwanted emission power were determined for various other bands in the EESS[151]. Changes were also made to the unwanted emission pfd threshold levels in the annex to Resolution 739 to protect the RAS from active satellite services.

Technological trends

With limited scope for further improvement of receiver sensitivities (particularly in the RAS), sensing applications are expected to tend towards larger collecting areas and wider operational bandwidths. At WRC-07, the X-band active EESS and SRS allocations were extended by 200 MHz down to 9300 MHz, in acknowledgement of such bandwidth increases. Sensing services are also expected to operate at increasingly higher frequencies. WRC-11 Agenda item 1.6 is to update the spectrum use by passive services, as outlined in Article 5.565 of the ITU *Radio Regulations*, to include the range 1000–3000 GHz.

It is expected that the communication components of the EESS, SRS and MetSat will use higher frequencies and wider channel bandwidths in the future. This is driven by the ongoing demand for higher data rates, which are expected to increase rapidly over the target period of this study. Meteorological satellites in particular, most of which currently use L-band[152] downlinks, are moving towards X-band data downlinks (already used by many EESS satellites). For example, China's FengYun-3 meteorological satellite use X-band transmitters, and the US's four National Polar-orbiting Operational Environmental Satellite System (NPOESS) satellites to be launched between 2013 and 2020 will also operate in X-

[151] Resolution 750 specifies unwanted emission power limits from the inter-satellite service in the 22.55–23.55 GHz band; the fixed service (excluding HAPS) in the 31–31.3 GHz band; the FSS in the 49.7–50.2 GHz and 50.4–50.9 GHz bands; and the fixed service in the 51.4–52.6 GHz band. It also specifies recommended maximum levels of unwanted emission power for the mobile, fixed, radiolocation and space operations services within the 1400–1427 MHz band and the FSS in the 30–31 GHz.

[152] L-band refers to the microwave frequency range between 1 GHz and 2 GHz.

band, along with the precursor mission NPOESS Preparatory Project (NPP), scheduled for launch in 2009. In addition to using the EESS downlink 8025–8400 MHz, these systems will also use the meteorological-satellite service downlink 7750–7850 MHz.

NPOESS will also use Ka-band[153] downlinks for stored mission data, and use of the Ka-band is expected to increase beyond the next five years.

An example of the higher frequency, wider bandwidth trend is the extension of the Ka-band meteorological-satellite downlink allocation to 300 MHz (18.1–18.4 GHz) at WRC-07. In addition, WRC-11 Agenda item 1.24 is to consider a similar extension of the 7750–7850 MHz space-to-Earth meteorological-satellite service allocation by 50 MHz (up to 7900 MHz), limited to non-geostationary satellites. Use of higher frequencies and wider bandwidths will also apply to the SRS and SOS, with plans to upgrade the facilities at New Norcia and CDSCC to commence and improve Ka-band reception at 37–38 GHz and 25.5–27 GHz, respectively. These Earth stations support many scientific spacecraft missions, which include exploration of the solar system utilising remote sensors, video and even robotic techniques. The next phase will include support of manned missions to the moon, and eventually, Mars. Both NASA and the European Space Agency (ESA) are increasing their solar system exploratory activities, and Ka-band frequencies for radio links to lunar and planetary missions via data relay satellites and direct to Earth stations are proposed. At WRC-11, an additional primary uplink allocation to the SRS in the band 22.55–23.15 GHz is to be considered in Agenda item 1.11. This allocation is proposed to be used in the future for such purposes, especially considering that data relay satellites are already using this band in the existing inter-satellite service allocation, and would be paired with 25.5–27.0 GHz. As missions venture further into space, the longer link lengths further complicate coordination due to the need for higher protection ratios and bandwidths. In turn, the higher potential for interference may slow technological development.

Square Kilometre Array

Another example of demand for more sensitive instruments with larger apertures and wider bandwidths is the Square Kilometre Array (SKA), a giant radio interferometer made up of an array of parabolic antennas with a combined collecting area of 1 km^2. The SKA will operate between 100 MHz and 25.25 GHz. Figure 5.19 shows an artist's impression of what the SKA may look like once completed.

Australia and South Africa have been short listed to host the SKA, and both countries are building technology demonstrators at their proposed sites. To support Australia's bid, and because of the high sensitivity of such an instrument, a radio quiet zone (RQZ) has been established in Western Australia under Embargo 41[154], which limits new assignments within the RQZ. The introduction of the SKA, if hosted by Australia, is the most significant foreseeable change in spectrum requirements for the RAS.

In addition, two test systems[155] will become operational within the next five years that may need between 80 MHz and 2 GHz of aggregate frequency assignments.

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[153] Ka-band, when related to satellite services, refers to the microwave frequency range from about 18 GHz to 40 GHz; the NPOESS downlink occupies the frequency range 25.5–27 GHz.

[154] Australian Communications and Media Authority, 2007, RALI MS3—Embargo 41, <http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712>.

[155] The Mileura International Radio Array in the RQZ, east of Geraldton, and the SKA Molonglo Prototype, east of Canberra.

Figure 5.19: An artist's impression of the SKA

FengYunCast

GEONETCast is a global network of satellite based data dissemination systems intended to provide meteorological and environmental data to a worldwide user community[156]. The broadcast stream relevant to Australia is that of FengYunCast, which transmits to the Asia-Pacific region using the C-band downlink (4033–4042 MHz) on the AsiaSat-4 satellite. Much of the data available on the GEONETCast network is already accessible by BoM through existing infrastructure. However, BoM considers that FengYunCast will improve data dissemination processes, particularly its efficiency—large amounts of data are sent at faster rates to a much larger population of users, with a reduced need for dedicated spectrum for individual MetSats. The operating frequency of FengYunCast (4.04 GHz) falls within the heavily used 3.8 GHz fixed service band for long haul, high density links, and the standard C-band satellite downlink band.

ACMA's proposed approaches

Passive services

The protection of passive services in the 10.6–10.7 GHz band from harmful interference caused by fixed P-P links was discussed at WRC-07 and sharing criteria have been established to limit potential interference. These are consistent with the proposed Australian arrangements and restrictions. Final arrangements to protect passive services in the band will be documented and formalised by ACMA in the near future, following the additional formal consultation required to implement the changes. Consultation on changes to the current arrangements is likely to consider measures to maintain the utility of the band for fixed P-P links, such as a review of minimum path length and antenna performance requirements.

For ACMA's proposed approach to spectrum sharing between 24 GHz UWB SRRs and the RAS and EESS, see section 5.6.2.

[156] EUMETSAT, 2007, *GEONETCast*, http://www.eumetsat.int/home/Main/What_We_Do/index.htm.

Furthermore, in the interest of the RAS, ACMA has established notification zones around the RAS facilities listed in section 5.8.1[157]. The CSIRO is informed of new frequency assignments within these zones so that if they are likely to cause detriment to the operation of RAS stations, negotiations with the new licensee can be undertaken. However, only the Parkes and Narrabri RAS stations hold Earth receive licences; if other stations seek protection within the RAS allocations, then appropriate licences should be obtained.

Recognition of space science services

ACMA must balance disadvantages associated with additional costs to Earth station operators of locating their stations in areas where spectrum demand is likely to be low with the benefits of making spectrum available for services to the community in the areas where demand is likely to be strongest.

Technological trends

Taking into account the observed trends of data communication technologies, ACMA recommends that Australian entities involved in the planning of future satellite systems in the space science services encourage continuation of the current trend towards the use of higher frequencies, particularly the Ka-band, with a view to simplifying potential future competing demand issues.

ACMA will continue to monitor the development of radiocommunications technologies for Earth observing and deep space missions, with a particular focus on NASA and ESA. Such missions using the most advanced technologies may be the driving force behind expansion of frequency allocations for space science services, as seen for the 18 GHz MetSat and the X-band EESS and SRS (active) allocations.

FengYunCast

If Earth stations for the reception of FengYunCast C-band data are to be constructed, the heavy use by fixed links in the 3.8 GHz band should be considered. These links commonly lie along major trunk routes and in the population centres (where they originate and terminate). Coordination requirements and ACMA’s Earth station siting policy (currently under development) may require any new Earth stations to be built away from major populated areas.

5.8.3 BEYOND 2013

The trend towards use of higher frequencies is expected to continue, and allocations may be made for passive observations in the RAS and EESS above 300 GHz.

Use of the L- and S-bands for communications is expected to continue (especially S-band TT&C), but most of the growth is expected in the X- and Ka-bands. It is anticipated that the Ka-band could possibly surpass the X-band as the primary data downlink band within the next 10 to 20 years. However, given the long lifespans of EESS satellites, X-band is expected to remain the primary data downlink for some time.

The SKA is expected to become operational between 2015 and 2020, although at this stage it is not known whether the SKA will be built in Australia or South Africa. In any case, the RQZ will continue to remain an appropriate place for the deployment and future development of radio astronomy activities.

[157] These notification zones are specified in *RALI MS 31 – Notification Zones for Apparatus Licensed Services around Radio Astronomy Facilities;* available at: http://www.acma.gov.au/webwr/radcomm/frequency_planning/frequency_assignment/docs/ms31.pdf.

5.9 Wireless access services

The term 'wireless access services' (WAS) encompasses the variety of ways that telecommunications carriers, internet service providers or other service providers deliver a radio connection to an end-user from a core network. This is usually a public network such as a public switched telephone network, the internet or a local/wide area network. WAS covers a range of other terms such as:

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

Mobile telephony services and mobile television can also be considered as types of WAS.

WAS are being deployed as both a supplement and an alternative to fixed and mobile telecommunications networks, digital subscriber line (DSL) technologies, cable and satellite[158]. WAS technologies are particularly attractive to service providers who do not have the capacity to build extensive fixed wireline infrastructure.

When wireless technology is used to provide the 'last mile connection', it avoids the high capital costs associated with the installation of fixed wireline and cable. The relatively lower infrastructure costs and potentially faster deployment have increased the viability of service provision in the less commercially attractive areas such as regional and remote Australia. Depending on the frequency band chosen, either bandwidth or distance can be optimised, and sometimes both.

Examples of technologies that can be used to provide WAS include:

- IEEE 802.11 (also known as Wi-Fi, short for 'wireless fidelity');
- IEEE 802.16 and ETSI HiperMAN[159] (commonly known as WiMAX[160]); and
- second, third and fourth generation (2G, 3G and 4G) mobile telephony systems.

Many of these technologies are part of the IMT[161] family of standards. There are also numerous examples of proprietary systems deployed in Australia that are providing WAS.

5.9.1 CURRENT SPECTRUM USE

Bands between about 450 MHz and 6 GHz are in high demand for fixed and mobile WAS applications. The higher microwave frequencies offer the advantage of more bandwidth for high speed communication applications, but communication distances are limited by propagation constraints.

The dynamic nature of the mobile radio environment is also dependent on frequency; lower frequencies are preferred, especially where cost considerations and low tele-density warrant

[158] Although satellite communications are also wireless, this section focuses on the requirements for WAS using terrestrial networks.
[159] HiperMAN stands for high performance radio metropolitan area network.
[160] WiMAX stands for worldwide interoperability for microwave access.
[161] IMT is an ITU-approved global standard for 3G and 4G (fourth generation) wireless communications which includes the WiMAX standard.

the installation of fewer base stations[162]. On the other hand, bands below about 500 MHz are inherently limited by bandwidth and congested with narrowband services (for example, the land mobile segments of the 400 MHz band).

Table 5.4 lists the bands available under apparatus, class and spectrum licensing that are capable of supporting WAS applications in Australia. With the convergence of fixed and mobile services, frequency bands supporting mobile telephony services are also included in this table.

