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Spectrum Licensing Technical Frameworks Review

Discussion Paper

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List of abbreviations

Abbreviation	Explanation
ACMA	Australian Communications and Media Authority
AP	Accredited Persons
A-PFD	Aggregated Power Flux Density
BEM	Block Edge Mask
CEPT	European Conference of Postal and Telecommunications
CFR	Code of Federal Regulations
CRTC	Canadian Radio-television and Telecommunications Commission
DBC	Device Boundary Criterion
DySpAN	Dynamic Spectrum Access Network
EC	European Commission
ECC	European Communications Committee
EIRP	Equivalent Isotropic Radiated Power
ERO	European Radiocommunications Office
ERP	Effective Radiated Power
EU	European Union
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FWA	Fixed Wireless Access
IC	Industry Canada
IIC	Interference Impact Certificate
ISM	Industrial Scientific and Medical
ITU	International Telecommunication Union
LMCS	Local Multipoint Communications System
LOP	Level Of Protection
MCB	Minimum Contiguous Bandwidth
NOI	Notice of Inquiry

NOI-NPRM	Notice of Inquiry and Notice of Proposed Rule Making
NPRM	Notice of Proposed Rule Making
NRA	National Regulatory Authority
PCS	Personal Communications Service
PFD	Power Flux Density
PSD	Power Spectral Density
R&O	Report and Order
RRL	Register of Radiocommunications Licences
RSS	Radio standard Specification
SDR	Software Defined Radio
SMI	Secondary Markets Initiative
SRSP	Standard Radio System Plan
STU	Standard Trading Unit
TDD	Time Division Duplex
TLG	Technical Liaison Group
ULS	Universal Licensing System
WAPECS	Wireless Access Policy for Electronic Communications Services
WTB	Wireless Telecommunications Bureau

Executive Summary

Spectrum Licensing in Australia

Spectrum licensing is one of three licensing options available under the regulatory arrangements implemented by the Australian Communications and Media Authority (ACMA) to manage the radiofrequency spectrum. Spectrum licences were introduced in the *Radiocommunications Act 1992* (the Act) and offer a technology-flexible and market-oriented approach to managing the radiofrequency spectrum.

Spectrum licences authorise the use of a parcel of spectrum space. Licensees are able to deploy transmitters or devices from any site within their licensed space, so long as the operation of the device complies with the core conditions and technical framework applicable to the spectrum licensed band.

A technical framework is the collection of technical regulatory conditions that apply to the use of devices within licensed frequency bands. ACMA designs these frameworks using a common approach that is based on maximising the efficiency of spectrum while minimising the potential for interference. This paper focuses on technical frameworks for spectrum licences. This is recognised as being only one part in ACMA's approach to technical frameworks overall.

The Act specifies the statutory requirements for a spectrum licence technical framework.[1] For example, a spectrum licence technical framework must include:

- a defined frequency and area;
- specified out-of-band limits and out-of-area limits;
- a written determination made under section 145 of the Act establishing what is considered to be an unacceptable level of interference; and
- advisory guidelines made under section 262 of the Act relating to any aspect of radiocommunication or radio emissions, including interference.

Typically, all of the above elements are included in spectrum licensing technical frameworks[2] and ACMA applies same underlying principles regarding space-centric spectrum management[3] for every technical framework.

[1] For specific detail, please see sections 66, 145 and 262 of the *Radiocommunications Act 1992*

Spectrum Licensing Technical Framework Review

ACMA is undertaking a review of spectrum licence technical frameworks.[4] With policy issues of spectrum licence expiry on the policy horizon, ACMA has identified an opportunity to review the technical frameworks for spectrum licensing. The intention of the review is to analyse the current approach to the development of spectrum licence technical frameworks.

The purpose of this review is to ensure:

- consistent application of the spectrum management methodology to future technical frameworks for different spectrum licensed bands;
- that technical frameworks are clear and easily understood by industry;
- that future technical frameworks can accommodate new technology developments and interference methods; and
- the development of future technical frameworks follow principles of international best practice in the design and consideration of interference management techniques.

The outcome of the review will not affect existing technical frameworks unless a variation to the technical framework is undertaken with the agreement of licensees. Instead outcomes of the review will be used to inform the development of future technical frameworks, including any new or altered technical frameworks that apply to previous spectrum licensed bands where a decision is made to re-issue or reallocate spectrum licences.

In February 2008, ACMA initiated the consultation phase of the review by writing to industry representatives, including Accredited Persons and spectrum licensees, seeking comment on the application of spectrum licensing technical frameworks.[5] After reviewing submissions and conducting further analysis, ACMA has identified the following issues fur further consideration:

- the current methodology applied in the development of technical frameworks is appropriate for Australian requirements;
- the methodology of developing Australian technical frameworks is consistent with international methodologies at the macro level. However, there are some differences at the micro level, such as out of band and out of area limits;
- an industry working group is the most appropriate forum for creating a technical framework;
- the creation of future technical frameworks will require underlay and overlay technologies to be considered.

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[2] The one exception is the 20/30 GHz Defence spectrum licence.

[3] Australia has used a "space-centric" methodology that allows a spectrum licensee to conduct interference coordination to an area instead of to a specific device.

[4] Technical frameworks are created for other licence types dealt with by ACMA, but it is important to note here that this review only takes into account those technical frameworks specifically developed for spectrum licences.

[5] The *Spectrum Licensing Technical Framework Information Paper* is available at the following link http://www.acma.gov.au/WEB/STANDARD/pc=PC_311701

- The purpose of this paper is to stimulate discussion and seek views from stakeholders to assist ACMA in developing future arrangements for spectrum licensing technical frameworks.

Chapter Summary

A brief summary of the chapters is provided below:

- Chapter 1 explains the purpose of the discussion paper and consultation process.
- Chapter 2 outlines the legislative, policy and regulatory context for spectrum management in Australia. This chapter also discusses ACMA's spectrum management principles and their application to the review and provides a general background on spectrum licensing policy.
- Chapter 3 provides an overview of the Australian spectrum licence technical framework.
- Chapter 4 discusses the development of core conditions for technical frameworks
- Chapter 5 discusses the role of device boundary criteria and identifies possible ways in which its effectiveness could be improved.
- Chapter 6 analyses the role and effectiveness of Advisory Guidelines made under section 262 of the Act.
- Chapter 7 provides discussion on technologies and applications, such as underlay and overlay technologies, which may require further consideration in the development of future technical frameworks.
- Chapter 8 provides a summary of the issues ACMA is seeking comment on.

The period for comments will close on **12 June 2009**.

At the close of the comment period, ACMA will analyse all responses to this consultation paper. Outcomes of the review will be used to inform the development of future technical frameworks.

1 Introduction

1.1 Spectrum Licences & Technical Frameworks

Spectrum licensing is one of three licensing options available under the regulatory arrangements implemented by the Australian Communications and Media Authority (ACMA) to manage the radiofrequency spectrum. Spectrum licences are legislatively provided for in Part 3.2 of the *Radiocommunications Act 1992* (the Act) and offer a technology-flexible and market-oriented approach to managing the radiofrequency spectrum.

Spectrum licences authorise the use of a parcel of spectrum space. Licensees are able to deploy transmitters or devices from any site within their licensed spectrum space, so long as the operation of the device complies with the core conditions and technical framework applicable to the spectrum licensed band.

A technical framework is the collection of technical regulatory conditions that apply to the use of devices within spectrum licensed bands. The Act specifies statutory requirements for a spectrum licence technical framework.[6] For example, a spectrum licence technical framework must include:

- a defined frequency and area;
- specified out-of-band limits and out-of-area limits;
- a written determination made under section 145 of the Act establishing what is considered to be an unacceptable level of interference; and
- Advisory Guidelines made under section 262 of the Act relating to any aspect of radiocommunication or radio emissions, including interference.

Typically, all of the above elements are included in spectrum licensing technical frameworks and ACMA applies the same underlying principles regarding space-centric spectrum management[7] for every technical framework. [8]

[6] For specific details, please see sections 66, 145 and 262 of the *Radiocommunications Act 1992*

[7] Australia has used a "space-centric" methodology that allows a spectrum licensee to conduct interference coordination to an area instead of to a specific device.

[8] The one exception is the 20/30 GHz Defence spectrum licence.

1.2 Purpose of the review

The Department of Broadband Communications and Digital Economy (DBCDE) and ACMA are currently considering policy issues involving spectrum licence expiry and re-issue in the public interest. Within this broader framework, ACMA has identified an opportunity to review the development of technical frameworks for spectrum licensing. This review will evaluate the current methodology used in developing technical frameworks to ensure that it continues to be appropriate for future spectrum licences. Therefore, the objectives of the review are to:

- identify potential improvements to the efficiency and effectiveness of technical frameworks for future spectrum allocations;
- ensure that technical frameworks are clear and easily understood by industry;
- ensure a consistent approach to the development of technical frameworks for different spectrum licensed bands;
- ensure future technical frameworks meet industry requirements;
- ensure future technical frameworks can accommodate new technology developments and interference methods; and
- ensure Australia is employing international best practice when creating a technical framework.

In order to meet these objectives, the review will focus on evaluating the following aspects of spectrum licensing technical frameworks[9]:

- the alignment, where possible, of Australia's technical framework methodology to ensure consistency with international methodologies. ACMA has conducted significant research into the methodologies used by other national regulatory authorities in the development of their respective technical frameworks;
- the process of creating a technical framework;
- the effectiveness of the current method for specifying technical conditions and recommendations for possible improvements;
- the effectiveness of the current interference management methodology and recommendations for possible improvements; and
- identification of possible implications for future technical frameworks.

ACMA does not intend to vary any of the technical frameworks that are currently in effect, unless requested and agreed to by all spectrum licensees.[10]

The purpose of this discussion paper is to analyse the development of spectrum licence technical frameworks and identify any potential areas for improvement in the process. In this

[9] The scope of this project does not cover other issues, such as spectrum licence expiry and the legislative issues relating to the coexistence of class licences in spectrum licence space. These issues, amongst others, are being considered by ACMA in other forums.

[10] Section 72 of the Act provides that ACMA may vary a spectrum licence with the written agreement of the licensee. ACMA has recently completed a variation to the technical framework for the 2.3 GHz band. This was achieved after extensive consultation with licensees and written agreement from all licensees affected by the variation.

context, a technical framework should be taken as the set of technical regulatory conditions that apply to spectrum licences in a given frequency band.