Table 5.4: Spectrum allocations available for the deployment of WAS in Australia

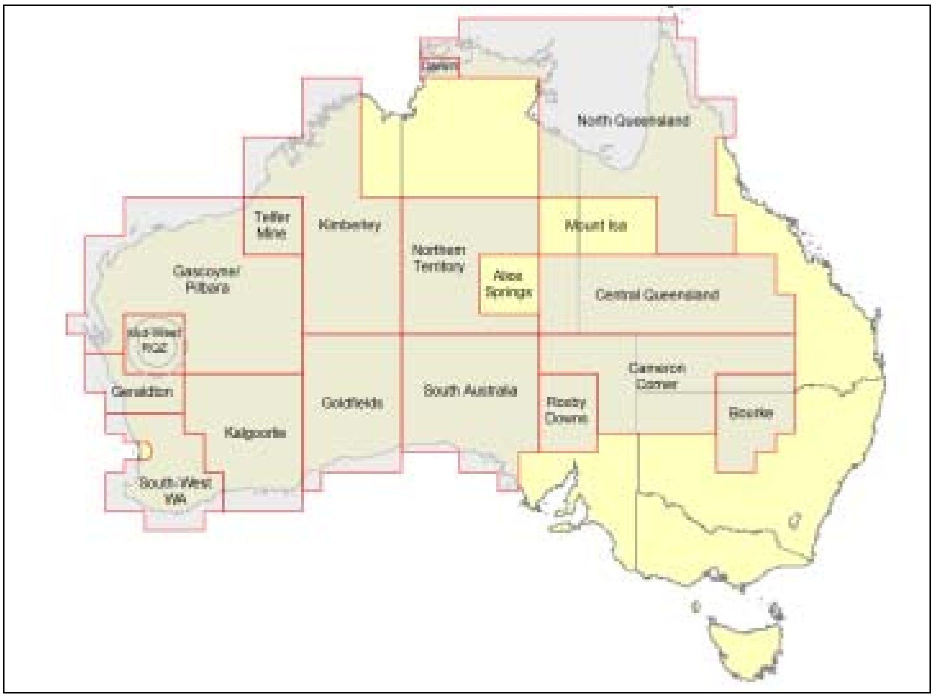
Band	Licensing regime	Current usage
825–845 MHz / 870–890 MHz	Spectrum (paired spectrum)	Mobile telephony (3G—WCDMA)
890–915 MHz / 935–960 MHz	Apparatus (paired spectrum)	Mobile telephony (GSM-900)
915–928 MHz	Class	RLAN/BWA, other low-powered devices
1427–1535 MHz	Apparatus	DRCS/HCRC and BWA in regional and remote areas (DRCS is not permitted within 200 km of capital city GPOs and other specified locations, BWA is not permitted in high and medium density areas).
1710–1785 MHz / 1805–1880 MHz	Spectrum (paired spectrum)	Australia wide (restricted to the lower 15 MHz in regional areas)—mobile telephony (GSM-1800).
1900–1920 MHz	Spectrum Apparatus	Capital cities only—3G and BWA services. Regional and remote areas only—BWA.
1920–1980 MHz / 2110–2170 MHz	Spectrum (paired spectrum)	Capital cities and regional areas (the latter is restricted to the upper 20 MHz)—3G mobile telephony and broadband.
2302–2400 MHz	Spectrum	Originally used for MDS systems supporting pay television and other applications, however the current framework supports other WAS deployments.
2400–2483.5 MHz	Class	RLAN/BWA, other low powered devices (e.g. Wi-Fi and Bluetooth).
3425–3442.5 MHz / 3475–3492.5 MHz	Spectrum (paired spectrum) Apparatus (paired spectrum)	Capital cities and major regional centres only—FWA/BWA. Regional and remote areas only—BWA.
3442.5–3475 MHz / 3542.5–3575 MHz	Spectrum (unpaired spectrum)	Capital cities and regional areas only—FWA/BWA.
5150–5350 MHz	Class	RLAN/BWA, other low powered devices (e.g. Wi-Fi).

[162] Resolution 224 (WRC-2000) and Article 5.317 of the ITU Radio Regulations.

Band	Licensing regime	Current usage
5470–5725 MHz	Class	RLAN/BWA, other low powered devices (e.g. Wi-Fi).
5725–5850 MHz	Apparatus	Regional and remote areas only—P-P links for BWA.
	Class	RLAN/BWA, other low powered devices (e.g. Wi-Fi and WiMAX).

In 2000, the 2302–2400 MHz band (2.3 GHz band) was converted to spectrum licences around Australia. A large amount of residual spectrum in the 2.3 GHz band is still available in regional areas, and it may be of interest to some telecommunications operators and other users. ACMA plans to make the remaining lots available via a price based allocation or for a pre-determined price in 2009. The shaded areas in Figure 5.20 depict the regions that are currently unallocated. The 2.3 GHz band is a WiMAX profile band and has also been identified for IMT by the ITU. The current arrangements in this band provide sufficient flexibility to allow for the use of all technologies covered by the IMT standards.

Figure 5.20: Unallocated regions in the 2.3 GHz band (as at November 2008)



5.9.2 2009–2013

Issues affecting spectrum demand

Growth of WAS

Rapid growth in the use of both fixed and nomadic wireless access and mobile telephony services is predicted in the near future. The demand for WAS and the spectrum to support them is being driven by a number of factors[163], including:

- proactive policies by government that provide funding for projects, such as the *Australian Broadband Guarantee* and *Clever Networks* programs;
- limited access to high data rate services provided by larger operators in regional and remote areas, which has led to smaller BWA operators filling the void and calling for additional spectrum to be made available to facilitate the deployment of WAS;
- spectrum harmonisation, facilitating international roaming and the increasing availability of low cost standardised equipment. This is particularly important for Australia because it is predominantly an importer of technology rather than a manufacturer, and typically does not independently drive markets of scale or developments in technologies; and
- evidence of increased reliance on mobility, including the rise of 'anything, anywhere, anytime' models for advanced mobile telecommunications. Since mobile data services have far greater demand for spectrum than traditional voice services, it is expected that a combination of more spectrum and more spectrally efficient technologies will be required.

Current and emerging WAS technologies are capable of becoming key economic enablers[164]. To respond to the needs of a competitive and diverse Australian communications industry, sufficient spectrum should be available at the right time so as not to inhibit the deployment of these new technologies.

WAS applications range in bandwidth from voice applications, using transmission bandwidths in the order of several kHz, through to high speed internet and video, with bandwidths in the order of several MHz. Many technological advances, particularly in coding and compression, have increased the spectrum efficiency of wireless devices, but the evolutionary development trend for new functionality and user expectations continue to increase demands on bandwidth for customer access. While bandwidth requirements for wireline are also increasing, the wireless situation is greatly complicated by interference and competition for limited spectrum bandwidth.

Outcomes of WRC-07

Even though gains in spectrum efficiencies will offset demand to a degree, spectrum requirements are still expected to exceed current allocations. This is an issue which is continually being addressed by the ITU, most recently at WRC-07.

At WRC-07, the parts of the 450–470 MHz, 790–806 MHz[165] and 2300–2400 MHz bands allocated to the mobile service were identified for use by administrations wishing to

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[163] For further discussion on demand drivers for WAS, please see ACMA's February 2006 discussion paper *SPP 1/06—Strategies for Wireless Access Services*, http://www.acma.gov.au/webwr/_assets/main/lib100639/was_discussion_paper_feb_06.pdf.

[164] The Australian Mobile Telecommunications Association (AMTA) states that the mobile telecommunications industry directly contributes $6.5 billion to Australia's GDP, employs over 22 000 people, and increases the productivity of business in Australia.

[165] ITU *Radio Regulations* Article 5.317A—the parts of the band 790–960 MHz (in Regions 1 and 3) allocated to the mobile service on a primary basis are identified for use by administrations wishing to implement IMT. This identification extends down to 698 MHz in Region 2.

implement IMT in Australia's region (Region 3)[166]. Over 100 countries (not including Australia[167] or the US, but including nine Region 3 countries) identified all or part of the 3400–3600 MHz band for use by IMT. This proceeds from similar identifications made at previous WRCs, including 806–960 MHz, 1710–1885 MHz, 1885–2025 MHz, and 2110–2200 MHz; all or parts of each of these bands are currently used for GSM, 3G or BWA services.

The 2500–2690 MHz band was also identified for IMT use at WRC-2000 and has been identified as a candidate band for WAS in Australia. There is strong support from within the public telecommunications sector for making this band available for WAS for the provision of high speed mobile broadband services. However, this band is currently used for ENG in Australia (see Appendix A).

The 3575–3710 MHz (3.6 GHz) band has also been identified as a candidate band for WAS in Australia through the WAS consultation process, with both support from the public telecommunications sector and opposition from the satellite industry. ACMA plans to make arrangements to allow WAS in regional and remote areas in this band, while acknowledging that there will be a need to appropriately address the interests of incumbent users of that band (see Appendix A).

The 698/790–806 MHz band identified for IMT referred to as the 700 MHz band—lies within the 520–820 MHz UHF television broadcasting band in Australia. This spectrum is seen by proponents of WAS and law enforcement, defence and security agencies to have optimum characteristics for new broadband wireless services; with the possibility of high data rates to mobile terminals, longer propagation characteristics suitable for extension of services into regional areas, and superior building penetration in urban environments, along with the added consequent advantages of being able to utilise internationally harmonised spectrum. Telecommunications carriers and equipment manufacturers have expressed their desire for 100–150 MHz of contiguous spectrum, mainly within ~698–820 MHz.

In the lead up to WRC-11, there will be further investigations relating to spectrum sharing between the mobile service and the fixed and broadcasting services in the 790–862 MHz band (part of the current UHF TV broadcasting bands) in accordance with Agenda item 1.17 of WRC-11. ITU Working Party 5D 'IMT Systems' will also continue developing requirements for and evaluating candidates for IMT-Advanced (i.e. the next generation of IMT technologies).

Convergence

An aspect of radiocommunications particularly applicable to WAS is that of service convergence. In the context of WAS, this refers to a progressive blurring of the boundaries between the different technical categories of (for the most part):

- mobility (fixed, nomadic or mobile); and
- information (for example, voice or different levels of multimedia) and activity types (for example, conversational, streaming or interactive).

For example, internet connection was once limited to desktop PCs, but is now available on nomadic laptops as well as mobile phones, which were in turn once restricted to voice

[166] Region 3 includes Asia and Oceania (including Micronesia and the Marshall Islands in the North Pacific, along with the South Pacific as far east as 120ºW; that is, including French Polynesia but not Easter Island). 'Asia' extends as far west as Iran and Afghanistan, but to the north excludes all former Soviet Socialist Republics, the entire Russian Federation and Mongolia,

[167] A large portion of the band 3400–3600 MHz is currently spectrum licensed with technical frameworks suitable for the deployment of WAS in Australia (see Table 5.4).

communications. This has the potential for the existing regulatory distinctions between applications to appear arbitrary as new applications are developed. ACMA may need to review relevant regulatory instruments to ensure that any artificial and unnecessary roadblocks to converged services are avoided. However, the distinction between fixed and nomadic broadband services and mobile telephony services is expected to remain reasonably clear in the coming five year period.

Mobile telephony services

GSM mobile telephone usage is reaching saturation levels, with the current number of subscriptions exceeding Australia's adult population. However, significant growth is still expected with the increased uptake of 3G (and beyond-3G) services, as demand grows for the sharing of digital multimedia, mobile internet access and video streaming, as well as a range of other services. 3G telephone services are expected to dominate the market within the next five years; some industry analysts have speculated that the phase out of GSM could commence as soon as 2010. Optus and Vodafone plan to re-farm part of the 900 MHz spectrum they use to provide GSM in regional and rural areas to extend 3G HSPA[168] networks to these areas. However, GSM is likely to continue to be operated well into the future, at least as a low cost telecommunications solution for consumers.

Another example of the increasing importance of 3G mobile telephony and the converging radiocommunications environment is the extension of Telstra's Next-G network along railways to provide 3G based train communications as part of an agreement with the ARTC. This network is intended to provide interoperable communications across Australia's railways and possibly replace existing land mobile radio systems.

The trend for next generation technologies is for more spectrally efficient standards and larger bandwidths (in the order of 20–100 MHz) to support higher data rates and IP-based network architectures. The data rates of next generation technologies are expected to reach 100–1000 Mbps. The commercial release of these next generation technologies is expected as soon as 2010.

Previous consultation reveals that smaller internet service providers (ISPs) and regional operators tend to have a preference for implementing systems based on WiMAX technology. However, larger telecommunications carriers appear to have a preference for the 3GPP[169] evolution path towards Long Term Evolution (LTE). The main reason for this appears to be compatibility with existing core networks, in which there is already a significant investment in terms of infrastructure and equipment.

The main target bands for LTE are the 2.5 GHz band (2500–2690 MHz) and the 700 MHz band (within ~698–820 MHz digital dividend spectrum). The main bands being targeted by WiMAX initially are 2300-2400 MHz, 2500-2690 MHz and 3400-3600 MHz.

Broadband wireless access

In the past few years, there has been an exponential increase in the number of broadband internet subscribers. However, growth of fixed and mobile wireless broadband services has been hindered somewhat by the niche nature of these services, considering that wireline alternatives are well established in metropolitan areas and already serve the vast majority of

[168] HSPA (high speed packet access) is a collection of mobile telephony protocols including two existing standards, HSDPA (high speed download packet access) and HSUPA (high speed upload packet access). HSPA Evolution (or HSPA+) is a development of these standards that increases data rates.

[169] Third Generation Partnership Project—a collaboration agreement bringing together a number of telecommunication standards bodies. Its work includes producing globally-applicable technical specifications and reports for 3G mobile systems, as well as the maintenance and development of GSM.

broadband internet users. Historically, wireline also offers higher download rates at cheaper prices. Because of this, most of the growth in spectrum requirements for fixed and nomadic wireless broadband services is expected for regional and remote areas in the short term. In such areas, the limited revenue obtainable from the sparsely populated service areas[170] renders wireline broadband service provision unviable. In order to reduce costs, it is desired that individual sites cover the maximum area possible, which makes wireless data transmission at the lowest possible frequency the most cost effective solution.

Growth of BWA in metropolitan areas is also anticipated—noting the proliferation of hotspots in cafes and airports—and an ever increasing demand for always on/available mobile and nomadic connections. Voice-over-IP (VoIP) is expected to be a major driving application of wireless broadband, especially considering that some statistics show a significant proportion of mobile phone calls are made indoors and at hotspots[171]. One prediction claims that by 2010[172], mobile broadband could comprise two thirds of all broadband subscription around the world.

In addition to the recent and expected future growth of wireless broadband users, spectrum demand is also expected to be driven by rapidly increasing data rates. Over the next few years, increasing data rates are expected for broadband access, with the need to support the convergence of services such as HDTV, VoIP, video telephony, gaming and high speed internet.

Mobile television

Mobile television involves the transmission of television programming to mobile handsets. The main options for the delivery of mobile television are:

- unicasting to a particular user over the mobile telephony network (as Foxtel already does), which requires dedicated network capacity for each user; or
- multicasting[173] or broadcasting, both of which are independent of audience size.

While unicasting or multicasting over mobile telephony 3G networks has the advantage of using infrastructure that is already established, there is insufficient capacity to serve a large audience. This could be satisfied by a broadcasting network, but its construction would incur large infrastructure establishment costs.

As explained in section 5.2.2, Channel B (one of two currently unassigned national channel sets) could potentially be used for mobile television broadcasting. Industry feedback regarding mobile television also identified the suitability of 1452–1492 MHz due to international discussions on this band. Mobile television could be implemented with DVB-H, which can deliver between 20 and 40 video channels on a single 7 MHz television channel. Other competing technologies in the mobile television market are Digital Multimedia Broadcast (DMB), MediaFLO (forward link only) and Multi-Broadcast Multimedia Service (MBMS).

Regulatory arrangements

ACMA aims to provide technology flexible licensing arrangements that give the government a return for use of a community resource, especially in highly populated areas, without

[170] For example,performance of an ADSL line becomes unacceptable after only about 4 km.
[171] Gao Jing, Huawei Technologies, 2006, *VCC, a solution of FMC Dual-Mode Handover,* Leading Edge, Issue 25, www.huawei.com/publications/viewRelated.do?id=1146&cid=1802,
[172] AMTA's response to the draft *Five year-Spectrum Outlook 2009–2013*, http://www.acma.gov.au/WEB/STANDARD/pc=PC_311369
[173] Multicasting is the transmission of data to a controlled set of users in a network.

delaying the deployment of WAS in regional and remote Australia. More flexible arrangements may also encourage and result in increased secondary markets (spectrum trading).Traditionally, interference is managed under apparatus or spectrum licensing by allowing each user an exclusive frequency band at a site or over an area respectively.

The challenges of licensing WAS include:

- achieving appropriately balanced pricing and delivery mechanisms across the country;
- making spectrum as widely available as possible while avoiding the 'tragedy of the commons'—unfettered use that can occur under class licensing—that can make the band less than ideal for some services;
- ensuring opportunities for new carriers to compete with established telecommunications carriers, particularly in regional areas; and

These issues are addressed to varying degrees by the radiocommunications licence types currently available (class, spectrum and apparatus). Each licence type has its own benefits and limitations, depending on the intended application[174].

Industry consultation suggests that improved regulatory arrangements may be needed to better support the continued and future operation of WAS.

Spectrum demand estimates

There is currently a total of 593 MHz (not including class licensed bands) of spectrum allocated to WAS in Australia; 213 MHz for fixed and nomadic wireless access and 380 MHz for mobile telephony services. Current indicators suggest that additional spectrum will be required over the coming years in order to meet demand.

The amount of spectrum required for future WAS will be influenced by the use of paired FDD (frequency division duplex) and unpaired TDD (time division duplex) spectrum. While current systems, particularly for mobile telephony, have similar levels of downlink and uplink traffic, they are likely to continue using FDD. TDD is considered favourable by some for BWA applications, for which traffic is typically asymmetric.

Previous consultation has indicated that smaller ISPs and regional operators are in favour of using TDD technologies due to such asymmetric data rates and lower system costs. However, industry feedback also indicates that upload traffic is also increasing, particularly with the growth of user generated content and peer-to-peer networking. Some stakeholders stipulate that technology flexibility is important to maintain in technical and licensing arrangements.

One of ACMA's roles is to promote competition in the communications industry. To pursue this role, ACMA is seeking to make spectrum access arrangements for WAS to allow for a number of potential operators. These considerations, along with Australian and international statistics on data traffic types, data rates, session durations and arrival rates, and population, have led to estimates that more spectrum will be required for WAS within the next five years.

It is estimated that spectrum requirements in metropolitan areas will be split relatively evenly between mobile telephony and BWA services. In regional areas, mobile telephony requirements may be significantly less and requirements for BWA services may be slightly

[174] For further discussion on the licence types, please refer to the February 2006 ACMA discussion paper *SPP 1/06—Strategies for Wireless Access Services*; available at: http://www.acma.gov.au/webwr/_assets/main/lib100639/was_discussion_paper_feb_06.pdf.

higher. However, the distinction between mobile telephony and BWA services will continue to blur over this period.

ACMA's proposed approaches

Planning for future WAS spectrum allocations

ACMA plans to undertake a number of steps in the medium term, in response to its review of spectrum options for meeting demand for WAS. The approach will have an initial focus on spectrum for BWA services in regional areas.

The key components of ACMA's medium term approach include (see Appendix A for further details):

- develop an early solution for users of BWA services in regional areas using spectrum in the 3.6 GHz band (3575-3700 MHz), while acknowledging that there will be a need to appropriately address the interests of incumbent users of that band;
- review the planning and licensing arrangements in the 2.5 GHz band to determine how the band can be planned and allocated to permit maximisation of the overall benefit derived from that spectrum. The review will have the twin objective of delivering suitable long term arrangements for electronic news gathering services, whether in the 2.5 GHz band, in other bands or in combinations of bands, so as to resolve the current uncertainty around spectrum arrangements for electronic news gathering.

The 700 MHz band is currently under review as part of the digital dividend process, and any decision on the future use of this band is for the Minister to make (see Chapter 4 and 5.2).

ACMA will need to continually monitor demand and trends for WAS both locally through internal research, consultation and modelling, and internationally by studying developments in organisations such as the APT, the ITU and the European Conference of Postal and Telecommunications Administration (CEPT); standards organisations such as 3GPP, 3GPP2, WiMAX Forum and UMTS Forum; and administrations such as Ofcom and the FCC[175]. As technologies evolve, the spectrum demands also change; for example, although 4G technologies are likely to be scalable to lower bandwidths, they will require approximately 20–100 MHz in order to realise their full potential.

Globally or regionally harmonised spectrum is preferred for WAS due to its global roaming abilities and the economies of scale it offers operators and consumers. However, in Australia (as elsewhere in the world) there are a large number of existing services in bands targeted for WAS applications. These existing services will need to be considered when determining possible future arrangements for WAS. As spectrum becomes increasingly congested and contested by various services, strategies for these services to coexist and share spectrum will become increasingly important. Some solutions will be provided for in the future by new technologies such as software-defined radio (SDR) or cognitive radio (see 5.9.3); however, many solutions will need to be developed through regulatory arrangements.

Such activities require time to perform appropriate sharing studies, consult with industry and develop transitional arrangements. The allocation of some bands to WAS may take several years due to various technical and incumbency issues; forward planning is therefore essential. Some bands have complex incumbency issues and the need to continue to support

[175] Ofcom (Office of Communications) and the FCC (Federal Communications Commission) are the respective communications regulatory administrations of the UK and the US.

existing services means that consideration of a number of bands rather than a single band in isolation may be required.

Re-farming spectrum as old technologies are phased out—for example, GSM—may offer some spectrum in the future to more spectrally efficient technologies. However, the amount may not satisfy demand for spectrum. The timing of any re-farming will also be important, as there can be significant social, political and economic consequences of such moves (as can be seen from Telstra's 2008 CDMA network switch off in the 850 MHz band).

Regulatory arrangements

The creation of a new licence framework and associated subordinate legislation that combines the characteristics of each of the existing licences types may provide the necessary flexibilities to accommodate WAS into the future. ACMA is currently investigating such a concept—called the 'private park'.

Conceptually, private park spectrum would be similar to class licensing arrangements for the 2.4 and 5.8 GHz bands. Each licensee could use the entire spectrum band and interference would be controlled by specifying conditions of use[176]. Limits would be needed to prevent overpowering and to ensure efficient re-use of the spectrum. These limits could be regionally specific; that is, different for each designated density area so as to recognise the need for more power in areas of dispersed population. Limits on the number of operators licensed to operate in an area or portion of spectrum would also be required in order to manage interference and improve service reliability. A framework for allocating these licences and preventing anti-competitive conduct would need to be developed.

Promoting efficient use of spectrum

As the demand for bandwidth from numerous services increases, the availability of spectrum decreases, especially in the highly contested region below 6 GHz. As the radiofrequency spectrum is a limited resource, it needs to be managed to ensure its most efficient use. There are various ways ACMA can promote the efficient use of the spectrum, including:

- creating incentives such as lower licence fees for using higher performance, spectrally efficient equipment, or offering higher levels of protection from interference for highly sensitive services to locate in low demand areas; and
- providing arrangements both in the framework of the licence as well as in the size of spectrum lots that allow the flexibility for the most efficient use of a particular technology.

[176] It is predicted that in the future, devices will have the capability to avoid interference automatically through techniques such as dynamic frequency selection and contention-based protocols. A private park would lend itself to the operation of these types of devices.

5.9.3 BEYOND 2013

Different WAS applications and services will continue to converge in the future. Broadband access will become increasingly more mobile, particularly with the development of the IEEE 802.20 standard on MBWA[177], which defines a packet based air interface for IP-based services.

Some spectrum will become available following the phase out of GSM, but the amount may not significantly ease the demand for additional spectrum allocations for WAS. However, this will depend on the take up of specific services by users, and the subsequent market demand and growth.

Dynamic Spectrum Access Technologies

Dynamic Spectrum Access (DSA) is a term used to describe technologies that are designed to operate in vacant spectrum that is not being used in a particular area or at a particular point in time. While these technologies operate at power levels that could cause interference to primary users, the constant monitoring of the DSA device's environment allow it to dynamically move its transmission to other 'unused' frequencies to minimise interference.

Software defined radios (SDR) and cognitive radio are two important concepts that could enable and maximise the utility of DSA in wireless communications. SDRs are radios in which the RF operating parameters can be set or altered using software, and provide the platform for DSA technologies. Cognitive radios are, in addition to basic DSA capabilities, envisioned to have machine learning capabilities, allowing them to detect the user's communications needs, be aware of the radiocommunications environment and provide the optimal radio resources.

Arrangements to address spectrum management issues associated with these technologies may be the subject of further work by ACMA in the future. WRC-11 Agenda item 1.19 is to consider regulatory measures that will be required to enable the introduction of SDR and cognitive radio.

[177] MBWA is mobile broadband wireless access.

6 Indicative work programs

This chapter contains ACMA's indicative spectrum management work programs for the 2009–2013 timeframe. The first work program contains spectrum management tasks and projects presented on a band-by-band basis. The work program is based on the assessment of future spectrum requirements of services contained in Chapter 5, and also includes ACMA's current spectrum management projects (see Appendix A for details). The second work program contains some of ACMA's significant spectrum management projects, as well as spectrum management tasks that are not attributable to specific frequency bands (Chapter 4 contains details of three of these projects). Incorporated within both work programs are projects of long term standing that arose in response to previous government decisions.

As ACMA considers each of the projects listed in the work programs, it will be guided by the spectrum management principles discussed in section 2.2. A key theme of the principles is to optimise the use of regulatory and market mechanisms to maximise public benefit. The principles include allocating spectrum to its highest value use, enabling and encouraging users to move spectrum to its highest value use or uses, providing flexibility and certainty, minimising cost and restrictions and balancing the cost of interference with the benefits of spectrum utilisation.

The timings in the work programs indicate when ACMA currently expects to commence work on each task or project. The timing and priority specified for each task or project is indicative only and is subject to adequate government resources, future changes to government priorities, and changing demands due to new issues that may emerge over time.

The timeframes can be interpreted as follows:

- sort term: within the next 12 months;
- medium term: within the next one to three years; and
- long term: within the next three to five years.

The work programs are living documents that will be constantly reviewed to ensure their relevance to current trends in radiocommunications. This will include regular updates of the timeframes and priorities for each task and project to ensure they reflect current demand.

Based on these indicative time frames, Table 6.3 includes the work which ACMA expects to undertake in 2009. Only a brief description of each project is provided, and more detail on each item can be found in the preceding Tables 6.1 and 6.2, or in some cases, in Appendix A.