1.3 Consultation process

ACMA initiated the consultation phase of the review by writing to spectrum licensees and Accredited Persons (APs) in February 2008 seeking initial comment on current arrangements for technical frameworks. The nine responses received were considered and contributed to the identification of issues that are outlined in this discussion paper.

Respondents indicated that there was a need for ACMA to provide further guidance on the current arrangements that apply to technical frameworks. Therefore ACMA has released an information paper on current technical frameworks policy in parallel with this paper.

The paper, *Spectrum Licensing Technical Frameworks Information Paper*, provides further explanation about existing technical frameworks and the manner of their use.

ACMA encourages potential respondents to this discussion paper to also read the information paper, which is available from ACMA's website.[11]

At the close of the comment period, ACMA will analyse responses to this discussion paper and consider whether changes should be made to arrangements for future technical frameworks.

1.4 Written submissions

ACMA welcomes comments on the issues raised in this consultation paper. Comments may be forwarded by **close of business 12 June 2009** to:

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

Any other enquiries may be directed to Gabriel Phillips on (03) 9963 6711 or by email to tfreview@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.

[11] The *Spectrum Licensing Technical Framework Information Paper* is available at the following link http://www.acma.gov.au/WEB/STANDARD/pc=PC_311701

ACMA prefers to receive submissions that 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, but will consider each claim 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.

1.4.1.1 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 providing that information to another body or agency, but ACMA cannot guarantee that confidential information will not be released through these or other legal means.

1.4.1.2 Sharing of information

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

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

2 Spectrum Management in Australia

This chapter outlines the legislative, policy and regulatory context for spectrum management in Australia. It also discusses the spectrum management principles that guide ACMA's decision making on spectrum management issues within a legislative and policy setting. This chapter also discusses spectrum licensing policy.

2.1 Legislative basis for Australian spectrum management

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

- Management of the radiofrequency spectrum in accordance with the Act; and
- To advise and assist the radiocommunications community.

ACMA undertakes its responsibility to manage the radiofrequency spectrum in accordance with the objects set out in section 3 of the Act. The objects are provided in the table below.

Section 3 – Object of the Act

(a) maximise, by ensuring the efficient allocation and use of the spectrum, the overall public benefit derived from using the radiofrequency spectrum;

(b) make adequate provision of the spectrum:

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

(ii) for use by other public or community services;

(c) provide a responsive and flexible approach to meeting the needs of users of the spectrum;

(d) encourage the use of efficient radiocommunication technologies so that a wide range of services of an adequate quality can be provided;

(e) 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;

(f) support the communications policy objectives of the Commonwealth Government;

(g) provide a regulatory environment that maximises opportunities for the Australian communications industry in domestic and international markets;

(h) promote Australia's interests concerning international agreements, treaties and conventions relating to radiocommunications or the radiofrequency spectrum.

ACMA also has related spectrum management obligations under the *Broadcasting Services Act 1992*, which guide the use of spectrum in the broadcasting services bands[12]. ACMA will continue to be guided by the objects set out in the Broadcasting Services Act when making decisions on matters that fall under that Act.

ACMA must consider government policies in the performance of its functions. The Minister may also give written directions to ACMA about the performance of its functions under the Radiocommunications Act.

Radiocommunications licences are also subject to provisions in the *Trade Practices Act 1974*, which prohibit acquisitions that result in a substantial lessening of competition.

2.2 Spectrum management principles

ACMA recognises that its planning and licensing decisions may affect the shape of the market and the value of spectrum to different parties. An essential and challenging element of spectrum management is recognising and meeting the needs of existing spectrum users, while at the same time, supporting the dynamic growth and changing uses of spectrum.

In order to meet this challenge in a consistent and effective way, ACMA proposes to adopt certain principles of good regulatory process and apply an agreed set of spectrum management principles.

The spectrum management 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 aim to:

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

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. The principles are listed below.

- Principle 1—Allocate spectrum to the highest value use or uses

[12] The broadcasting services bands are those parts of the radiofrequency spectrum that, under s.31 of the Radiocommunications Act, are designated as being primarily for broadcasting purposes.

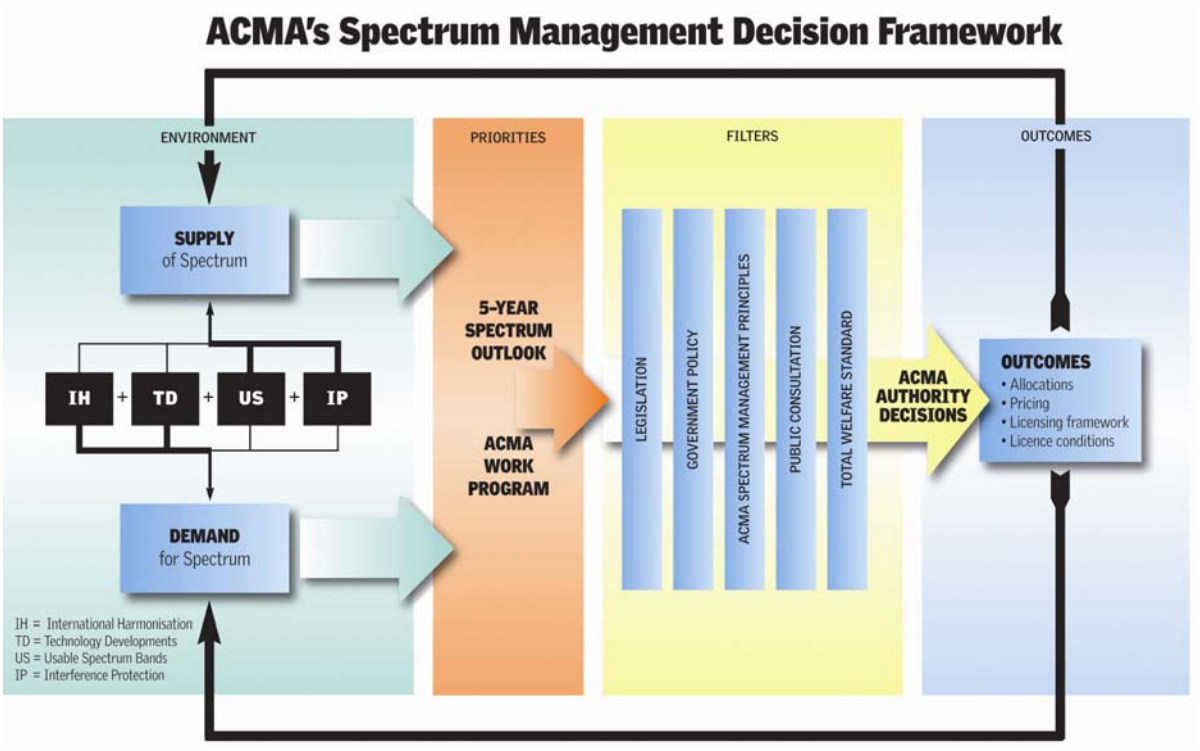
- Principle 2—Enable and encourage spectrum to move spectrum to its highest value use or uses
- Principle 3—Use the least cost and least restrictive approach to achieving policy objectives
- Principle 4—To the extent possible, promote both certainty and flexibility
- Principle 5—Balance the cost of interference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

ACMA will consider the principles when analysing responses to this discussion paper and identifying any recommended changes to technical frameworks policy as a result of this review.

2.3 Spectrum management decision framework

Figure 2.1 was developed to illustrate ACMA's spectrum management decision-making framework. It shows the use of the principles and other factors that ACMA considers in the overall process for making decisions about spectrum management.

Figure 2.1 – ACMA spectrum management decision framework



The application of the spectrum management decision framework is evident in the development of technical frameworks in the following way.

Environment

Although all the factors listed in the Environment section that influence the demand and supply of spectrum, the factor regarding interference protection (IP) may be key in the development of technical frameworks.

Priorities

The Spectrum Licence Technical Framework Review is listed as a priority on ACMA's work program and is also recognised in the current *Five Year Spectrum Outlook 2009-2013*.[13]

Filters

The development of a technical framework takes into account a number of the elements listed as filters in ACMA's spectrum management decision framework. There are legislative issues that must be addressed, as well as the need to balance government policy agendas with the objects of the Act and the spectrum management principles.

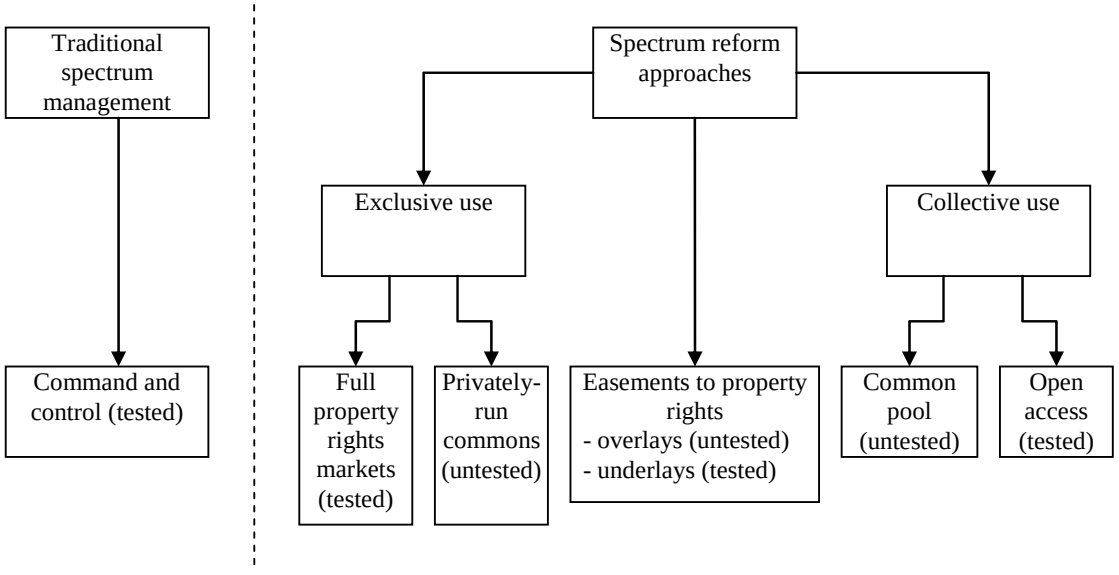
Outcomes

By taking into account the elements of ACMA's spectrum management decision framework, the delivery of a robust, defensible and effective spectrum licensing technical framework should be ensured. The technical framework would have been developed in consultation with industry and consistent with technology developments and international harmonisation of services and equipment generally.

In 2007, ACMA commissioned *The Economics of Spectrum Management – a review*[14]. The paper examines different approaches to spectrum management used by international spectrum regulators – command and control, exclusive rights, easements and commons.

Figure 2.2 illustrates standard (or mainstream) and intermediate models for spectrum management. It identifies the regulatory models that are currently being used internationally, as well as those approaches that have been identified but not yet implemented.

Figure 2.2 – Spectrum management: standard and intermediate models



[13] The *Five Year Spectrum Outlook 2009-2013* is available at the following link http://www.acma.gov.au/WEB/STANDARD/pc=PC_311686

[14] B. Freyans, School of Economics, Australian National University, 2007, *The Economics of Spectrum Management: A Review*, http://www.acma.gov.au/WEB/STANDARD/pc=PC_311025

In general terms, the apparatus licensing regime is related to the command and control approach in figure 2.2, class licensing is related to the collective use/open access model, and spectrum licensing is related to exclusive use/full property rights markets.

2.4 Spectrum licensing

Spectrum licensing is one of three licensing arrangements authorising the operation of radiocommunications devices. Spectrum licensing has been applied to frequency bands for which there is likely to be high demand, or bands which are considered likely to be of high value. Spectrum licences are usually allocated by market-based mechanisms such as auctions. They are issued for a fixed term of up to 15 years, and may be sub-divided, combined and traded[15].

Technical conditions on spectrum licences are intended to promote technology flexibility. The licences permit the deployment of any device from any site within the spectrum licensed space, subject to the conditions of the licence and relevant technical specifications.

With spectrum licence expiry and other issues appearing on the policy horizon, DBCDE and ACMA are considering the policy and licensing options available in these bands. The first spectrum licences are due to expire in 2012. The policy options available include:

- Re-issuing the spectrum licence to the person whom it was previously issued; or
- Issuing a spectrum licence to new persons; or
- Converting the spectrum licensed band to either an apparatus or class licensed band.

2.5 Expiring spectrum licences

There are a number of spectrum licences due to expire in the next five years. Any decisions regarding the future allocation of these licences will also require reconsideration of the effectiveness and ongoing utility of those existing technical frameworks for the spectrum licensed bands. ACMA must review the use of each spectrum licensed band and consider existing and proposed technologies that may be able to be deployed in that spectrum. If a decision is made to continue with spectrum licensing in a band, the options available to ACMA are:

1. Use the existing technical framework, which has been optimised for the existing technology;
2. Develop a new technical framework that provides for the co-existence of the existing technology alongside new technologies; or
3. Develop a new technical framework that takes into account the likely or expected technologies that may be available over the term of the new spectrum licence.

[15] Further information about spectrum licensing is available from http://www.acma.gov.au/WEB/STANDARD/pc=PC_300171

There are potential issues with each of these alternatives. They are as follows:

Option 1: ACMA considers it unlikely that technical frameworks developed 15 years ago would be able to adequately facilitate new technologies that may be deployed over the next licence term.

Option 2: This approach would present a challenge in ensuring that the technical framework does not limit the deployment and proliferation of new technologies.

Option 3: The effect of this option may be to make the operation of the existing technology less efficient under the new technical framework.[16]

ACMA will consider and consult with stakeholders on the appropriate options in relation to individual spectrum bands. However, ACMA invites comments on technical framework issues relating to expiring spectrum licences.

2.6 Spectrum trading

Under section 88 of the Act, ACMA may make legal instruments relating to the trade of spectrum licences. Most spectrum licences are covered by *Radiocommunications (Trading Rules for Spectrum Licences) Determination 1998* ('Trading Determination') which sets out:

- the Minimum Contiguous Bandwidth that may be traded;
- other rules such as the requirement that trades must be in whole Standard Trading Units (STUs) (see section 4.4); and
- some information that must be included when notifying ACMA of a trade.

ACMA considers spectrum trading as crucial to improving spectrum efficiency.[17] Some of the advantages of a dynamic secondary market for spectrum include:

- the facilitation of new services;
- the promotion of innovative technologies;
- the removal of barriers to market entry and promotion of competition in the supply of spectrum-derived services; and
- the improved efficiency of under utilised spectrum.

A technical restriction specific to spectrum licence trades is that resulting licences must be consistent with rules regarding size in terms of frequency and geographic area. Licences may not be divided except into whole numbers of Standard Trading Units (STUs) defined in area and frequency, and each licence must be at least the Minimum Contiguous Bandwidth (MCB). This is intended to ensure the expected technology was implemented in the

[16] For example, if the out of band emission limits for the new technology are lower than the existing technology, the existing technology will need to operate further away from the band edge to ensure compliance. Therefore, the existing technology will have to operate with a larger guard band and thus have access to less spectrum to operate in. This has the potential to influence an operator to discontinue the operation of the existing technology more quickly than it may otherwise.

17 ACMA released an industry consultation paper on Spectrum Trading, "Spectrum Trading – Consulatation on trading and third party authorisations of spectum and appartus licences" in November 2008. This paper can be found at http://www.acma.gov.au/WEB/STANDARD/pc=PC_311532

spectrum licensed bands. A consequence of these trading rules has been the prevention of fragmentation of the band resulting in orphan spectrum.

STUs and MCB are predetermined for each spectrum licensed band. Spectrum licensees can trade whole or part of a licence using these trading units as long as all the technical requirements are met. The trade takes effect after ACMA has amended the Register of Radiocommunications Licences with the new licensing information.

3 Background to Technical Frameworks

This chapter provides an explanation of the importance of spectrum licence technical frameworks for interference management and outlines ACMA's approach to the development of technical frameworks for spectrum licences. The issues discussed include the need to balance certainty and technology flexibility with the complexity of the technical framework, along with the role of the industry working group in developing technical parameters for inclusion in the technical framework.

3.1 Overview of interference management

Interference management is the fundamental goal of the spectrum licence technical framework. Although the out-of-band emission limits specified in the core conditions of a technical framework manage the interference issues between frequency adjacent spectrum licensees, it is also necessary to provide additional interference management tools for the core condition related to out-of-area emission limits to ensure transmissions do not cause unacceptable interference with geographically adjacent users. In spectrum licensed bands the primary interference management methodology is a propagation loss model.

The following should be considered in the development of any interference management methodology:

- Defined levels of interference – this is a key aspect of interference management. The interference management methodology that provides a spectrum licensee with certainty regarding the amount of power that may be received across a spectrum licence boundary.

- Technology – the technology to be deployed plays a central role in determining the propagation model to be developed. For example, technologies using TDD (single frequency) require a high site to high site model, where as technologies using FDD (two frequencies) require a high site to low site model.

- Clarity – the interference management tool should provide a spectrum licensee with a clear understanding of the conditions of the spectrum licence. While the tools may be technically complex, they should be clear and concise and allow for relatively ease of implementation.

Although the interference management methodology provides a level of certainty to a spectrum licensee, it does not ensure there will be no instances of interference. There is no legal, policy or engineering requirement to provide a completely interference free spectrum licence. It is a decision for ACMA, after consultation with industry, to determine the appropriate balance in regards to the level of acceptable interference and certainty with the overall efficiency of the interference management tool.

3.2 Australia's interference management approach

ACMA adopts a space-centric approach to interference management in the development of technical frameworks for spectrum licences. A space-centric approach defines explicit transmit rights to licensees within a defined geographic space authorised under the spectrum licence. In this approach, the maximum radiated power at each antenna is prescribed, along with interference provisions which must be adhered to.

ACMA specifies interference provisions in the form of legislative instruments, such as a determination (made under section 145 of the Act) and Advisory Guidelines (made under section 262 of the Act). Further to this, ACMA also provides public access to the Register of Radiocommunications Licences (RRL) which, amongst other things, lists all devices registered under a spectrum licence.

ACMA is confident that the space-centric approach continues to be the most effective and efficient approach to interference management. Feedback received from industry for past reviews and discussions has indicated that it also believes that this is a viable approach. Some identified benefits include:

- The ability to deploy networks with a high level of certainty regarding the possibility of interference; and
- The ability to register networks without the need for direct contact and negotiation with other licensees in most circumstances.

3.3 Overview of Technical Frameworks

A spectrum licence technical framework is the set of technical regulatory conditions and rights that apply to spectrum licences in a given band. Australian technical frameworks are based on a system of specifying explicit transmitter rights (in terms of radiated power) that provide an inherent level of receiver protection. Transmitter rights are used to manage interference at the geographic boundary from same band (or channel) services in the adjacent area.

Transmitter rights define a maximum radiated power level as a function of antenna height and distance to the boundary and also manage the potential for interference:

- at the frequency boundary from adjacent band (or channel) services in the same area unwanted emissions by specifying emission masks in terms of radiated power; and
- at the frequency boundary from adjacent band (or channel) transmissions due to non-linear effects such as blocking, selectivity and inter-modulation.

Technical frameworks may also include arrangements to manage legacy services.

Each spectrum licensed band has a technical framework that includes these elements:

- the technical conditions (called core conditions), which specify the area and frequency limits of the licence, the permitted emission outside the area and frequency limits of the licence. These conditions are provided for by section 66 of the Act and define the fundamental transmit rights of a spectrum licence;
- a methodology for determining maximum radiated transmitter power outside the geographic area of the spectrum licence. The methodology is known as the device boundary criteria (DBC) and is provided for by a determination made under section 145 of the Act relating to requirements for device registration and unacceptable interference; and
- requirements for management of non-linear interference effect and legacy services specific to each frequency band in one or more Advisory Guidelines made under section 262 of the Act relating to device coordination and alternative registration procedures.

Technical frameworks are designed to define spectrum space and to manage interference between licensees across frequency and geographic boundaries. Frameworks are further supported by technology standards and registration of certain types of equipment. When developing a technical framework, the technical parameters of the expected technology or technologies guide the creation of the technical conditions. Other technologies that may be deployed in the spectrum licensed band will also be taken into account.

3.4 Technology Flexibility and Certainty

The goal in spectrum licensing technical frameworks is to increase technology flexibility, while maintaining certainty in interference management. This approach often results in increased complexity. The technical framework for a technology inflexible framework is less complex, and the risk of interference is more easily managed. In comparison, a technology flexible framework introduces a higher level of complexity to effectively manage interference to the same risk level.

ACMA has sought to achieve a balance between complexity, flexibility and certainty by developing technical frameworks in consultation with industry stakeholders to accommodate the technologies that are likely to be used in each spectrum licensed band. This is consistent with Principle 4 of ACMA's spectrum management principles set out in section 2.2 above.