Table 6.1: Indicative spectrum management work program (band-by-band basis)

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
MF	526.5–1606.5 kHz (MF-AM band)	Possible congestion in the MF-AM band.	Some alleviation may be achieved through the possible introduction of DRM digital radio, which may include channel replanning. ACMA will continue to support digital radio trials.	Long/Low	Review of merits of digital radio technologies and market demand/viability of particular technologies.
HF	25670–26100 kHz	Industry proposals to introduce DRM into this band.	Spectrum Embargo 44 is intended to preserve planning options. ACMA will consult with industry to canvass interest in the possible use of DRM technology.	Medium/Low	• Responses to discussion paper. • Level of competition for this spectrum. • Review of merits of digital radio technologies and market demand/viability of particular technologies.
	-	Development and increasing use of digital maritime HF data services, possibly requiring identification of additional spectrum allocations for future use. Relevant WRC-11 Agenda item: 1.9	ACMA will continue to monitor the progress of HF data services and relevant technology developments. Options for planning arrangements will be assessed when spectrum requirements are known.	Medium/Low	• International developments. • WRC-11 outcomes.
	-	ACMA has been approached to facilitate the trialling of HF surface wave radars. Relevant WRC-11 Agenda item: 1.15	ACMA will continue to facilitate HF surface wave radars through temporary arrangements. The development of permanent arrangements is dependent on the outcomes of WRC-11.	Medium/Medium	• International developments (proposed. frequency bands) • Compatibility with existing services. • WRC-11 outcomes.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
VHF	45–52 MHz and 56–70 MHz (VHF Band I) and 87.5–108 MHz (VHF Band II)	Switch off of analog television in VHF Bands I and II as part of the digital switchover process.	The Minister has proposed to switch off analog services in a staged process, from 2010 until 2013. Final decisions regarding digital switchover are made by the Minister, however ACMA will assist with this work, where appropriate. ACMA is currently involved in assessing digital coverage to ensure an equivalent level of service post switchover; and monitoring the nationwide roll out of digital television infrastructure.	Short/High	• Government policy formulation and decisions regarding the switchover timeline. • Rollout of digital television in VHF Band III and UHF Bands IV and V.
		Introduction of digital radio broadcasting in VHF Bands I or II	ACMA will continue to monitor the development of different digital radio technologies. ACMA will continue to support digital radio trials, and assist government where appropriate in its policy formulation (as above).	Long/Medium	• Review of merits of different digital radio technologies. • Government policy formulation and financial support. • Demand for non-commercial and regional radio broadcasting services.
		Competing demands in VHF Band I from different services and spectrum users to operate in the vacated spectrum after digital television transition is complete.	Policy development relating to digital switchover and future use of the spectrum once vacant rests with the Minister. Where appropriate, ACMA will be ready to assist in this work; namely by gathering information on spectrum demands of potential alternative uses.	Medium/Medium	Government policy formulation.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
VHF	87.5–108 MHz (VHF-FM band)	Congestion in the VHF-FM band.	Possible reduced pressure in the band through the introduction of digital radio (T-DAB) in other bands. Some alleviation may be possible in some areas following digital television switchover. In addition, consideration is being given to the future reduction of channel spacing.	Long/Low	• Digital switchover. • T-DAB take up.
	108–117.975 MHz	Allocated to the AM(R)S on a primary basis at WRC-07 for LOS applications, including RNSS signal corrections.	ACMA will consider the impact of the introduction of AM(R)S on existing services. In particular, sharing studies between AM(R)S and VHF-FM band radio broadcasting services are needed.	Medium/Low	• Compatibility between GBAS/GRAS correction signals and FM broadcasting. • International sharing studies. • International deployment of technology.
	117.975–137 MHz	VHF aeronautical mobile band congestion overseas, which may intensify with the growth in aircraft traffic.	Additional primary allocations made to the AM(R)S at WRC-07 are intended to alleviate congestion. However, ACMA first needs to consider the impact of the introduction of AM(R)S on existing services.	Long/Low	• International sharing studies. • International deployment of technology. • Compatibility with existing services.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
VHF	174–230 MHz (VHF Band III)	Introduction of T-DAB—VHF channel 9A in mainland state capital cities, but there is limited spectrum availability for regional areas, particularly those close to capital cities.	Channel plans and frameworks for licensing of initial multiplexes and transmitters have been determined. ACMA will continue to facilitate T-DAB trials. Deployment of T-DAB in regional areas requires further consideration by ACMA and government, following a government review to occur by 2011. Digital television switchover may create opportunities for T-DAB. Where appropriate, ACMA will assist government in the formulation of relevant policy.	Short/High	• T-DAB introduction by July 2009. • T-DAB take up in cities. • Demand for T-DAB in regional areas. • Government policy formulation.
		Switchover from analog to digital television broadcasting.	The Minister has proposed to switch off analog services in a staged process, from 2010 until 2013. Final decisions regarding digital switchover are made by the Minister, however ACMA will assist with this work, where appropriate. ACMA is currently involved in assessing digital coverage to ensure an equivalent level of service post switchover; and monitoring the nationwide roll out of digital television infrastructure.		

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
VHF	174–230 MHz (VHF Band III)	Digital dividend—Benefits and opportunities are expected to arise following the conversion from analog to digital television. Analog switch off will leave significant amounts of spectrum vacant in this range.	Final decisions regarding digital switchover and future use of the spectrum once vacant are made by the Minister. However, however ACMA will assist with this work, where appropriate.	Medium/High	• Government policy formulation. • Public benefit that can arise from the use of spectrum by potential candidates for digital dividend.
UHF	403–520 MHz (400 MHz band)	Spectrum congestion in fixed and land mobile service segments in major capital cities. Assigned but unused/lightly used channels. Growing need to provide spectrum for more spectrally efficient technologies. Proposed consolidation of government spectrum. Identification of 450–470 MHz for use by IMT at WRC-07.	ACMA released a public consultation paper in April 2008 that explores options for replanning the way the 400 MHz band is used, with the overall goal of facilitating more access. This paper considered, among other things, re-channeling to narrower bandwidths, changes to licensing arrangements to reduce inefficient channel usage, and the accommodation of new technologies and trunked networks for more efficient spectrum use.	Short/High	• Further planning subject to responses to ACMA discussion paper. • Suitable timeframes to implement changes. • Costs incurred by users as a result of such changes • Suitability of available. technologies • Feasibility of alternative bands for users (in the interim).
	448–450 MHz	Indication of BoM plans for increased use of wind profiler radars.	ACMA will liaise with BoM on future requirements for wind profiler radars.	Long/Low	BoM requirements.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
UHF	520–820 MHz (UHF Bands IV and V)	Channels A and B — Planned but currently unassigned television broadcasting channels that ACMA is assembling into national packages in preparation for a price based allocation.	Allocation of Channels A and B is dependent on the finalisation of the Government's position on relevant technical and policy settings.	Short/High	Government decision.
		Switchover from analog to digital television broadcasting.	The Minister has proposed to switch off analog services in a staged process, from 2010 until 2013. Final decisions regarding digital switchover are made by the Minister, however ACMA will assist with this work, where appropriate. ACMA is currently involved in assessing digital coverage to ensure an equivalent level of service post switchover; and monitoring the nationwide roll out of digital television infrastructure.	Short/High	• Government policy formulation and decisions regarding the switchover timeline. • Technical implications of digital transmissions and receivers that affect coverage.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
UHF	520–820 MHz (UHF Bands IV and V)	Digital dividend—Benefits and opportunities are expected to arise following the conversion from analog to digital television. Analog switch off will leave significant amounts of spectrum vacant in this range.	Final decisions regarding digital switchover and future use of the spectrum once vacant are made by the Minister. However, however ACMA will assist with this work, where appropriate.	Medium/High	• Government policy formulation. • Public benefit that can arise from the use of spectrum by potential candidates for digital dividend.
	820–960 MHz (900 MHz band)	Spectrum congestion in fixed and land mobile service segments. Poor use of bands allocated for CT2, CT3 and DSRR systems; bands are currently embargoed.	ACMA will commence examination of the 900 MHz band after replanning of the 400 MHz band is well underway. Advantage may be taken of the poorly utilised CT2, CT3 and DSRR bands to increase spectrum availability for fixed links and land mobile systems. ACMA is currently applying annual licence tax increases to fixed services in order to ease congestion and bring licence fees closer to market valuations.	Medium/Medium	• Current consultation on planning options for the 400 MHz band. • Clearance of CT2, CT3 and DSRR bands. • Level of competing demands. • Available alternatives for competing users.
L-band	960–1164 MHz	Allocated to the AM(R)S on a primary basis at WRC-07 for LOS communications.	ACMA will consider the impact of the introduction of AM(R)S on existing services. In particular, sharing studies between AM(R)S and ARNS and adjacent band GNSS are needed. No AM(R)S systems (apart from UAT) may operate prior to their completion.	Long/Low	• International sharing studies. • International deployment of technology.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
L-band	1164–1610 MHz	Growth of GNSS—Introduction of Galileo, QZSS and Compass, along with other regional positioning systems and augmentation systems.	ACMA plans to continue to accommodate GNSS in this spectrum, and holds the position that GNSS should not be constrained by other services in this band. ACMA will continue to monitor international policy and technological developments.	Medium/Medium	• Deployment of Galileo, replenishment of GLONASS, modernisation of GPS. • International developments (augmentation systems).
		Interference concerns between Defence's JTIDS and Galileo	ACMA is working to facilitate communications between Defence and the EC to resolve potential interference issues.	Medium/Medium	Deployment of Galileo.
	1452–1492 MHz	Possible use by digital radio (T-DAB) for in fill transmissions and regional coverage.	ACMA may revise the *1.5 GHz Band Plan* to permit the operation of planned T-DAB services and provide arrangements for clearance of incumbent users in the band. Planning in the band will also consider the potential future use by satellite digital radio and other services. ACMA will continue to facilitate T-DAB trials.	Medium/Medium	• Subject to Government decisions regarding digital radio and the *1.5 GHz Band Plan.* • T-DAB (VHF) take up and regional area demand. • Government policy formulation and financial support. • Satellite digital radio provisions. • Clearance of incumbents. • Market feasibility of multi-band receivers.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
	1518–1544 MHz/ 1626.5–1675 MHz (L-band extension bands [1518–1525 MHz/ 1668–1675 MHz] and MSS down/uplink [1525–1544 MHz/ 1626.5–1660.5 MHz])	Possible introduction of MSS systems, in particular for the satellite component of IMT (identified at WRC-07).	Introduction of MSS would require revision of the *1.5 GHz Band Plan* to permit MSS systems and clearing of incumbent users in the 1525–1535 MHz band. ACMA plans to continue to protect DRCS/HCRC in the 1518–1525 MHz band, and the protection of 1660–1670 MHz RAS and 1668–1668.4 MHz SRS will be considered. ACMA will monitor demand in these bands for MSS.	Medium/Medium	• Revision of the *1.5 GHz Band Plan.* • International MSS satellites planned to cover Australia. • Introduction of Australian MSS systems. • Compatibility with existing services.
S-band	1980–2010 MHz/ 2170–2200 MHz and 1610–1626.5 MHz/ 2483.5–2500 MHz	Increased interest in mobile television and MSS systems (possibly including ATC).	ACMA will continue to monitor national and international demand for MSS systems and satellite delivery of mobile television. In the case that an MSS system is introduced, consideration will need to be given to the effects of such a system on co- and adjacent band services.	Medium/Low	• International MSS satellites planned to cover Australia. • Introduction of Australian MSS systems. • Compatibility with existing and potential future services.
	2302–2400 MHz (2.3 GHz)	Spectrum is available for WAS in several regional areas.	ACMA will allocate residual spectrum via a price based allocation process..	Short/Medium	