3.4.1 TECHNOLOGY FLEXIBILITY

When spectrum licensing was first introduced, the general consensus was to employ a "command and control" approach that sought to impose technical conditions enabling the deployment of a known, or intended, service or technology type. One of the reasons for restricting the numbers of technologies was to limit the potential for interference and to maximise the ability of licensees to deploy networks based on specific technologies. As the parameters and deployment of the intended technology were known, the technical framework was designed to ensure that the probability of interference between service providers using similar technologies was minimised.

More recently however, technical frameworks are being developed that enable both current (likely) and potential new technologies to operate under the one set of technical conditions without introducing any additional interference potential. The Australian spectrum licensing experience provides an example of this approach where the development of technical frameworks is considered to be "technology flexible". This is different to other approaches adopted internationally.

For example, the United States adopts a service specific approach. That is, in a given spectrum licence band a licensee must provide a specific service, such as mobile phone services or mobile wireless broadband, but the technology to provide this service is generally left to the discretion of the spectrum licensee.

In the Australian spectrum licensing environment, all current technical frameworks have been designed with technology flexibility as a goal. While the Australian communications industry is very innovative and strives to be at the forefront of technology advances, it primarily adopts global technologies and standards. This means the spectrum licensee will typically have one likely service in mind. Employing a technology flexible approach provides industry with a level of confidence in implementing the expected service, as well as allowing the opportunity to implement a different service where technically feasible.[18]

Therefore, the benefits of developing technical frameworks that facilitate the deployment of multiple technologies in the same band include[19]:

- Encouraging the movement of spectrum to its highest value use by offering flexibility in the type and number of technologies or services that are able to be deployed under the spectrum licence;
- Offering the spectrum licensee certainty in the interference management model that is provided under the technical framework;
- Providing flexibility for either a number of different services or operators to co-exist under the spectrum licence, or to trade, or partially trade, spectrum licences on a secondary market.

ACMA recognises that a technology flexible approach is appropriate and best suits the requirements of industry.

3.5 Development of technical frameworks

To date, technical frameworks have been developed by industry working groups comprised of representatives from ACMA and industry stakeholders with technical and engineering expertise. A full discussion of the process undertaken by an industry working group is

[18] An example of this is in the 2 GHz band where the majority of licensees employed 3G mobile services while one company used a proprietary technology to provide wireless broadband services.

[19] The NRAs reviewed that have demonstrated a move towards a technology flexible approach are Australia, Canada, Ofcom and CEPT.

provided in the *Spectrum Licence Technical Frameworks Information Paper*.[20] Specific issues relating to the work of industry working groups are discussed below.

3.5.1 INDUSTRY WORKING GROUPS

To ensure the specifications included in a technical framework meet the needs of those likely to use the spectrum licensed band, participation in the relevant industry working group is open to all interested industry stakeholders. Members of an industry working group will generally include:

- radiocommunications equipment manufacturers, wholesalers and retailers;
- operators or existing licensees (in the case of conversion to spectrum licensing);
- accredited persons;
- standards bodies; and
- ACMA representatives.

ACMA chairs all industry working groups to facilitate discussion that will ensure appropriate technical conditions for the technical framework are developed.

The benefits of establishing an industry working group when considering the development of technical conditions include:

- enabling an appropriate and open forum for discussion of technical and regulatory issues;
- allowing all possible technologies to be considered when creating specifications; and
- ensuring that the technical framework that is developed is appropriate for Australian requirements.

ACMA considers that the development of an industry working group to consider issues in the development of a technical framework is necessary and provides evidence of good regulatory practices.

ACMA welcomes views from industry and interested parties on the value of the industry working group process.

3.5.2 TECHNICAL FRAMEWORK DOCUMENTATION

When ACMA decides to issue spectrum licences, ACMA prepares an Applicant Information Package (AIP) that contains the following:

- an overview of spectrum licensing;
- an explanation of what is being allocated and the allocation process;

[20] The *Spectrum Licensing Technical Framework Information Paper* is available at the following link http://www.acma.gov.au/WEB/STANDARD/pc=PC_311701

- information on how to participate in the allocation process;
- an explanation of the technical framework;
- attachments to the AIP, including:
    - the relevant application forms;
    - the spectrum Designation Notice or Re-allocation Declaration[21];
    - the Marketing or Conversion Plan[22];
    - the section 145 determination (Device Boundary Criteria)[23]; and
    - the section 262 determinations (Advisory Guidelines)[24].

The Marketing Plan sets out both the regulatory and technical conditions for spectrum licences issued in the relevant band. An outcome of the consultation process from February 2008 highlighted a need for ACMA to provide additional information to further inform industry of the theory, processes and methodologies involved in developing technical frameworks for spectrum licences.

The need to supply additional information may be attributed to the inclusion of technical information within the Marketing Plan. The review of other national regulatory authorities highlighted alternate methods for documenting technical conditions. The majority of other national regulatory authorities provide technical information in documents separate to their equivalent Marketing Plan.

ACMA currently places the core conditions within Schedules of the Marketing Plan. This approach is consistent with the information provided in sections 39 and 39A of the Act. Despite this, a person who is unfamiliar with AIP, and spectrum licensing more generally, may find it difficult to locate the technical conditions. The separation of the documents may allow licensees to more readily locate and identify the relevant technical conditions.

The information paper released in conjunction with this discussion paper is partly intended to address some of these issues. Consequently, ACMA welcomes views on how the applicant information package may be improved.

[21] Section 36 of the Act refers to the Minister making a Spectrum Designation Notice for unencumbered spectrum. Section 153B of the Act refers to the Minister making a Spectrum Re-allocation Declaration that encumbered spectrum may be re-allocated by the issue of spectrum or apparatus licences, respectively.

[22] Sections 39 and 39 A of the Act provide that ACMA must prepare a Marketing Plan for unencumbered spectrum that has been designated for spectrum licensing, or where spectrum has been re-allocated for spectrum licensing, by the Minister respectively.

[23] Further analysis of the Determination made under section 145 of the Act is provided in Chapter 5.

[24] Further analysis on the Advisory Guidelines developed under section 262 of the Act is provided in Chapter 6.

Issues for comment

1. ACMA welcomes comment from industry in relation to the following issues:

- the value of the industry working group process in the development of technical frameworks for spectrum licences;
- the clarity and effectiveness of current Applicant Information Packs, and how they could be improved;
- the types of issues that ACMA should consider in relation to technical frameworks for spectrum licences that are coming up to expiry; and
- the flexibility and effectiveness of the development process for technical frameworks, and how it could be improved.

4 Core Conditions

The purpose of this chapter is to provide an overview of the core conditions applicable to spectrum licences. It also provides an opportunity for industry to comment on the development and applicability of the core conditions, and identify any possible improvements that may be considered by ACMA.

4.1 Overview of Core Conditions

The development of core conditions for a spectrum licensed frequency band is dependent upon a number of factors related to the designation or re-allocation of the spectrum by the Minister. In either case, the Minister makes a Designation Notice or a Re-allocation Declaration that specifies the frequency band that is to be allocated via the issue of spectrum licences. Further to this, the Designation Notice or Re-allocation Declaration will state whether the frequency band is to be spectrum licensed in certain geographic areas, or across the whole of Australia. Once these factors have been determined, ACMA develops appropriate technical conditions for the relevant spectrum licences in accordance with section 66 of the Act.

4.2 Specification of Core Conditions

Core conditions define the parameters of a spectrum licence. These conditions play a critical role in determining the technology flexibility of a spectrum licence. The conditions can be categorised into the following criteria:

- ***Frequency of operation*** - specifies the frequency band in which devices are authorised to operate in under the spectrum licence. This is specified using the upper and lower limits of the band.
- ***Geographic area of operation*** - specifies the geographical area to which a spectrum licence relates. Each spectrum licence will have this area detailed in terms of longitude and latitude.
- ***Out-of-band emission limits*** - controls the amount of emissions across the frequency boundaries of spectrum licences and includes limits for spurious and non-spurious unwanted emissions.

a. Non-spurious unwanted emissions[25] are modulated-generated noise or intermodulation products caused by the transmission of information, switching transient or broadband noise generated by the transmitter.

b. Spurious emissions[26] include intermodulation products, harmonics and frequency conversion products not associated with the transmission of information by the transmitter.

- ***Out-of-area emission limits*** - controls the level of emissions that fall outside the geographic area of the spectrum licence. The maximum radiated transmitter power of a licence is specified and used as part of the overall site management and control of non-linear interference.

The level of detail in the technical conditions directly affects the technology flexibility of a spectrum licence. Technical arrangements become more prescriptive if more detail is included in the technical conditions. In turn this limits the number of technologies that meet the criteria and that are therefore able to be deployed in the band. The level of detail included in technical conditions consequently depends upon the intended level of technology flexibility for a spectrum licence.

4.2.1 FREQUENCY OF OPERATION

In this core condition, ACMA specifies the part or parts of the spectrum that the operation of radiocommunications devices are authorised under the spectrum licence. Some of the issues taken into account by ACMA include:

- the minimum bandwidth likely services may require to operate efficiently;
- the operating characteristics of adjacent services; and
- the number of likely operators.

Previous consultation with industry has indicated that ACMA's process may not need to be amended. However, ACMA invites comments from licensees or and industry on possible improvement to developing this core condition.

4.2.2 GEOGRAPHIC AREA

This core condition specifies the geographic area within which operation of radiocommunications devices are authorised under the spectrum licence. Once the Designation Notice or Re-allocation Declaration is in place, ACMA undertakes some analysis of the technical, commercial and economic environment to determine appropriate geographic areas for allocation.