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
	2500–2690 MHz (2.5 GHz band)	Current planning and licensing arrangements for the band are unlikely to support its efficient allocation and use into the future.	ACMA will review current planning and licensing arrangements with a view to maximising the overall benefit derived from the use of the band. The review will have the twin objective of delivering suitable long term spectrum arrangements for ENG services, whether in the 2.5 GHz band, in other bands or in combinations of bands, so as to resolve the current uncertainty around spectrum arrangements for the service.	Short/High	• Sharing studies. • Outcomes of ACMA consultation process. • Further consultation with broadcasters and other stakeholders. • Development of long term arrangements for ENG.
	2700–2900 MHz	Assignment coordination difficulties between radar operators.	ACMA will work with Defence, Airservices Australia and BoM to establish spectrum sharing agreements. ACMA will investigate the need to develop further spectrum planning guidelines for future use of the band by radars.	Medium/Medium	Consultation processes.
S-band	2900–3100 MHz	Increased use of S-band maritime radar and possible replacement of racon technology.	ACMA will monitor the deployment of maritime radars and the developments of non-magnetron radars, and will consult with AMSA regarding the continuation of racons after 2013.	Long/Low	• Technology developments overseas. • Growth of radar deployment.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
C-band	3575–3700 MHz (3.6 GHz band)	Proposed introduction of BWA in regional and remote Australia through apparatus licensing arrangements; incumbent FSS Earth station operators are concerned that suitable coordination arrangements with WAS are developed to ensure adequate protection of their services.	ACMA plans to: • establish, through industry consultation, protection and coordination criteria; • modify Embargo 42 to allow BWA in regional and remote areas; • modify Embargo 42 to allow FSS Earth stations in regional and rural areas one year after the band is open to WAS; • review the status of fixed P-P services after two years. Further planning work on 3.6 GHz band in major city areas will be deferred until after the demand for WAS in regional areas has been addressed. Existing licensed FSS Earth stations will continue to be protected during this time.	Short/High	• Consultation with potential WAS operators and FSS Earth station operators. • Development of suitable licensing and coordination criteria. • Development of suitable major city exclusion areas. • Subsequent demand for spectrum for WAS and FSS when embargo is lifted.
C-band	4033–4042 MHz	Introduction of FengYunCast, a satellite-based data dissemination system that will transmit to the Asia-Pacific region. Its operating frequency falls within a heavily used fixed service band and the standard C-band satellite downlink band.	ACMA will liaise with BoM on the future planning of Earth stations for FengYunCast. Protection of fixed links and future options in the 3.8 GHz band will be considered.	Medium/Low	BoM spectrum requirements and Earth station plans.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
C-band	4940–4990 MHz (4.9 GHz band)	Potential use by public protection and disaster relief (PPDR) organisations for broadband data applications.	ACMA will undertake a consultation process to assist the development of appropriate spectrum management processes to support use of the band by public safety applications.	Short/Medium	• Consultation with Defence and other stakeholders. • Band/ channellling arrangement options for PPDR.
	5091–5150 MHz	Allocated to the AM(R)S on a primary basis at WRC-07 for surface applications at airports, aeronautical telemetry and security related transmissions.	ACMA will consider the effect of the introduction of AM(R)S on existing services, including the impact on Globalstar feeder links. Sharing between possible future AM(R)S systems and the FSS should be possible by adhering to the provisions of Resolutions 418, 419 and 748.	Medium/Low	• International sharing studies. • International deployment of technology. • Coordination with Globalstar Earth stations.
	5600–5650 MHz	BoM is concerned about the introduction of class licensed RLANs and the interference potential to its weather radars.	ACMA believes that sharing between RLANs and weather radars based on international arrangements is possible. However, ACMA will proceed carefully in the implementation of RLANs sharing this band to minimise the likelihood of interference, and will monitor the outcomes of sharing overseas.	Short/Medium	• Success of sharing overseas. • Level of proliferation of RLANs.
	5850–5925 MHz (5.9 GHz band)	Introduction of intelligent transportation systems (ITS), possibly by 2010.	Embargo 48 currently protects options for the future use of this band. ACMA is currently awaiting input from industry to progress the development of spectrum access and licensing arrangements. ACMA will consult with stakeholders prior to establishing any such arrangements.	Short/Medium	• Industry submissions. • Protection of incumbents. • Technological developments. • Feasibility of implementation in automobiles/ infrastructure.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
	5850–7075 MHz	The identification of spectrum for gateway links for HAPS, under WRC-11 Agenda item 1.20.	ACMA is currently monitoring HAPS developments with a view to forming a position for WRC-11.	Medium/Low	• Requirements of gateway proponents. • Sharing studies.
X-band	9300–9500 MHz	Increased use of X-band maritime radar and possible replacement of racon technology.	ACMA will monitor the deployment of maritime radars and the developments of non-magnetron radars, and will consult with AMSA regarding the continuation of racons after 2013.	Long/Low	• Technology developments overseas. • Growth of radar deployment.
X-band	10.6–10.68 GHz	Reported interference to the EESS from fixed links.	Sharing criteria were established at WRC-07 to limit potential interference. Final arrangements to protect passive services in the band will be documented and formalised by ACMA in the near future, following the additional formal consultation required to implement the changes.	Short/Medium	• Outcome of consultation process. • Possible changes to technical and operating requirements in RALI FX3.
Ku-band	10.7–11.7 GHz (11 GHz band)	The deployment of Earth station receivers and the protection of future options for the use of this band by the fixed service and other terrestrial services.	ACMA will maintain its policy to not support the ubiquitous, uncoordinated deployment of Earth station receivers in bands shared with terrestrial services.	N/A/ Medium	• Alternatives for the fixed service. • Consultation with satellite operators.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
Ku-band	13.75–14.0 GHz	Some interest in simplified licensing arrangements in the band, which still satisfies current international sharing arrangements.	Any consideration of revision to licensing arrangements would first require consultation with interested and affected stakeholders in the band.	Long/Low	Results of consultation.
	14.40–14.83 GHz / 15.15–15.35 GHz	Introduction of Defence common data link (CDL) systems—spectrum is currently used extensively by fixed links and FSS.	ACMA will work with Defence and other government users to identify appropriate whole of government approaches to support use of the band by CDL systems while maintaining access for existing and future fixed and satellite services. ACMA will also work with Defence to explore options for customised CDL systems that maintain interoperability with overseas systems, but are better suited to Australian spectrum arrangements.	Short/Medium	• Technological developments overseas. • Feasibility of customising systems for Australia. • Demand for CDL from other government agencies. • Compatibility with fixed links and Earth stations.
	15.7–16.6 GHz	Use of this band for the operation of ASDE overseas; possible interest for future use in Australia. This band is designated to be used principally for the purposes of defence.	ACMA will continue to monitor ASDE developments and its possible future introduction in Australia. Any future introduction of ASDE would require prior consultation with Defence.	Long/Low	• International developments. • Airservices Australia and Defence requirements.

Frequency band		Issue	Proposed approach	Timing/ACMA priority	Dependencies
Ka-band	21.4–22 GHz	Increasing level of interest internationally in HDTV satellite broadcasting at Ka-band frequencies. Relevant WRC-11 Agenda item: 1.13.	ACMA will monitor international developments in HDTV satellite broadcasting in this band. ACMA will also monitor demand in Australia for this purpose, which may involve public and industry consultation.	Medium/Medium	Demand and plans for satellite delivery of HDTV to Australia.
Ka-band	23.6–24 GHz (24 GHz band)	Sharing issues between automotive UWB short range radar (SRR) and the EESS and RAS.	Sharing with RAS facilitated by separation distances, antenna elevations and terrain shielding. Exclusion zones have been established around licensed RAS facilities. ACMA considers the density of SRRs required to cause harmful interference to the EESS will not occur in the short to medium term. In addition, a migration to 79 GHz SRRs is expected within the next 10 years.	N/A/ Low	• International developments (automobile industry and European Commission). • Success of sharing in Australia.
	27.9–28.2 GHz/ 31 – 31.3 GHz and 47.2–47.5 GHz/ 47.9–48.2 GHz	Possible introduction of HAPS. Relevant WRC-11 Agenda item: 1.20.	ACMA supports the future deployments of HAPS provided that work, including detailed sharing studies, is undertaken to ensure the successful cohabitation of HAPS with other services.	Long/Low	• Technological developments overseas. • Plans to implement HAPS in Australia.
EHF	77–81 GHz (79 GHz band)	Possible introduction of automotive 79 GHz UWB SRR in Australia.	ACMA will monitor developments in 79 GHz UWB SRR through consultation with peak groups, and will liaise with potentially affected users as appropriate.	Long/Low	International developments (automobile industry and European Commission).

Table 6.2: indicative work program—significant spectrum management projects and other spectrum management tasks

Project/issue	**Proposed approach**	**Timing/ priority**	**Dependencies**
Independent Review of Government Spectrum Holdings (IRGSH)	ACMA is considering the outcomes of the final IRGSH report and addressing recommendations in a number of ongoing projects, and in consultation with stakeholders will seek to improve the effectiveness and transparency of the management of government spectrum holdings. This is likely to include the development of a government spectrum management strategic plan consistent with the spectrum management principles outlined in Chapter 2. ACMA released the final IRGSH report and its preliminary responses to the report in April 2008.	Short/High	Some identified issues outside the scope of ACMA—refer issues to relevant agencies.
Expiring spectrum licences	ACMA will: • work closely and assist with the DBCDE to ensure all relevant issues are considered; • examine options for pricing and licensing arrangements and allocation methodologies: • be guided by the spectrum management principles set out in section 2.2: • initiate timely review of each band where there are expiring spectrum licences: • consult with a wide range of stakeholders to promote transparency and accountability of decision making; • inform incumbent licensees of the processes and criteria well ahead of expiry of the licences; and • take into account all relevant factors, including the approaches adopted by other leading spectrum regulators in managing expiring spectrum licences.	Medium/ High	Ministerial decisions.

Project/issue	Proposed approach	Timing/ priority	Dependencies
Siting of Earth stations in areas of high spectrum demand (such as urban areas).	ACMA supports the deployment of Earth stations in less populated areas where spectrum demand is low, but recognises that this needs to be balanced against issues such as the cost to Earth station operators. Extensive consultation with stakeholders is required to address this issue.	Short/High	• Demand for alternate services (e.g. WAS, fixed links). • Consultation with satellite operators.
Technological developments and trends in the EESS and SRS.	ACMA will continue to monitor the development of radiocommunications technologies for Earth observing and deep space missions.	Long/Low	International developments (NASA and ESA).
Proposed e-Navigation network for maritime services.	ACMA will monitor its development and consider its spectrum requirements when more information is available.	Long/Low	International development of standards, technologies and protocols.
TFTS for the provision of in flight telephony services.	ACMA has proposed to allow TFTS—that is, the possession and installation of in flight mobile phone systems by Australian airlines for domestic and international flights. Appropriate licensing arrangements would need to be made to support the introduction of TFTS.	Long/Low	Industry enquiries and assignment applications.
Increased use of UAVs is expected over the next decade.	In the short to medium term, ACMA will investigate the demand for military and civilian UAVs as it arises. Agenda item 1.3 of WRC-11 is to determine allocations for remote flight command and control and ATC communications relay. The introduction of satellite communications systems for UAVs in the band 5000–5150 MHz is one area of study.	Medium/ Medium	• Defence developments. • Development of civilian applications. • WRC-11 outcomes.
The proposed use of low power UWB devices indoors and concerns about the interference potential.	ACMA is currently developing a public discussion paper to seek comments on proposed regulatory arrangements for indoor short range ubiquitous UWB applications. ACMA expects the paper to be released in mid 2009.	Short/ Medium	• Outcome of consultation process. • Sharing studies.

Table 6.3 contains a summary of work that will be undertaken in 2009 in order to address several of the issues in Tables 6.1 and 6.2 above. Refer to these tables for further detail on

the ACMA's approaches and other variables that may have a significant influence on the course of the project.

Table 6.3: Projects to be undertaken in 2009

Frequency band		**Project**
HF	25670–26100 kHz	Consultation with industry to canvass interest in the possible use of DRM technology.
VHF	45–52 MHz and 56–70 MHz (VHF Band I) and 87.5–108 MHz (VHF Band II)	Tasks to assist the government that are related to the switch off of analog television in VHF Bands I and II as part of transition to digital television broadcasting in Australia.
		Tasks to support the government that are related to options for the future use of spectrum vacated after analog services are switched off.
	174–230 MHz (VHF Band III)	Introduction of T-DAB—development of options for improved coverage for metropolitan areas, and consideration of options for deployment in regional areas.
		Tasks to assist the government that are related to digital switchover including coverage testing and monitoring infrastructure rollout.
		Tasks to support the government that are related to options for the future use of digital dividend spectrum.
UHF	403–520 MHz (400 MHz band)	Spectrum access in the 400 MHz band—continued public consultation on increasingly refined options for replanning and facilitating more access to the band.
	520–820 MHz (UHF Band IV and Band V)	Tasks to assist the government that are related to digital switchover including coverage testing and monitoring infrastructure rollout.
		Tasks to support the government that are related to options for the future use of digital dividend spectrum.
L-band	1164–1610 MHz	Continued support for the introduction and growth of GNSS.
		Facilitate communications between Defence and the EC to resolve potential interference issues between JTIDS and Galileo
S-band	2302–2400 MHz	Allocate residual spectrum in the 2.3 GHz band.
	2500–2690 MHz (2.5 GHz band)	Review of current planning and licensing arrangements in the 2.5 GHz band, and the development of suitable long term spectrum arrangements for ENG services.
C-band	3575–3700 MHz (3.6 GHz band)	Facilitate the introduction of WAS in regional and remote Australia through coordination and licensing arrangements.
C-band	4940–4990 MHz (4.9 GHz band)	Consultation regarding the use of the 4.9 GHz band by public protection and disaster relief (PPDR) organisations for broadband data applications.
	5850–5925 MHz (5.9 GHz band)	Development of spectrum access and licensing arrangements to facilitate the introduction of intelligent transportation systems (ITS).

Frequency band	Project
	Consultation on review of planning arrangements for microwave fixed services bands in the range 1.5 GHz to 3.8 GHz
	Activities resulting from the Independent Review of Government Spectrum Holdings.,
	Investigation of arrangements for spectrum currently licensed under expiring spectrum licences.
	Earth station siting policy (currently under development).
	Consultation on proposed regulatory arrangements for indoor low power ubiquitous UWB devices.

Appendix A: Current and imminent projects

This appendix identifies the frequency bands that ACMA is either currently examining or will soon commence work on. For each band, there is an overview of its current use, identification of the significant issues facing the band and an outline of ACMA's proposed actions to initially address the issues.

26 MHz

BACKGROUND

The Spectrum Plan allocates the 26 MHz band (25.670–26.100 MHz) to the broadcasting service on a primary basis.

The band is currently very lightly used.

ISSUES

Digital Radio Mondiale (DRM) is a digital broadcast radio technology that was developed by broadcasters and manufacturers as a digital replacement for AM broadcast radio systems. The design objectives of DRM included providing significant improvement in audio quality and reliability compared with existing AM radio, to be capable of competing with FM radio services.

DRM advocates consider that the technology is suitable for use in bands below 30 MHz (150 kHz to 30 MHz), and are now working to extend the system to broadcasting services operating up to 108 MHz with the DRM+ system.

Industry has approached ACMA seeking licences to transmit DRM in the 26 MHz band. In this band, DRM can provide local coverage from low power transmitters. When operating in single frequency networks (SFNs), DRM transmitters can provide metropolitan area coverage with good spectral efficiency.

5.9.4 ACTIONS

Spectrum Embargo 44[178] was put in place in September 2006 to support planning of a number of bands, including the 26 MHz band, to accommodate DRM. ACMA will consult with industry to canvass interest in the possible use of DRM technology.

[178] RALI MS3—Embargo 44, http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712.

45–70 MHz

BACKGROUND

The 45–52 and 56–70 MHz bands are allocated, inter alia, to the broadcasting service on a primary basis. There are also primary fixed and mobile services (subject to footnote AUS11) in most of these bands. The first priority for the use of these bands is currently analog television services; however, this usage does not cover all parts of Australia. Defence operates fixed and mobile services in these bands from time to time. ACMA will not be allocating digital television services in these bands.

ISSUES

Defence has indicated some interest in expanding its existing usage of the band, the amateur radio community is interested in upgrading its 50–52 MHz allocation to primary status, and the band may also be suitable for the operation of some other fixed or mobile applications. There is also potential to use a portion of these bands for digital radio broadcasting using the foreshadowed, but not yet available, DRM+ technology.