Generally, ACMA determines the geographic areas, or lots, after taking into account factors such as:

- The equipment available for the band and its technical specifications; or
- The location of existing services; or

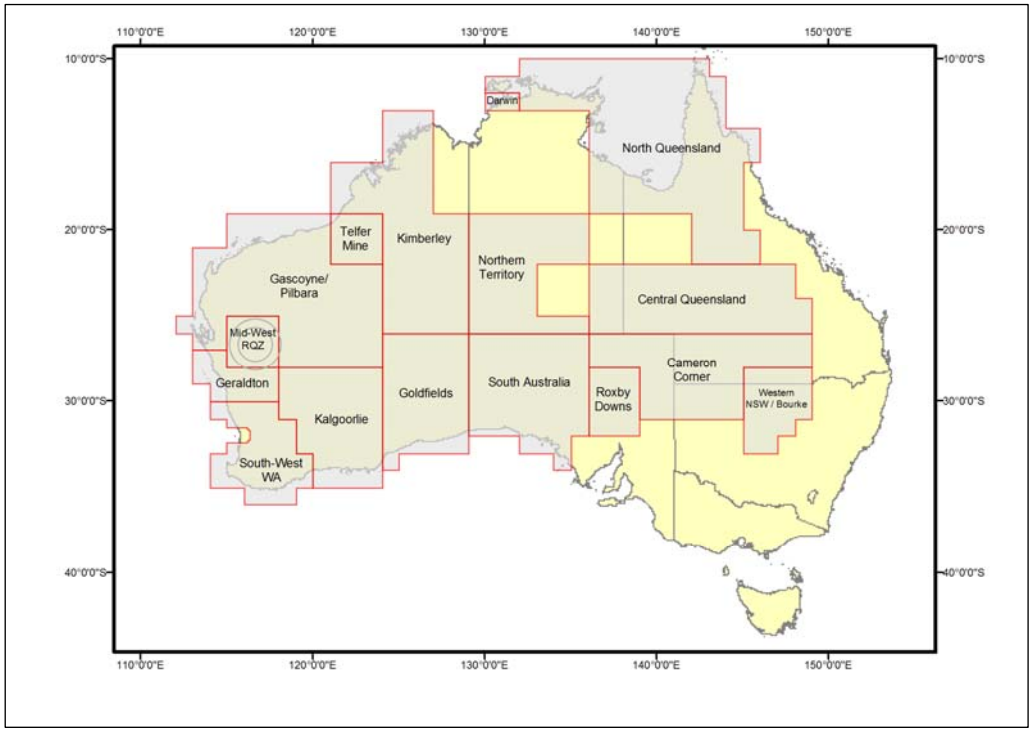
[25] Non-spurious unwanted emissions are emission that occur outside the band of operation that are expected with the normal operation of the transmitter

[26] Spurious emission are emissions that are not deliberately created outside the band of operation by a transmitter

- The economic characteristics of a community or geographic area; or
- Existing and forecast population densities for geographic areas.

For example, ACMA has recently varied the technical framework for the 2.3 GHz band and is on track to allocate the residual spectrum in the first half of 2009. During this process, ACMA consulted with interested parties on the development of a regional licence area model to allocate spectrum licences in rural and remote Australia. ACMA has used economic zones described by state and federal legislation to determine separate geographic areas in rural and remote Australia that are available for allocation. The regional licence area model is demonstrated in Figure 4.1 below. ACMA intends to use this model for the allocation of future spectrum licence bands in rural and remote Australia.

Figure 4.1 Regional Licence Area Model



Although ACMA identifies the geographic areas available for spectrum licence allocation as each technical framework is being developed, the industry working group and other interested parties are able to provide comment during the public consultation period.

ACMA welcomes comment from industry and interested parties in relation to the development of geographic areas for spectrum licences and the regional licence area model.

4.2.3 OUT OF BAND EMISSION LIMITS

This core condition specifies the maximum permitted level of radio emissions across frequency boundaries that may be caused by transmitters operated under the spectrum licence. ACMA currently specifies out-of-band emission limits by providing an emission mask.

The emission mask defines the maximum allowable spurious and non-spurious emissions for a transmitter. These emission masks are expressed as absolute values measured in X dBm EIRP/ Y kHz between given frequencies. The out of band emission limits are developed by the industry

working group and consider the emission limits of the expected and other likely technologies for the band.

The approach for specifying out-of-band limits provides a high level of certainty and in ACMA's preliminary view the underlying rationale for this approach remains valid at this time.

4.2.4 OUT OF AREA EMISSION LIMITS

This core condition specifies the maximum permitted level of radio emissions across geographic boundaries that may be caused by transmitters operated under the spectrum licence. Australia manages out-of-area emission limits using a combination of the following methods:

- Applying an absolute limit on maximum radiated transmitter power for spectrum licences by specifying the maximum transmit power EIRP in X dBm / Y kHz[27] to the horizon for a transmitter. The emission levels are to be estimated with a level of confidence not less than 95%.

- Including a requirement to calculate a device boundary to determine radiated transmitter power based on distance to the boundary and terrain.

ACMA's understanding is that the current approach in developing the technical condition specifying the out-of-area emission limit is generally well understood and applied by industry.

Issues for Comment

2. ACMA welcomes comment from industry in relation to the following issues:

- the effectiveness of the current process undertaken by ACMA to develop geographic areas for spectrum licences;

- the value of the regional licence area model for allocating spectrum licences in areas of rural and remote Australia; and

- the effectiveness of the current processes applied by ACMA in specifying the core conditions for inclusion in the technical framework, or how it could be improved.

[27] Is the amount of power in dBm measured in a rectangular bandwidth of kHz.

5 Device Boundary Criteria

This chapter provides an overview of the use of device boundary criteria and sets out possible methods for improving its application in spectrum licensing technical frameworks. A discussion on deployment constraints and device registration is also provided.

5.1 Device Boundary Criteria

ACMA applies device boundary criteria (DBC) to prevent interference to services in adjacent frequency bands and geographic areas. As a spectrum licensee places transmitters closer to a geographic boundary, they are required to reduce the maximum transmit power of the transmitters to ensure the spectrum licensee in the adjacent geographic area does not receive unacceptable interference. The DBC provides a spectrum licensee with a method for determining the maximum transmit power of a transmitter depending on its placement.

However, a recurring concern raised by some licensees has been the difficulty associated with placing transmitters close to a geographic spectrum licence boundary, predominantly at an apparatus/spectrum licence boundary.

It is impractical to provide a technical framework that provides for no interference between spectrum licenses as the result of such an approach is large and unnecessary buffer zones (areas where services can not be provided). The DBC aims to provide a balance between ensuring the use of a spectrum licence area is maximised, while managing the risk of interference to an acceptable level.[28]

5.1.1 IMPROVING THE DEVICE BOUNDARY CRITERIA (DBC)

The current level of information available in the documentation on how to calculate the device boundary criteria (DBC) may be recognised as contributing to spectrum inefficiency occurring close to spectrum licence boundaries. This section looks at possible methods of improving spectrum efficiency close to boundaries by amending the s.145 Determination and the DBC in particular. The possible areas for improvement include:

- Reducing step sizes to allow more accurate modelling of DBC; and
- Amending the DBC to encourage more efficient use of the buffer zone area.

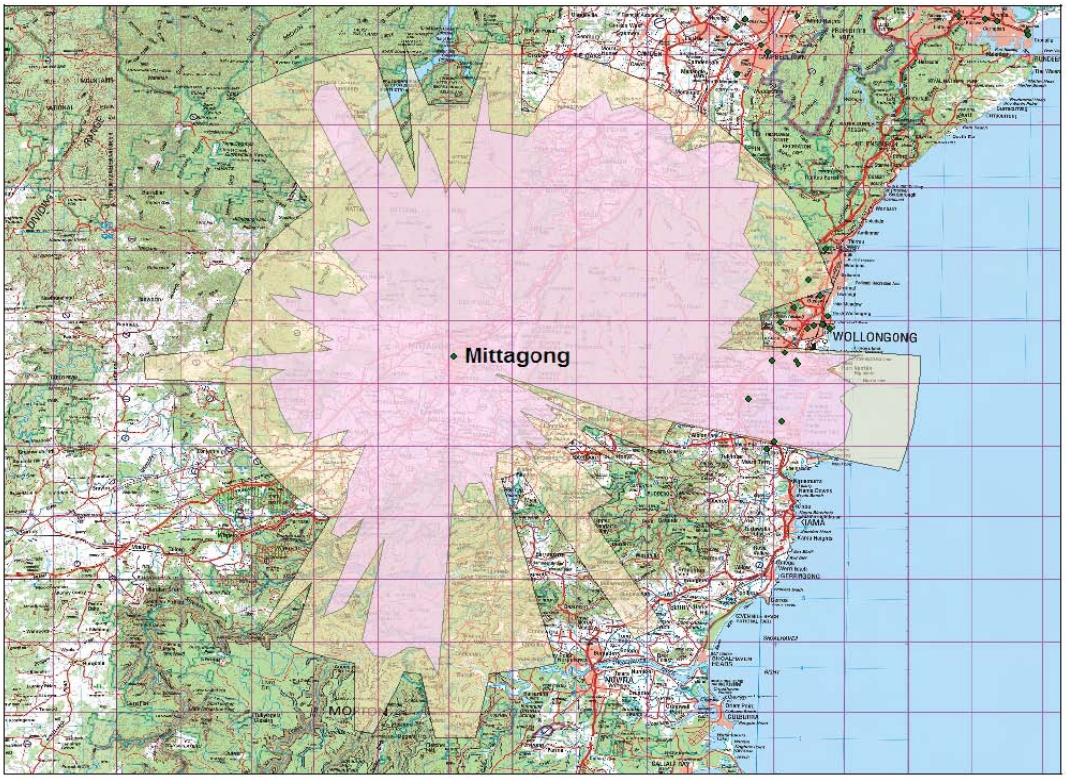
[28] The acceptable level is determined through public consultation when technical frameworks are developed

5.1.1.1 Reduction of step sizes

Step size[29] is determined during the development of a technical framework when considering of the characteristics of the band. For example, no device boundary calculation is specified for the 27, 28 & 31 GHz spectrum licences. The step size in the 500 MHz band is 5 minutes. During the creation of the first spectrum licences in 1996, the use of 5 minutes was considered practical given the DBC modelling technology of the day. In the development of the 2 GHz band in 2000, 1 minute steps were considered appropriate without a substantial increase in risk of interference.

Figure 5.1 demonstrates how different step size resolutions impact on the device boundary polygon. ACMA intends to continue the practice of determining step size (and the need for DBC) on a case-by-case basis in the development of future technical frameworks.

Figure 5.1 1800 MHz Example Device Boundary Criterion*



* applied to an omni-directional transmitter using 1 minute segment increments (the smaller red polygon) and 5 minute segments (the larger yellow polygon).

5.1.1.2 Encouraging efficient use of buffer zone areas

The application of the current DBC methodology results in situations where spectrum licensees are required to negotiate with licensees of adjacent spectrum licence areas to deploy transmitters in buffer zone areas. For the purposes of discussion the buffer zone is assumed to be 30 km, but this would vary between bands depending on the characteristics present in the particular situation.