ACTIONS

The development of policy for the digital switchover and future use of spectrum that will become vacant following the switchover rests with the Minister for Broadband, Communications and the Digital Economy.

Where appropriate, ACMA will assist the government in this work. In that context, ACMA will gather information on the spectrum demands of potential alternative uses and will monitor the status of DRM+ development (and its relevance to wider government digital radio policy).

174–230 MHz

BACKGROUND

The 174–230 MHz band is allocated to the broadcasting service on a primary basis. The broadcasting service use of this band is currently for analog and digital television. Additionally, terrestrial digital audio broadcasting (T-DAB) digital radio broadcasting services will operate in this band from 1 January 2009. The band is also used by class licensed low interference potential devices.

ISSUES

In more populated areas this band is heavily used for the provision of analog and digital television services. This has limited the opportunity to introduce DAB services in capital cities and especially its introduction in surrounding regional areas. The switch off of VHF Band III analog television services may create more opportunities for T-DAB digital radio broadcasting services in many, but not all, regional areas.

ACTIONS

The development of policy for the digital switchover and future use of spectrum that will become vacant following the switchover rests with the Minister for Broadband, Communications and the Digital Economy. Where appropriate, ACMA will assist the government in this work.

ACMA is currently working, in consultation with the radio industry, to review the initial digital radio channel plans that provide for T-DAB to operate in state capital cities. The review aims at exploring options for increased coverage and availability of T-DAB services.

403–520 MHz

BACKGROUND

Spectrum in the ranges 403–420 MHz and 450–520 MHz is administered in accordance with the *400 MHz Plan*[179]. It specifies planning arrangements primarily for the operation of narrowband land mobile services[180] and fixed services[181]. The *400 MHz Plan* also provides for the operation of the wideband fixed P-P and P-MP systems in rural parts of Australia.

Allocation arrangements for the 420–450 MHz band are defined by the Spectrum Plan. The 420–450 MHz band is allocated to the radiolocation service on a primary basis. It is subject to footnote AUS11, which states:

> This service is intended to be used primarily for the purposes of defence. The Department of Defence is normally consulted in considering non-defence use of the service.

Defence considers this band critical to its operations due to its suitability for long range aeronautical radar and foliage penetration radar, which is under development. In addition, the 420–430 MHz range is used by the land mobile service for government (federal, state and territory) purposes, and a portion of the band is used by Multi-Trak Pty Ltd for vehicle locating services.

The amateur service has access to 420–450 MHz on a secondary basis. Most amateur activity takes place in the 430–440 MHz range. Use of the range 433.05–434.79 MHz for short range devices is also supported by the LIPD class licence.

The 440–450 MHz frequency range has relatively limited use by any service. It is lightly used for repeater links and amateur television[182].

ISSUES

There is increasing pressure from industry and users of the 403–520 MHz frequency range to restructure the range to better accommodate current and future technology. Much of this spectrum is congested in the major capital cities. There is a growing need to provide spectrum for more technically efficient technologies including trunking, and a more extensive use of narrower channels for the land mobile and fixed P-MP services. In addition, there is an embargo on new assignments in some parts of the band to support defence, national security and law enforcement operations, and emergency services. In the 518–520 MHz band, this supports the possible expansion of UHF television channel 27 and preserves planning options for adjacent channel sharing. Furthermore, the band 450–470 MHz was identified for use by International Mobile Telecommunications (IMT) at WRC-07.

ACTIONS

ACMA released a public discussion paper in April 2008 (see section 5.4.2) to explore options for replanning the way this spectrum is used, with the overall goal of facilitating

[179] Radiofrequency Planning Group, Australian Communications Authority, 2002, *RALI MS 22—400 MHz Plan*, http://www.acma.gov.au/webwr/radcomm/frequency_planning/band_plans/400mplan.pdf.

[180] Arrangements for narrowband land mobile services currently accommodate for both single- and two-frequency systems, with 12.5 kHz and 25 kHz channelling, as well as two-frequency trunked systems with 12.5 kHz channelling.

[181] Arrangements for fixed services in the 400 MHz band currently accommodate single-frequency systems with 12.5 kHz and 25 kHz channelling, two-frequency point-to-point systems with 25 kHz channelling and two-frequency P-MP systems with 12.5 kHz and 25 kHz channelling.

[182] Wireless Institute of Australia Band Plan can be found at: http://www.wia.org.au.

more access. Arrangements in the band are currently being reviewed, and ACMA expects to release a second discussion paper in 2009 with further developed proposals for future arrangements in the band.

520–820 MHz

BACKGROUND

This band is allocated to the broadcasting service on a primary basis, and to the fixed and mobile services on a secondary basis. The broadcasting service use of this band is for the provision of analog and digital television broadcasting. The 520–820 MHz band is also used by class licensed low interference potential devices, and by some apparatus licensed devices via ‘drop through’ arrangements[183].

ISSUES

A key issue for the 520–820 MHz band is the ‘digital dividend’. This is a term used to describe the benefits and opportunities that are expected to arise following the conversion of analog to digital television. The switch off of analog television services will leave significant amounts of spectrum vacant in this range.

ACTIONS

The development of policy relating to the digital switchover and future use of spectrum that will become vacant following the switchover rests with the Minister for Broadband, Communications and the Digital Economy.

Where appropriate, ACMA will assist the government in this work.

[183] A ‘drop-through’ refers to making spectrum in the BSB available for non-broadcasting uses under section 34 of the BSA. For more information please see <http://www.acma.gov.au/WEB/STANDARD/pc=PC_1263>.

820–960 MHz

BACKGROUND

The 820–960 MHz band currently supports a variety of radiocommunications services, including:

- public mobile telephony services;
- trunked land mobile services;
- single channel, low capacity and wideband fixed services;
- broadcasting studio-to-transmitter links (STLs);
- miscellaneous low power fixed and mobile services; and
- radiolocation services.

The *900 MHz Band Plan* was created in 1992, primarily to facilitate the introduction of public mobile telecommunications competition. The LIPD class licence also authorises the operation of a variety of devices in the 915–928 MHz range, including radiofrequency identification (RFID) transmitters. Figure A.1 shows the distribution of the above assignment types in the *900 MHz Band Plan*.

ISSUES

In the *900 MHz Band Plan*, the 857–865 MHz and 933–935 MHz bands were allocated for use by CT2 and CT3 digital cordless telephone systems, and DSRR systems. However, CT2 and DSRR systems failed to gain acceptance in Australia or internationally, and the CT3 system has been effectively superseded by the European digital enhanced cordless telecommunications (DECT) system. Consequently, the bands 857–865 MHz and 933–935 MHz appear to be poorly utilised.

Industry has requested that ACMA provide additional opportunities for telecommand and telemetry applications, and for STLs, in these bands.

ACMA recently finalised a variation to the LIPD class licence, which included an increase to the maximum permitted EIRP for RFID transmitters operating in the 920–926 MHz band from 1 W to 4 W, in cases where 1 W is insufficient to achieve satisfactory system performance. In 2003, GS1 Australia (on behalf of industry) requested that ACMA increase the maximum EIRP to support improved inventory management systems. As illustrated in Figure A.2 below, the RFID band is adjacent to the GSM (Global System for Mobile communications) base station receive band. The interference potential between RFID transmitters and GSM base station receivers was studied by industry (RFID and GSM operators) in a number of theoretical, laboratory and field trials. The trials identified out-of-band emission limits necessary to protect GSM services, which were adjusted accordingly and included in the variation to the LIPD class licence. More general work on the compatibility of RFIDs with other services will be completed by the ITU in the lead up to WRC-11. Agenda item 1.22 is to consider the results of studies into the emissions of short range devices (SRDs), including RFIDs, in order to ensure adequate protection of radiocommunications services.

Figure A.1: Distribution of assignments[184] in the 900 MHz Band Plan (November 2007)

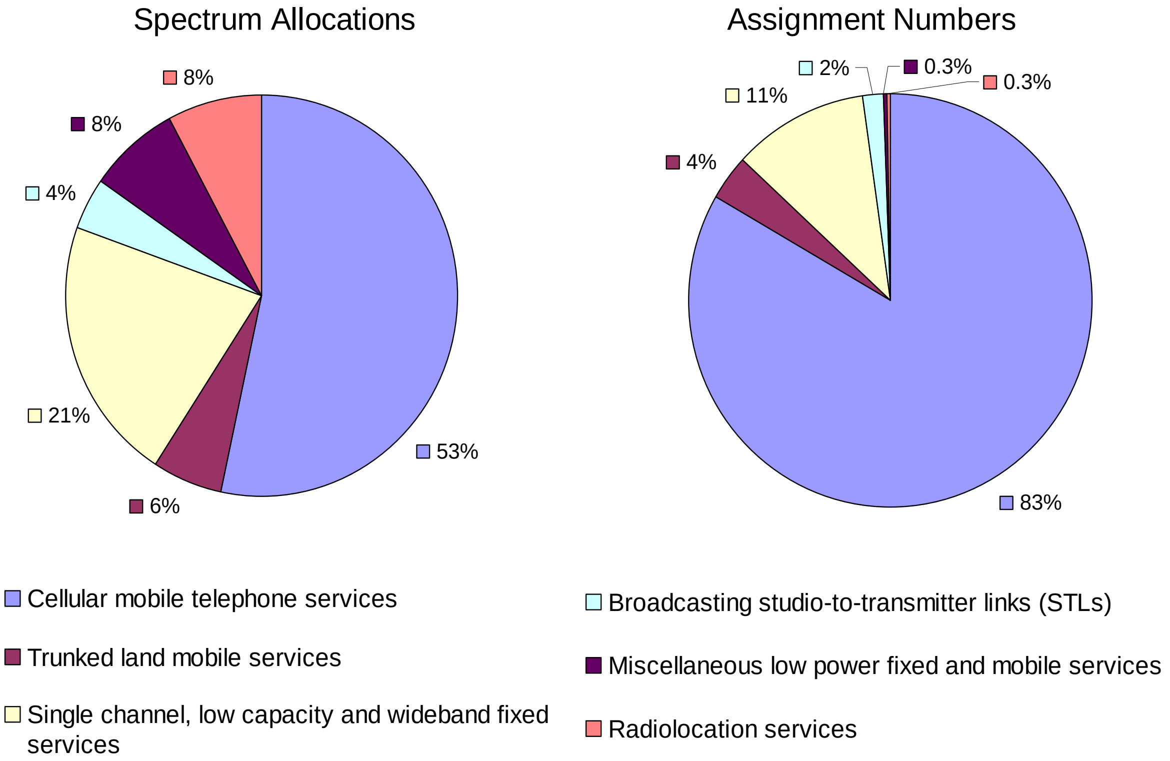
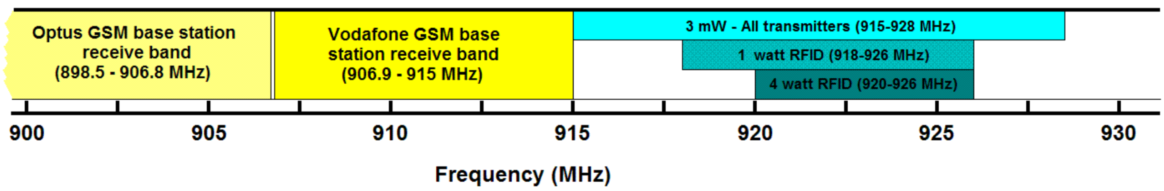


Figure A.2: Services operating in the 900 MHz band



ACTIONS

To preserve planning flexibility, ACMA created spectrum Embargo 34[185] preventing any further licensing of CT3 systems or single channel single frequency fixed links in the 857–859 MHz, 861–865 MHz and 933–935 MHz frequency ranges. ACMA is monitoring developments in this spectrum and believes it is not a high priority to replan its use within the next 12 months. ACMA expects that an examination of the 900 MHz band will commence once replanning of the 400 MHz band is well underway.

1.5 to 3.8 GHz bands

Background

Section 5.3.1 categorises the band included in *Radiocommunications Assignment and Licensing Instruction (RALI) FX 3—Microwave Fixed Services Frequency Coordination*

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[184] 'Assignments' included consist of device registrations under spectrum licences for CMTS, as well as frequency assignments corresponding to apparatus-licensed land mobile base station transmitters, P-MP transmitters, sound-outside-broadcast transmitters, point-to-point links and licensed CTS. Class-licensed usage is not included in the graph.

[185] RALI MS3—Embargo 34, <http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712>.

based on the typical length of the link and data rate supported. The ‘microwave’ bands below 5 GHz are typically used for long haul links. The 1.5, 1.8, 2.1 and 2.2 GHz bands generally deliver lower data rate communications; of particular importance is the use of DRCS/HCRC for the provision of telecommunications services to rural and remote areas. The 3.8 GHz band is useful for connecting major towns and cities over long distances, and is generally used by higher capacity links.

Issues

As explained in section 5.3.1, there are a number of measures currently implemented that restrict the usage of fixed services in parts of the 1.5, 1.8, 2.1, 2.2 and 3.8 GHz bands; including for spectrum licensing provisions and future planning options in populated areas. These bands are facing increasing pressure from other services, particularly WAS, and this has led to a decline in the number of low capacity long haul links in recent years. To address this, ACMA commissioned a consultancy into the long term aspirations of microwave fixed P-P users in microwave bands below about 5 GHz. The consultant produced a discussion paper and survey questionnaire canvassing the views of stakeholders (licensees, equipment manufacturers and suppliers) on their perceived future spectrum requirements in these bands, and their views on possible future band planning arrangements. 23 organisations participated in the survey and interviews held by the consultant.