[29] The incremental increase (m·1) minutes in distance by reference to the Australian National Spheroid along a radial

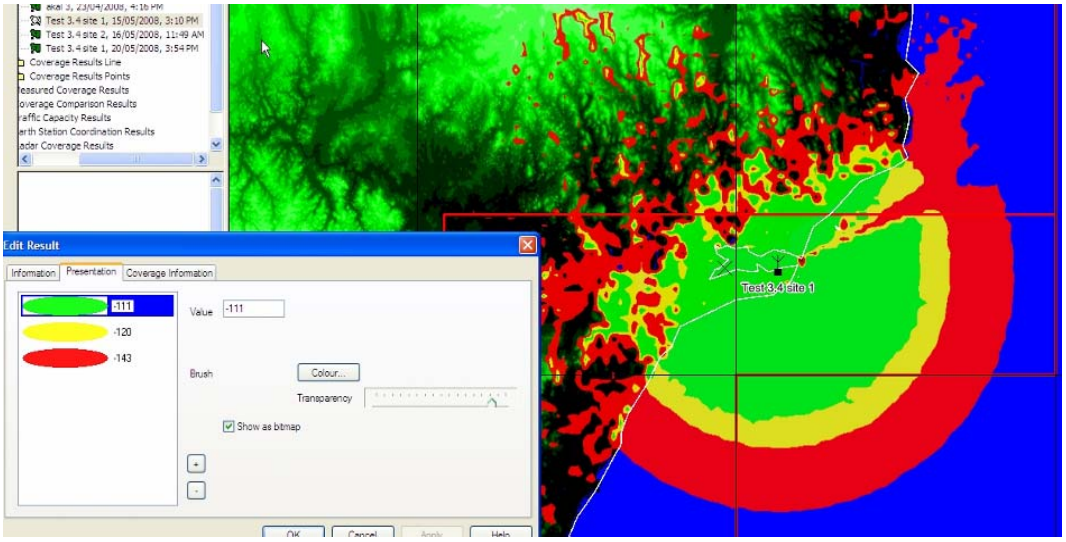
ACMA is considering the use of the following approaches in developing future DBC to encourage efficient use of the buffer zone of spectrum licence areas. ACMA has considered the following scenarios:

- device boundaries over water; and
- transmitters within 30 km of a boundary.

Device boundaries over water

The first scenario analyses a transmitter that has been deployed along a coast line near a spectrum license boundary. It is recognised that propagation distances over water will be much larger than propagation distances over land. Figure 5.2 illustrates a transmitter in the spectrum licensed 3.4 GHz band that is located approximately 29 km from the spectrum licence boundary. The green zone indicates the area where the received power level is greater than the sensitivity level of the receiver, that is, the coverage area. The red zone indicates where the transmitter fails to meet the DBC, that is, the interference area.

Figure 5.2 Spectrum licensed transmitter near water



Possible solutions for the scenario where a transmitter is

- within the buffer zone; and
- where the radial meets a device boundary over a body of water; and
- the transmitted signal extends over the body of water to the end of the radial;

are:

1. the DBC is not required as the length of the radial being over water implies that an adjacent spectrum licensee (if there is one) will not suffer unacceptable interference; or

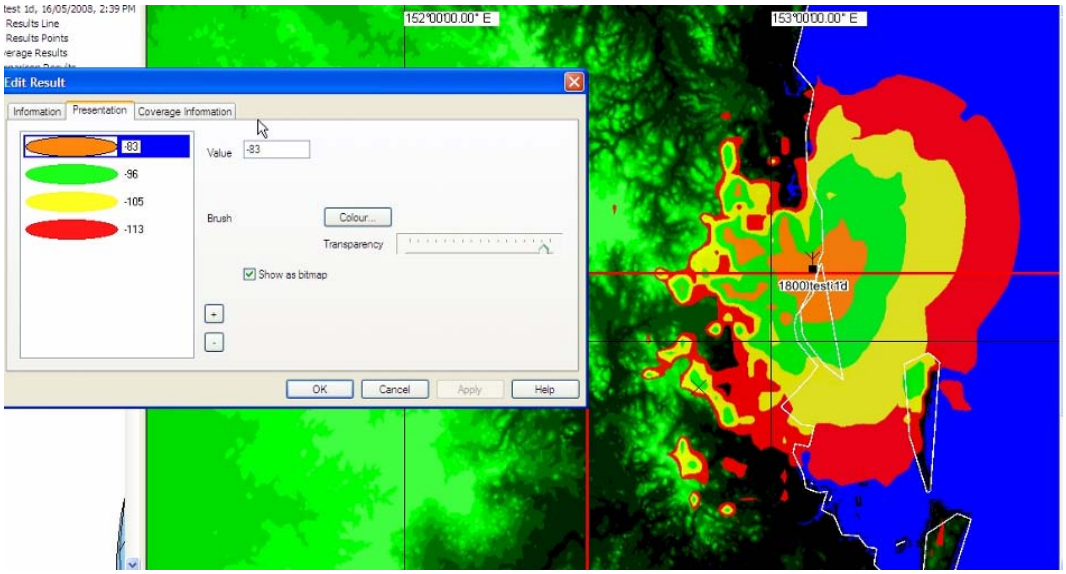
2. the DBC scaling parameter is adjusted to accommodate the altered propagation characteristics; or

3. an additional DBC is created to accommodate this situation.

Transmitters within 30 km of a boundary

The second scenario demonstrated in Figure 5.3 below analyses a 3 sector transmitter that has been deployed in the 1800 MHz band approximately 5 km from the spectrum licence boundary. The EIRP used by the transmitter was 53 dBm. The orange zone indicates the guaranteed coverage area from the transmitter. The green zone indicates the area where the received power level is greater than the sensitivity level of the receiver. The red zone indicates where the transmitter fails to meet the DBC.

Figure 5.3 1800 MHz transmitter deployed near a boundary



One possible solution would be to develop an additional DBC for transmitters that are within 30 km from a boundary. The additional DBC for these transmitters could include:

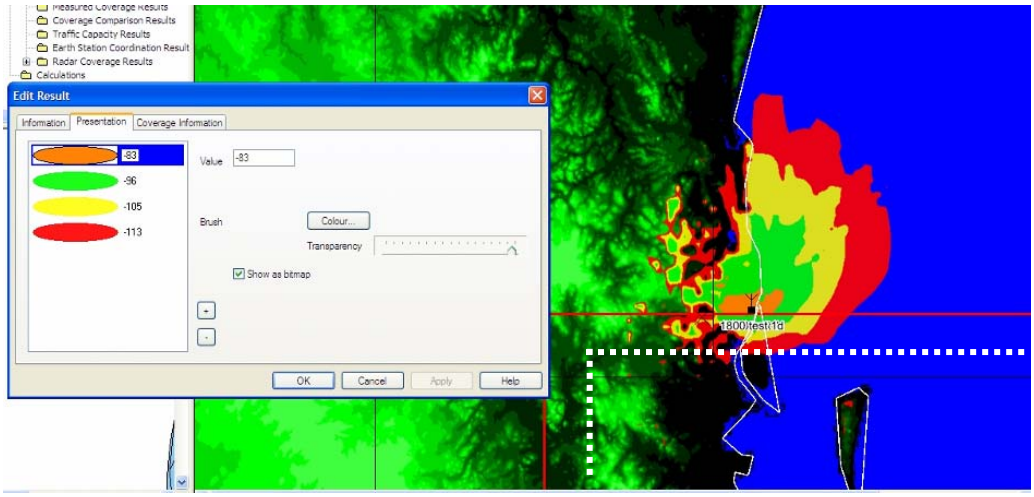
1. A requirement for transmitters within 30 km of the device boundary to calculate a DBC to X km past the boundary. Both the distance and DBC (i.e. the interference level) would be specific to each band and would need to be considered by the industry working group developing the technical framework.

2. A requirement for transmitters to meet an additional DBC to ensure fortuitous coverage is minimised. This additional DBC would be similar to the revised DBC, except it would be calculated on a coverage level and not a LOP.

Figure 5.4 illustrates the same transmitter shown above in Figure 5.3 using the proposed DBC. To meet the proposed DBC, the transmitter was changed from a 3 sector to a single sector transmitter

pointing directly away from the spectrum licence boundary. The transmitter's EIRP was maintained at 53 dBm. The DBC was calculated to 15 km past the boundary for amendment #1 and the guaranteed coverage area level was used for amendment #2. The orange zone indicates the guaranteed coverage area from the transmitter. The green zone indicates the area where the received power level is greater than the sensitivity level of the receiver. The red zone indicates where the transmitter fails to meet the DBC. The white dotted lines detail the distance of 15 km from the spectrum licence boundary

Figure 5.4 1800 MHz transmitter deployed near a boundary meeting modified DBC



In this situation, the transmitter would meet the proposed DBC requirements.

5.1.2 SUMMARY

While the current DBC approach used in Australia has a number of benefits, there are areas where it can be improved. ACMA has suggested ways in which spectrum could be used more efficiently at geographic boundaries.

The reduction in step sizes will allow a more accurate DBC to be created. This will allow a licensee to place a transmitter closer to the geographic licence boundary, while still adhering to the DBC. Amending the DBC for transmitters near boundaries over water will allow transmitters to be registered using the s.145 Determination, where previously they would have not been able to. The amendment of the DBC for transmitters within 30 km of a boundary will allow licensees to provide coverage closer to a boarder. While this may increase the probability of interference within a limited distance from the boundary, this is an area that is unused due to current DBC arrangements.

ACMA has identified an area for improvement relating to the documentation of technical or engineering assumptions that are made regarding the development of device boundary calculations for the technical framework. While the device boundary is determined by the industry working group and used in the technical framework, the methodology and assumptions (such as the maximum power allowed at the licence boundary, also known as the Level of Protection) that are applied are not always recorded. This consequently results in a perceived lack of transparency about the device boundary calculation.

By improving the documentation and recording processes for the development of the technical framework, spectrum licensees and industry will be informed and have an understanding of the basis of the technical requirements.

5.2 Deployment constraints

Technical frameworks may impose some additional constraints on the deployment of transmitters. The deployment constraints vary from band to band. The constraints are generally expressed in terms of effective antenna height or through limits on power levels.

The decision to apply deployment constraints is based on analysis of the standards for the service likely to be deployed in the band. The standards are reviewed and the deployment constraints specified by the industry working group process during the development of the technical framework.

It is ACMA's view that the current identification of possible deployment constraints to be applied on a case by case basis is effective. However, ACMA welcomes comment from industry in relation to the development, and application, of deployment constraints in spectrum licence technical frameworks generally.

5.3 Device registration

Licensees are required to comply with the conditions of the spectrum licence through mandatory certification and registration of transmitters on the Register of Radiocommunications Licences (RRL).[30] The device registration process allows for both paper and electronic submissions, however electronic submissions appear to be the norm.

The RRL is available to the public via the ACMA website; however it is recommended that industry subscribe to the CD-ROM that contains an extract of the data contained in the RRL.[31]

Compliance with the certification and registration process assures ACMA, and other licensees, that a spectrum licensed device does not cause unacceptable interference, either outside its geographic area or outside its allocated bandwidth.

It is ACMA's view that the condition regarding device registration is necessary in terms of overall management of interference. However, ACMA invites comment from industry on the effectiveness of device registration and any possible improvements to this process.

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[30] It is important to note that some transmitters in spectrum licensed bands may be exempt from the device registration process. Generally, the exemption is applied to some mobile transmitters or those fixed transmitters that operate with low power or are located within premises. Further details on the exemption are provided in the licence conditions and are available in the respective marketing plan for the band.

[31] The CD-ROM is available from ACMA for $114.40 AUD (GST inclusive) postage paid within Australia. A set of order forms and end-user agreements, together with instructions for purchasing a copy of the CD-ROM, is at available at: http://www.acma.gov.au/WEB/STANDARD/pc=PC_1613

Issues for Comment

3. ACMA welcomes comment from industry in relation to the following issues:

- the effectiveness of the current method used to specify the device boundary criteria, and how it could be improved;
- the effectiveness of the current method used to specify deployment constraints, and how it could be improved; and
- the effectiveness of the current device registration process, and how it could be improved.

6 Advisory Guidelines

Advisory Guidelines are made in accordance with section 262 of the Act to enable effective coordination between licensees. The Advisory Guidelines set out coordination and protection criteria for transmitters and receivers deployed in any frequency bands and geographic areas in, or adjacent to, the spectrum licence. This section discusses the role of Advisory Guidelines and provides interested parties with an opportunity to comment on their overall effectiveness.

6.1 Overview of Advisory Guidelines

The types of interference issues addressed in the Advisory Guidelines are based on concerns regarding the potential for interference to new or existing services that may have been raised by the industry working group in the development of the technical framework. Generally there are two guidelines for each spectrum licensed band including:

- An Advisory Guideline providing protection for spectrum licensed receivers; and
- An Advisory Guideline providing protection for frequency-adjacent apparatus and class licensed receivers.[32]

There is also a third Advisory Guideline that is applicable to all spectrum licences, irrespective of frequency band. The *Radiocommunications Advisory Guideline (Registration of Devices under Spectrum Licences without an Interference Impact Certificate) 1998* provides specific information relating to the registration of devices that do not comply with the core conditions specified in the spectrum licence or the applicable device boundary criteria.

6.1.1 PROTECTION OF SPECTRUM LICENSED RECEIVERS

Out-of-band interference refers to a number of non-linear types of interference that may occur across the frequency boundaries of licences.

[32] Some bands have additional Advisory Guidelines made under section 262 that may also be applicable. It is advisable to consult the relevant technical framework documentation to determine the actual s262 guidelines for that spectrum licensed band. Technical frameworks can be found on the ACMA website - http://www.acma.gov.au/WEB/STANDARD/pc=PC_1583

Out-of-band interference management:

- has the potential to extend either side of the frequency boundary of the spectrum licence for many MHz; and
- is dependent on the quality of the receiver as well as the levels of transmitter emission.

For ACMA, the process of managing out-of-band interference presents a different challenge to that of managing in-band interference because of the difficulties associated with accurately predicting the levels of unwanted emissions.

As a result of the above issues, the Advisory Guidelines now include Minimum Level of Receiver Performance requirements to effectively manage out-of-band interference. The receiver requirements are informed by the members of the industry working group and internationally recognised standards which consider factors such as receiver selectivity[33], blocking[34], intermodulation immunity[35] and spurious response immunity.[36]

It is ACMA's view that the Advisory Guidelines for the protection of spectrum licence receivers are effective and may not require any adjustment. However, ACMA welcomes comment from industry in relation to the effectiveness or development of Advisory Guidelines to protect spectrum licensed receivers.

6.1.2 PROTECTION OF APPARATUS AND CLASS LICENSED RECEIVERS

ACMA also applies Advisory Guidelines to afford the same level of protection to existing apparatus and class licensed receivers from spectrum licensed transmitters. As potentially affected services vary considerably in the different spectrum licensed bands, band specific guidelines for each new spectrum licensed band are required.

It is ACMA's view that the Advisory Guidelines that protect existing apparatus and class licensed devices are effective and valued by industry. However, ACMA welcomes comment from industry in relation to the effectiveness and development of Advisory Guidelines to protect existing services.

6.1.3 REGISTERING A DEVICE WITHOUT AN INTERFERENCE IMPACT CERTIFICATE

The purpose of the *Radiocommunications Advisory Guideline (Registration of Devices under Spectrum Licences without an Interference Impact Certificate) 1998* (referred to herein as the

[33] Receiver selectivity is a measure of the ability of the receiver to receive a wanted signal in the presence of an unwanted frequency-adjacent signal at a given frequency offset. Selectivity of a receiver relates to its Radio Frequency (RF) and Intermediate Frequency (IF) bandwidth specifications.

[34] Blocking is a measure of the ability of a receiver to receive a wanted signal, in the presence of a high level unwanted interferer on frequencies other than those of the adjacent channels. Receiver blocking relates to the receivers RF bandwidth characteristics.

[35] Intermodulation immunity is a measure of the ability of the receiver to receive a wanted signal without the receiver's grade of service falling below the compatibility requirement due to the presence of two or more unwanted interfering signals which have a specific frequency relationship to the wanted signal. This immunity relates to the RF bandwidth and linearity performance characteristics of the receiver.

[36] Spurious response immunity is a measure of the ability of the receiver to discriminate between the wanted signal at its nominal frequency and an unwanted signal to which the receiver responds. Spurious response immunity is related to the RF bandwidth and signal mixing characteristics of the receiver.

Registration of Devices without an IIC Advisory Guideline) is to set out ways in which a device under a spectrum licence can be registered although it does not comply with the requirements of the relevant device boundary criteria as set out in the s.145 Determination.

These devices can only be registered when:

- increased emission levels are contained within the licence due to frequency and distance separation from the boundaries of the spectrum licence (guard space); or
- affected licensees in adjacent frequency or geographic areas agree to allow increased levels of emissions from the device to spill into their spectrum space which is recognised as either a Spectrum Sharing Agreement or Core Condition Agreement.

6.1.3.1 Guard space

The basic principle of guard space is that an AP may issue an IIC if they are satisfied that a spectrum licensed transmitter is sufficiently isolated from other potentially affected devices, and that it will not cause unacceptable interference to adjacent licensees. Further information on the guard space option is provided in the *Spectrum Licensing Technical Frameworks Information Paper*.

Although the procedure for determining whether sufficient guard space is available is not clear, it is ACMA's view that this provision is required nevertheless. ACMA invites comment from industry in determining whether formal criteria should be developed regarding guard space for particular spectrum licensed bands. An example of a possible criteria could be specifying that transmitters within X km for a given spectrum licensed band would be eligible to be registered using guard space. If industry indicates support for the development of formal criteria, it appears that the most appropriate forum would be the industry working group in their consideration of the overall technical framework. ACMA invites comment on this issue also.

6.1.3.2 Spectrum Sharing Agreements

ACMA will accept an application for a device registration if a spectrum licensee is able to provide evidence of an agreement with other licensees who could be affected by emissions from transmitters operating under the spectrum licence that do not meet the s.145 Determination. It is important to note that the existence of a spectrum sharing agreement does not allow for the variation of core conditions applicable to the spectrum licence. It is ACMA's view that the ability for spectrum licensees to enter into spectrum sharing agreements with affected licensees is an effective interference management technique.

6.1.3.3 Core Conditions Agreements

Spectrum licensees are able to form agreements with other licensees to allow devices to be registered that fail to meet the core conditions of the spectrum licence. These agreements are core condition agreements. ACMA will accept an application for a device registration if a spectrum licensee is able to provide evidence of a core condition agreement with other licensees who could be affected by emissions from transmitters operating under the spectrum licence.

It is ACMA's view that the ability for spectrum licensees to enter into core condition agreements with affected licensees is an effective interference management technique.

6.2 Effectiveness of the Registration of Transmitters Using Advisory Guideline

It is ACMA's view that device registration requirements are necessary as part of an overall interference management strategy. Compliance with such certification and registration processes provides assurance to ACMA and other licensees that a spectrum licensed device should not cause unacceptable interference outside its geographic area or allocated bandwidth.

Consultation with industry indicated that Advisory Guidelines made under s.262 are effective instruments for interference management. However, this indication contrasts with ACMA's analysis of the number and types of devices that are registered in accordance with the Guideline. Analysis has suggested that:

- Only 2% of all spectrum licence transmitters that are registered on the RRL have been registered in accordance with the Registration of Devices Advisory Guideline (as opposed to the 98% who are registered under s.145 Determinations – see footnote 46 below)*;*
- The majority of these registered transmitters belong to 2 licensees; and
- The majority of registered transmitters are located in either low density or remote areas.

It is ACMA's view that the limited number of transmitters registered using the various Advisory Guidelines made under s.262 of the Act can be attributed to the fact that the majority of spectrum licensed services are deployed in medium and high density areas. In addition, ACMA does note that the registration process is complex and may need to be reviewed into the future.

Issues for Comment

4. ACMA welcomes comment from industry in relation to the following issues:

- the effectiveness of the current approach in developing Advisory Guidelines to protect spectrum licensed receivers, and how it could be improved
- the effectiveness of the current approach in developing Advisory Guidelines to protect existing services or transmitters, and how it could be improved
- whether the Registration of Devices without an IIC Advisory Guideline is a useful tool for interference management
- whether formal criteria should be developed regarding the application of guard space for particular spectrum licensed bands. If so, how should the criteria be developed; and who should be involved in determining their development?