Actions

ACMA is currently reviewing the consultant’s report, together with other associated materials, and expects to release a public discussion paper in mid 2009. Should the response to the proposals in the public discussion paper be favourable, the assignment arrangements in *RALI FX 3* will be updated to reflect the proposals.

2500–2690 MHz

BACKGROUND

The 2500–2690 MHz (2.5 GHz) band is currently used almost exclusively by free to air television broadcasters for electronic new gathering (ENG) applications Australia wide. ENG typically involves the rapid, unplanned deployment of radiofrequency video links to cover live news events, generally for short periods of time. Use is greatest in metropolitan areas, and for significant news and sporting events.

In December 2006, ACMA released a public discussion paper that identified this band as a potentially suitable candidate band for wireless access services (WAS) in Australia. This discussion paper sought feedback from stakeholders about the suitability of the band for WAS, the potential impact on incumbent services, and the best way to segment the bands and license operation of WAS. 36 submissions were received that dealt generally with issues raised in the discussion paper. A further 130 submissions were received specifically relating to wireless microphone usage[186].

This band is currently subject to Embargo 43[187] to preserve spectrum options to support the review of planning arrangements for the band.

ISSUES

The 2.5 GHz band was identified at WRC-2000 for use by administrations wishing to implement IMT. This band was also identified through the ACMA WAS consultation processes as a potential candidate to address emerging demand for WAS.

Existing ENG services have faced uncertainty about their long term spectrum home since international identification and harmonisation of this band for WAS in 2000. ACMA has formed the view that current planning and licensing arrangements for the band are unlikely to support its efficient allocation and use into the future, particularly in light of the identification of the band internationally for use by WAS and indications of the rising value of the band.

5.9.5 ACTIONS

ACMA will review current planning and licensing arrangements in the 2.5 GHz band, with a view to maximising the overall benefit derived from this spectrum.

The review will have the twin objective of delivering suitable long term spectrum arrangements for ENG, whether in the 2.5 GHz band, in other bands or in combinations of bands, so as to resolve the current uncertainty around spectrum arrangements for electronic news gathering.

A number of possible approaches will be considered regarding the future management of the band. These approaches might include one or more of:

- reviewing apparatus licence fees to better reflect the changing value of the band;
- changing licensing arrangements in some or all parts of the band to facilitate future changes in uses, including by way of spectrum trading; and

[186] The discussion paper and responses are available on the ACMA website at http://www.acma.gov.au/WEB/STANDARD/pc=PC_100424.
[187] RALI MS3—Embargo 43, http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712.

- conducting a price based allocation to distribute some or all of the spectrum to its highest value use or uses.

Implementation of any new approach will have implications for ENG operators, so there needs to be certainty around future arrangements for ENG before the final adoption of any approach or approaches.

3575–3700 MHz

BACKGROUND

The 3.6 GHz (3575–3700 MHz) band includes part of what is commonly known as the extended C-band[188]. In Australia, the band is used mainly by Telstra for fixed P-P services and, to a lesser extent, by the fixed satellite service (FSS). FSS ground stations are located in Perth and Sydney in this band while the fixed P-P links occupy major trunk routes along the east coast. There are also radiolocation (radar) and secondary amateur services considerations in the band 3400–3600 MHz. The application of the AUS 11 footnote in this band means that the radiolocation service is intended to be used principally for the purposes of Defence.

As at October 2008, there were a total of 137 P-P assignments and 8 FSS assignments in the band. The major FSS operators are Lockheed Martin, Optus, Telstra, Gallery Gold and NewSat Networks.

In December 2006, ACMA released a public discussion paper that identified this band as a suitable candidate band for WAS. The December 2006 discussion paper sought feedback from stakeholders about the suitability of a number of identified bands for WAS (including the 3.6 GHz band), the potential impact on incumbent services, and the best way to segment the bands and license operation of WAS. 28 submissions commented on this band. These ranged from providers and users of services in the 3.6 GHz band, to current and prospective WAS providers, suppliers and manufacturers of WAS equipment[189].

Internationally, several countries including the USA, Canada, the UK, Sweden, Norway, Denmark, Portugal, Switzerland and Japan have allocated or are considering allocating spectrum in and around this band for WAS. The band is part of the spectrum that the WiMAX Forum has defined as the 3.5 GHz band (3.4–3.8 GHz).

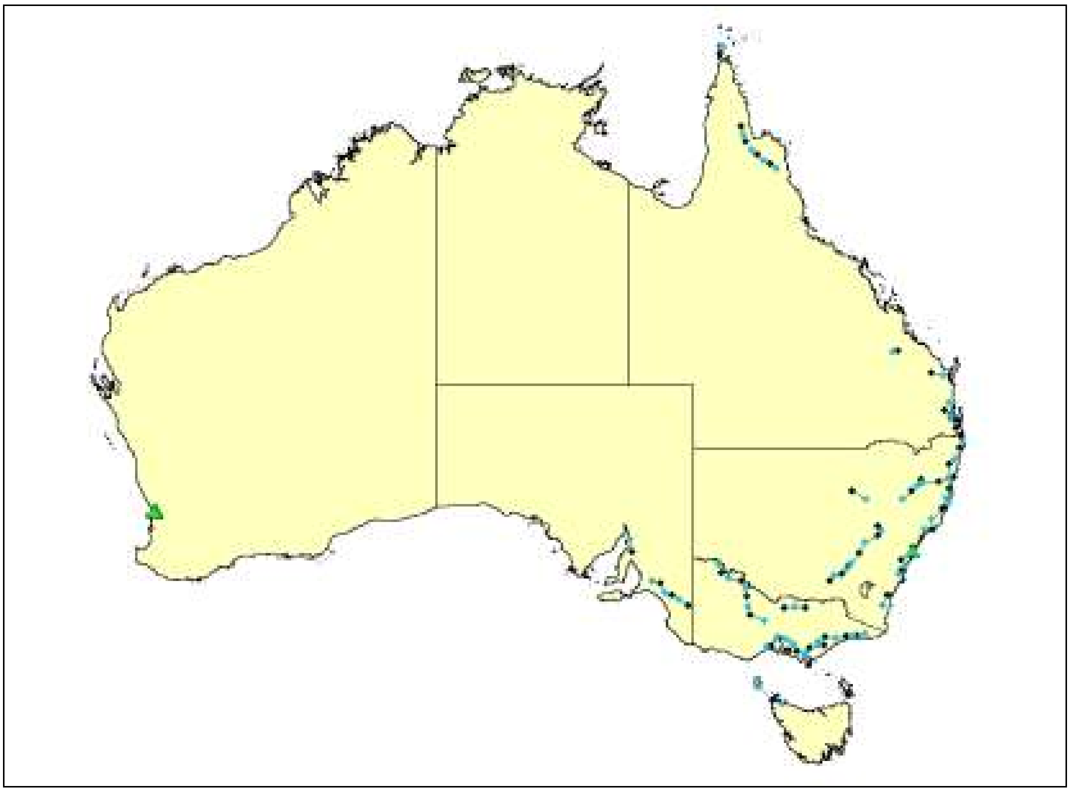
The 3.6 GHz band is currently subject to Embargo 42[190] to preserve spectrum options in support of further planning for WAS. Figure A.3 shows the location of P-P links and Earth stations in the 3.6 GHz band.

[188] C-band generally refers to the microwave frequency range between 4 GHz and 8 GHz. However, in this case the ‘extended C-band’ (3400–3700 MHz) is considered an extension of the satellite downlink band 3700–4200 MHz (‘standard C-band’).

[189] The discussion paper and responses are available on the ACMA website at <http://www.acma.gov.au/WEB/STANDARD/pc=PC_100424>.

[190] RALI MS3—Embargo 42, <http://www.acma.gov.au/WEB/STANDARD/pc=PC_2712>.

Figure A.3: Location of Earth stations (green triangles) and P-P links (dots) in the 3575–3700 MHz band (October 2008)



ISSUES

The satellite industry has a number of concerns about the possible reallocation of the band for WAS. These generally relate to the protection of existing services (in both extended and standard C-band), the restriction on their ability to deploy new FSS, the high cost associated with the physical relocation of FSS Earth station sites, the costs and the lack of equivalent alternative spectrum for the FSS. If the band is to be made available for WAS, these issues will need to be considered.

Public submissions to the December 2006 discussion paper indicate there are an unknown number of unlicensed satellite receivers in the 3400–4200 MHz band, many of which receive fortuitous transmissions intended for overseas audiences.

Use of the band by fixed link operators and Defence maritime radiolocation services also needs to be considered.

ACTIONS

ACMA is considering a range of options to enable access to spectrum capable of supporting WAS (including BWA systems) that will facilitate the deployment of emerging broadband technologies across Australia.

ACMA intends to review arrangements in the 3.6 GHz band to allow for WAS in regional and remote areas, while recognising that the interests of incumbent operators need to be addressed.

The terms of this review will take into account protection requirements for existing services and other incumbency issues highlighted by stakeholders, including the ongoing utility of this band for satellite services. The current embargo will be continued in major city areas in order to facilitate a faster release of spectrum in regional and remote areas, preserve future planning options for the major city areas and offer greater protection to gateway Earth stations located in Sydney and Perth. Similar areas will also be defined for existing defence facilities operating in the band.

As part of the review, ACMA plans to:

- establish, through consultation with industry, appropriate protection and coordination criteria;
- modify the embargo to allow apparatus licensed broadband services in regional and remote areas;
- develop and implement an Earth station siting policy (see section 5.7.2) one year after the band is opened to WAS and subsequently modify the embargo to allow FSS Earth stations in regional and rural areas; and
- review the status of terrestrial fixed P-P links in the band after two years.

The introduction of WAS into metropolitan areas will be the subject of further work, only after the demand for broadband services in regional areas has been addressed. FSS Earth stations in city areas will continue to be protected, and for now, the embargo on new frequency assignments in these areas will be maintained.

The use of unlicensed satellite receivers in this band will not be considered in any licensing and coordination arrangements developed by ACMA. Under legislative and regulatory arrangements, unlicensed receivers are not afforded protection and as a consequence are subject to interference from any existing or future licensed services in the band. However, it is likely that a continued embargo on major city areas will reduce the impact on unlicensed receivers in the medium term. Numerous mitigation techniques are also available to reduce interference into unlicensed receivers.

4940–4990 MHz

BACKGROUND

The Spectrum Plan allocates the 4940–4990 MHz band (the 4.9 GHz band) to the fixed and mobile services on a primary basis, and to the RAS on a secondary basis. Footnote AUS11 indicates that the fixed and mobile services are intended to be used primarily for the purposes of defence. Accordingly, Defence has essentially exclusive access to the 4.9 GHz band.

Like most communications users, public safety organisations such as police, fire and ambulance services have an increased need for broadband systems to meet evolving operational requirements.

In partial response to the unique radiocommunications needs of public safety (often referred to as public protection and disaster relief [PPDR]) organisations), at WRC-03 the ITU identified the 4.9 GHz band for regionally harmonised PPDR use in Regions 2 (the Americas) and 3 (Asia-Pacific). Since WRC-03, a number of countries (notably Canada and the US) have implemented arrangements in the 4.9 GHz band in support of public safety applications.

ISSUES

A number of organisations with an interest in the band for public safety applications have approached ACMA seeking formal access to the band.

Two 2006 ACMA discussion papers[191] on the identification of additional spectrum for WAS highlighted the 4.9 GHz band for potential broadband public safety use. These papers concluded that the band would not be made available for general WAS use.

ACMA has been developing arrangements to support public safety use of the 4.9 GHz band, including by Defence and other security agencies.

There are also a limited number of other incumbent uses of the band for fixed P-P and scientific applications. The RAS is also identified as having an interest in the band via footnote AUS87 in the Spectrum Plan.

ACTIONS

ACMA will undertake a consultation process to assist in developing appropriate spectrum management processes to support use of the band by public safety applications. ACMA's aim is to implement spectrum management arrangements that will provide an appropriate degree of flexibility in spectrum usage, facilitate interoperability between public safety organisations and minimise the licensing burden on both ACMA and users. The identification and specification of which organisations and agencies will have access to this band will be crucial.

[191] *Strategies for Wireless Access Services* (Spectrum Planning Discussion Paper SPP 1/06) and *Strategies for Wireless Access Services: Spectrum Access Options* (Spectrum Planning Discussion Paper SPP 10/06), available at: http://www.acma.gov.au/web/STANDARD//pc%3DPC_100424.

5850–5925 MHz

BACKGROUND

The 5.9 GHz band (5850–5925 MHz) is allocated to the fixed service, the FSS (Earth-to-space) and the mobile service on a primary basis, and to the radiolocation service on a secondary basis. The band is lightly used; as at January 2008 there were only 33 assignments in the band, with the majority for fixed Earth licences.

The RAS conducts passive observations in the 4350–6700 MHz band,[192] although the 5.9 GHz band does not overlap with any of the preferred frequency bands for radio astronomical measurement (as specified in ITU-R Recommendation RA.314-10).

The lower part of the band is also used by class licensed low interference potential devices, and industrial, scientific and medical (ISM) devices[193].

ISSUES

In the 5.9 GHz band, the use of intelligent transportation systems (ITS) is becoming widespread internationally. ITS covers a broad range of wireless technologies that, when integrated into the transportation system infrastructure and in vehicles themselves, help to monitor and manage traffic flow, relieve congestion, provide alternative routes to travellers, improve safety and potentially save lives. The ITS technologies are enabled using dedicated short range communications (DSRC).

DSRC for ITS applications involves the use of non-voice radio techniques to transfer data over short distances between in-vehicle mobile radio units and roadside units, and between the in-vehicle mobile units themselves. This enables operations for the improvement of traffic flow, traffic safety and other intelligent transport service applications in a variety of public and commercial environments.

ACMA predicts that ITS may be introduced into Australia by about 2010, depending on developments within the automotive industry. Accordingly, ACMA has been liaising with the transport sector and actively planning for its introduction. In order to support the possible introduction of ITS ACMA has put Embargo 48 in place, which prohibits new assignments from being made.

ACTIONS

ACMA is currently awaiting input from industry to progress the development of spectrum access and licensing arrangements for ITS in Australia. ACMA will consult with stakeholders prior to establishing any such arrangements, but some initial thoughts and options are outlined below:

- Pending an assessment of the interference potential of 5.9 GHz ITS vehicle mounted units, a class licence (most likely the LIPD class licence) is an option to authorise their use.
- To enable coordination with spectrum users, the use of roadside units could be apparatus licensed. ACMA will investigate the feasibility of and possible arrangements for sharing with existing services in the band.

[192] As per Australian footnote AUS87 of the Spectrum Plan.
[193] ISM devices operate in the 5725–5875 MHz band, as per Article 5.150 of the ITU *Radio Regulations*.

- The use of channels above 5895 MHz for ITS could potentially pose an interference risk to existing spectrum users. To enable the early introduction of ITS into Australia, these channels could initially not be made available for ITS. ITS vehicle mounted units would be authorised with an all channel capability to provide compatibility with overseas arrangements and minimise costs to the consumer. However, as channel selection is determined by the controlling roadside units, it would still be possible to initially prevent the use of channels above 5895 MHz.
- If a staged release of spectrum for ITS occurred, it would ensure that sufficient time was available for any incumbent spectrum users who considered themselves at significant interference risk to relocate.

Ultra wideband

BACKGROUND

Ultra wideband (UWB) technology generally involves the radiation, reception and processing of very wide bandwidth radiofrequency emissions for short range applications. UWB applications include automotive collision avoidance systems and high data rate interference tolerant communications.

Typically, the emissions from a UWB transmitter will span a number of radiofrequency bands that have been allocated for a range of different purposes. For example, a 24 GHz UWB transmitter might occupy a bandwidth of about 5 GHz, which would span frequencies used for such purposes as microwave fixed links, space research, radio astronomy, amateur radio and satellite communications.

In July 2006, ACMA introduced arrangements in the LIPD class licence to authorise the use of 24 GHz UWB short range radar (SRR) devices for automotive use in Australia.

ISSUES

UWB technology has been proposed for an array of very short range indoor ubiquitous applications such as wireless universal serial bus (USB) links, data links connecting television set top boxes and digital displays, and precision position indicating RFID tags. The US introduced arrangements supporting the indoor use of UWB devices in 2000, but in Europe and other countries there is significant concern about the risk of interference to existing services. This has led to a number of more restrictive regulatory arrangements being proposed. In addition, WRC-11 Agenda item 1.22 is to examine the effects of emissions from SDRs, including those using UWB technologies, on radiocommunications services.

ACTIONS

ACMA is currently developing a public discussion paper that will seek comments on proposed regulatory arrangements for the indoor use of low power UWB devices in Australia. The discussion paper will examine frequency bands, in-band and out-of-band limits, and licensing arrangements. ACMA expects to release the discussion paper in 2009.

Appendix B: Table of frequency bands

Frequency band		Frequency range	
VLF		3–30 kHz	
LF		30–300 kHz	
MF		300–3000 kHz	
HF		3–30 MHz	
VHF		30–300 MHz	
UHF		300–3000 MHz	
	L-band		1000–2000 MHz
	S-band		2000–4000 MHz
SHF		3–30 GHz	
	C-band		4–8 GHz
	X-band		8–12 GHz
	Ku-band		12–18 GHz
	K-band		18–26 GHz
	Ka-band		26–40 GHz
EHF		30–300 GHz	

Note: there are variations in the frequency ranges corresponding to the band names for the microwave frequency bands (L-band, S-band, etc.). In particular, several exceptions to the above frequency bands exist for allocations to the satellite services and, when referring to the satellite service, Table 5.2 should be used instead (see section 5.7.1). Similarly, for the definition of frequency bands in relation to space science services, Table 5.3 should be used (see section 5.8.1).

Appendix C: Acronyms and abbreviations

Acronym	Definition
2G	second generation mobile telephone services
3G	third generation mobile telephone services
4G	fourth generation mobile telephone services
3GPP	Third Generation Partnership Project
A-SMGCS	advanced surface movement and guidance control system
AAD	Australian Antarctic Division
ABC	Australian Broadcasting Corporation
ACARS	aircraft communications addressing and reporting system
ACMA	Australian Communications and Media Authority
the ACMA Act	*Australian Communications and Media Authority Act 2005*
ACMI	air combat manoeuvring instrumentation
the Act	*Radiocommunications Act 1992*
ADS-B	automatic dependent surveillance-broadcast
AEW&C	airborne early warning and control
AFTN	aeronautical fixed telecommunications network
AIS	automatic identification system
AM	amplitude modulation
AMHS	Aeronautical Message Handling System
AM(R)S	aeronautical mobile (route) service
AMSA	Australian Maritime Safety Authority
AMSR	advanced microwave scanning radiometer
AMSU	advanced microwave sounding unit
AMT	aeronautical mobile telemetry
APT	Asia-Pacific Telecommunity
ARNS	aeronautical radionavigation service
ARSG	Australian Radiocommunications Study Group

ASDE	airport surface detection equipment
ASTRA	Australian Strategic Air Traffic Management Group
ATC	air traffic control
ATM	air traffic management
ATN	aeronautical telecommunications network
ATPC	automatic transmitter power control
AusSAR	Australian Search and Rescue
AWACS	airborne warning and control system
BGAN	Broadband Global Area Network
BoM	Bureau of Meteorology
the BSA	*Broadcasting Services Act 1992*
BSB	broadcasting services bands
BSS	broadcasting-satellite service
BWA	broadband wireless access
CASA	Civil Aviation Safety Authority
CB	citizen band
CBRS	citizen band radio service
CDL	common data link
CDMA	code division multiple access
CDSCC	Canberra Deep Space Communication Complex
CEPT	European Conference of Postal and Telecommunications Administration
CPDLC	controller pilot data link communications
CRS	cognitive radio system
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTS	cordless telecommunications service
DAB	digital audio broadcasting
DBCDE	Department of Broadband, Communications and the Digital Economy
DCITA	Department of Communications, Information Technology and the Arts
DECT	digital enhanced cordless telecommunications
Defence	Department of Defence
DMB	digital multimedia broadcast
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
DRCS	digital radio concentrator system
DRM	Digital Radio Mondiale
DSC	digital selective calling
DSL	digital subscriber line

DSRC	dedicated short-range communications
DSRR	digital short-range radio
DTH	direct-to-home
DTTB	digital terrestrial television broadcasting
DVB RCS	digital video broadcasting-return channel via satellite
DVB-S	digital video broadcasting-satellite
DVB-S2	digital video broadcasting-satellite-second generation
EC	European Commission
ECC	Electronic Communications Committee (Europe)
EDGE	enhanced data rates for GSM evolution
EESS	Earth exploration-satellite service
EHF	extremely high frequency
EIRP	equivalent isotropically radiated power
ENG	electronic news gathering
EPIRB	emergency position-indicating radio beacon
ESA	European Space Agency
ESTRACK	ESA Station Tracking Network
ETSI	European Telecommunications Standards Institute
FANS	future air navigation system
FCC	Federal Communications Commission
FDD	frequency division duplex
FLO	forward link only
FM	frequency modulation
FSK	frequency shift keying
FSS	fixed-satellite service
FWA	fixed wireless access
GA	Geoscience Australia
GBAS	ground-based augmentation system
GBSI	Global Broadband Satellite Infrastructure
GHz	gigahertz
GMDSS	Global Maritime Distress and Safety System
GNSS	global navigation satellite system
GOES	geostationary operational environmental satellite
GPRS	general packet radio service
GPS	Global Positioning System
GRAS	ground-based regional augmentation system

GSM	Global System for Mobile communications
GSM-900	GSM services operating in the 900 MHz band
GSM-1800	GSM services operating in the 1800 MHz band
HAPS	high altitude platform stations
HCRC	high capacity radio concentrator
HD	high definition
HDTV	high definition television
HF	high frequency (3–30 MHz)
HIPERMAN	high performance radio metropolitan area network
HPON	high power open narrowcasting
HSDA	high spectrum density area
HSDPA	high-speed downlink packet access
HSPA	high-speed packet access
HSUPA	high-speed uplink packet access
ICAO	International Civil Aviation Organisation
IEEE	Institute of Electrical and Electronics Engineers
ILS	instrument landing system
IMO	International Maritime Organisation
IMT	International Mobile Telecommunications
IP	internet protocol
IRGSH	Independent Review of Government Spectrum Holdings
IRNSS	Indian Regional Navigation Satellite System
ISP	internet service provider
ITS	intelligent transportation systems
ITU	International Telecommunication Union
JTIDS	joint tactical information distribution system
kHz	kilohertz
LEOP	launch and early orbit phase
LF	low frequency (30–300 kHz)
the LIPD class licence	*Radiocommunications (Low Interference Potential Devices) Class Licence 2000*
LMDS	local multipoint distribution system
LOS	line-of-sight
LPON	low power open narrowcasting
LRIT	long range identification and tracking
LTE	long-term evolution

Mbps	megabits per second
MBWA	mobile broadband wireless access
MDS	multipoint distribution system
MetAids	meteorological aids service
MetSat	meteorological-satellite service
MF	medium frequency (300–3000 kHz)
MHz	megahertz
MIMO	multiple-input and multiple-output
the Minister	Minister for Broadband, Communications and the Digital Economy
MLS	microwave landing system
MPEG	Moving Picture Experts Group
MSDA	medium spectrum density area
MSI	maritime safety information
MSS	mobile-satellite service
MSS/ATC	mobile-satellite service ancillary terrestrial component
MTSAT	Multi-Functional Transport Satellite
NAS	narrowband area service
NASA	National Aeronautics and Space Administration
NBDP	narrow-band direct printing
NDB	non-directional beacon
NMSC	National Marine Safety Committee
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NTIA	National Telecommunications and Information Administration
OFDMA	orthogonal frequency-division multiple access
OR	off-route
P-MP	point-to-multipoint
P-P	point-to-point
PDC	pre-departure clearance
pfd	power flux density
POES	Polar Operational Environmental Satellite
PPDR	public protection and disaster relief
PSR	primary surveillance radar
QZSS	Quasi-Zenith Satellite System
R	route
racon	radar beacon

RALI	Radiocommunications Assignment and Licensing Instruction
RAS	radio astronomy service
RCC	Radiocommunications Consultative Committee
RFID	radiofrequency identification
RLAN	radio local area network
RNSS	radionavigation-satellite service
RQZ	radio quiet zone
SAR	search and rescue
SAR	synthetic aperture radar
SART	search-and-rescue radar transponder
SBS	Special Broadcasting Service
SCADA	supervisory control and data acquisition
SD	standard definition
SDR	software-defined radio
SFN	single frequency network
SHF	super high frequency (3–30 GHz)
SKA	Square Kilometre Array
SMS	short message service
SNG	satellite news gathering
SOLAS	(International Convention of) Safety of Life at Sea
SOS	space operations service
the Spectrum Plan	Australian Radiofrequency Spectrum Plan 2009
SRD	short-range device
SRR	short-range radar
SRS	space research service
SSM/I	special sensor microwave imager
SSR	secondary surveillance radar
STL	studio-to-transmitter link
T-DAB	terrestrial digital audio broadcasting
TACAN	tactical air navigation
TCDL	tactical common data link
TCR	telemetry, command and ranging
TDD	time division duplex
TDMA	time division multiple access
TETRA	Terrestrial Trunked Radio
TFTS	terrestrial flight telecommunications system

TMI	Tropical Rainfall Measuring Mission microwave imager
TOB	television outside broadcast
TRMM	Tropical Rainfall Measuring Mission
TT&C	tracking, telemetry and control
UAV	unmanned aerial vehicle
UHF	ultra high frequency (300–3000 MHz)
UK	United Kingdom
UMB	ultra-mobile broadband
UMTS	universal mobile telecommunications system
US	United States (of America)
USB	universal service bus
USO	universal service obligation
UWB	ultra wideband
VHF	very high frequency (30–300 MHz)
VLF	very low frequency (3–30 kHz)
VoIP	voice over internet protocol
VOR	VHF omnidirectional range
VSAT	very small aperture terminal
WAAS	wide area augmentation system
WAS	wireless access services
WCDMA	wideband code division multiple access
Wi-Fi	wireless fidelity
WiMAX	worldwide interoperability for microwave access
WLL	wireless local loop
WRC-2000	World Radiocommunication Conference 2000
WRC-03	World Radiocommunication Conference 2003
WRC-07	World Radiocommunication Conference 2007
WRC-11	World Radiocommunication Conference 2011
XPIC	cross-polarisation interference cancellation