7 Future Considerations

For its review of spectrum licensing technical frameworks, ACMA has considered a number of existing and emerging spectrum management issues across both domestic and international markets. One issue that is likely to have a significant impact on future technical frameworks is the ability to accommodate technologies that can provide significant spectrum utilisation advantages. These advantages may provide the ability for multiple spectrum users to operate in the same spectrum licensed space, therefore providing greater spectrum efficiency.[37]

Current technical frameworks are designed to allow one licensee to control devices that are operated in a given geographic area and frequency band. However, this can lead to the under utilisation of spectrum in some cases, where other valuable uses may be possible. With increasing demand for access to spectrum, new technologies are being developed that can operate in the same geographic area and frequency band as another technology, meanwhile causing minimal or no interference to the existing technology. The terms *overlay* and *underlay* are increasingly used to describe these technologies and techniques.

An *overlay* technology is designed to operate in spectrum that is not being used by the existing primary user at a specific time and location. Although they operate at a power that could cause interference to the primary user, overlay technologies have the potential to avoid interference. By constantly monitoring their surroundings, systems using overlay technology have the ability to dynamically move their transmission to spectrum unused by the primary user in order to minimise and potentially avoid interference. The term *Dynamic Spectrum Access Network* (DySpAN) is used to describe a range of overlay type technologies.

An *underlay* technology is designed to operate at such a low power level that it can function in the proximity of other radiocommunication devices without causing harmful interference. Examples of underlay technologies include *Ultra wide band* (UWB) devices and the low powered body scanners tested by the Office of Transport Security.

An important difference between overlay and underlay technologies is nature of their potential impact on the interference environment to the primary user. In the case of overlay technologies, the goal is that they would not transmit simultaneously on the same frequency and area as the

[37] The authorisation of multiple spectrum users in the same spectrum licensed space is available under the current regulatory arrangements. This could include options such as third party authorisations and the issue of apparatus licences in spectrum licensed bands; or possible future options, such as class licensing in a spectrum licence band. ACMA recognises that future options, such as the class licensing in spectrum licensed space, will require amendments to the Act.

primary user and would therefore normally cause minimal, or no, interference. However, in practice it is possible that the dynamic spectrum access techniques might not provide adequate protection for the primary user. In the case of underlay technology, the idea is that secondary user's transmission would always be present, albeit at a sufficiently low power level that it would not impact significantly on the primary user. However, in practice there may be complexities associated with addressing aggregated interference from multiple 'underlay' users.

It may be challenging for ACMA and an industry working group to develop technical frameworks that facilitate the use of these types of technologies, while still providing sufficient certainty to the spectrum licensee. While outside the scope of this review, ACMA is considering the regulatory arrangements that would be required to facilitate underlay and overlay technologies while providing appropriate protection to primary services.

The following sections provide one example of overlay and underlay technologies, DySpAN and UWB respectively, and a discussion of possible implications that may need to be considered in developing future technical frameworks.

7.1 Spectrum Access Requirements using Dynamic Spectrum Access Networks

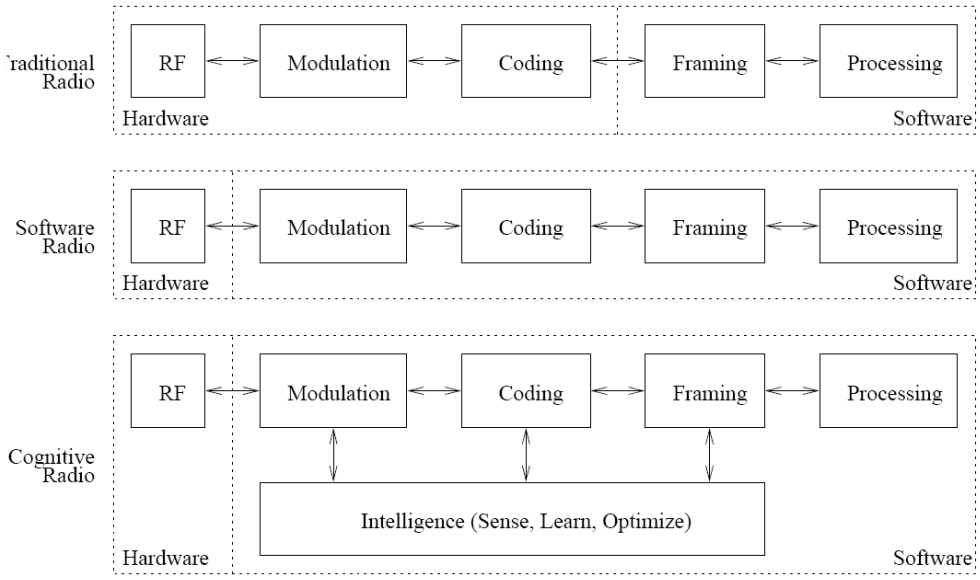
The concept of dynamic spectrum access networks (DySpAN) is the ability for a system to adapt its operation to achieve greater spectrum efficiency. Spectrum use may be subsequently improved through opportunistic access to spectrum that does not cause interference to existing users.

Two technologies that have made DySpANs possible are Software Defined Radio and Cognitive Radio. A Software Defined Radio (SDR) system is a radio communication system where components that have typically been implemented in hardware are instead implemented using software on a personal computer or other embedded computing device. Cognitive radios are essentially software defined radios with artificial intelligence, capable of sensing and reacting to their surroundings. Figure 7.1 below graphically contrasts traditional radio, software radio, and cognitive radio.

Analysis of available equipment on the international market has indicated that DySpANs are capable of operating in high demand spectrum bands, such as the class-licensed ISM bands, 2.4 GHz and 5.8 GHz, and the apparatus licensed land-mobile bands, 400 MHz and 500 MHz, respectively.

Regulators will face a challenge in developing regulatory arrangements that improve or maintain equivalent technical efficiency, through effective interference management, for technologies such as DySpAN into the future.

Figure 7.1 Comparison of traditional, software defined, and cognitive radio



7.1.1 DYSPAN TECHNOLOGIES AND CURRENT REGULATORY ARRANGEMENTS

A number of dynamic spectrum access scenarios in spectrum licensed bands are already possible under existing regulatory arrangements including:

- Spectrum trading;
- Spectrum leasing; and
- Third party agreements.

A spectrum licensee prepared to authorise the operation of DySpAN technologies might consider real time spectrum trading[38] or leasing, or perhaps even selling under utilised frequency (white space) capacity to secondary users, in order to extract greater value from their licence holding.

Spectrum pooling[39] refers to the proposed practice of licensees cooperating with each other to pool their under utilised spectrum to generate greater spectrum capacity. Parties engaged in a spectrum pooling arrangement could sell their collective unused capacity to secondary users, or to each other. The purpose of this approach would be to increase spectrum efficiency by encouraging greater use of the spectrum. In a spectrum pooling scenario, third party agreements could be

[38] See S Gandhi, C Buragohain, Cao Lili, Zheng Haitao and S Suri, *A General Framework for Wireless Spectrum Auctions*, New Frontiers in Dynamic Spectrum Access Networks, 2nd IEEE International Symposium on DySPAN 2007, 17 – 20 April 2007

[39] See F Jondral, *Cognitive Radio: A Communications Engineering View*, IEEE Wireless Communications Magazine, Vol 14 No 4. August 2007. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4300980

formed between spectrum licensees, or other users, for spectrum that may be under utilised. The agreement will need to be consistent with the core conditions for the spectrum licence.

All spectrum licences have provisions for spectrum licensees to trade or lease either completely unused spectrum (i.e. in the frequency-domain - known as whitespace) or intermittently used spectrum (i.e. in the time-domain – known as greyspace). However, there have only been a limited number of trades or third party agreements between companies. The introduction of DySpANs may increase industry willingness to consider third party authorisation of spectrum on a real-time basis.

Depending on the business case, a spectrum licensee may prefer to lease spare capacity of its spectrum, retaining ownership and control over the licence. Similarly, an access seeker may prefer not to take on the full obligations of purchasing and maintaining dedicated spectrum. Third party agreements can allow for DySpANs to be introduced into a market without changes to the Australian radiocommunications regulatory arrangements.

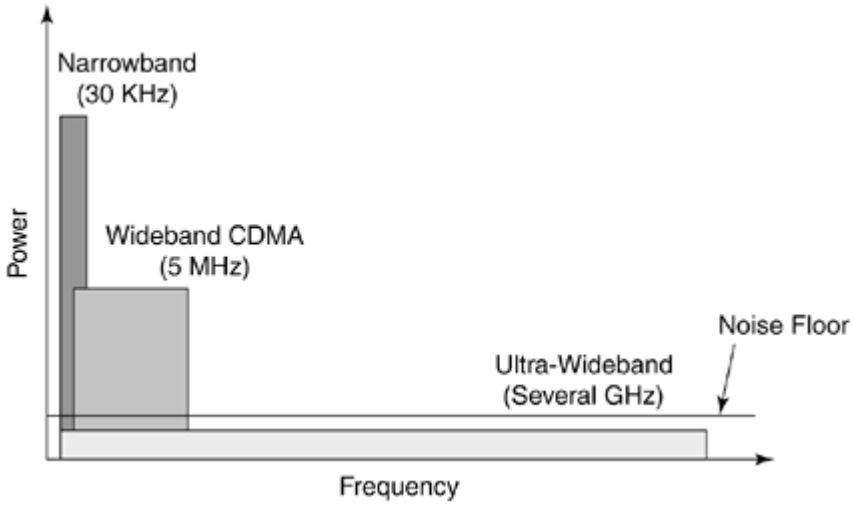
The above scenarios assume the operation of similar radio technologies operating by multiple users or licensees. Regulatory and technical challenges arise when heterogeneous radio access technologies seek to share the same spectrum in a dynamic coordinated manner. While using an interference management practice that coordinates to an area instead of to a specific technology provides a level of technical flexibility, more consideration would obviously need to be given once dynamic spectrum access technologies further develop and network design approaches are more defined.

7.2 Ultra Wideband (UWB) Technology

Ultra Wideband (UWB) technology involves the radiation, reception and processing of radiofrequency emissions with very wide bandwidths. The emission might be used to illuminate an object for the purposes of wideband spectral analysis, as in the case of radar, or to provide a means of interference-tolerant communications in a multi-path radio environment.

The bandwidths used by UWB technologies can often be up to 100 times larger than the bandwidth of other technologies operated at similar frequencies. For example, a 24 GHz UWB transmitter might occupy a bandwidth exceeding 5 GHz, whereas a 24 GHz wideband microwave link might occupy a bandwidth of 50 MHz. This large bandwidth usage is offset by very low power density levels, which means UWB devices essentially operate below the noise floor. A comparison of the bandwidth and power levels used by UWB and other technologies is illustrated in the figure 7.3 below.

Figure 7.3 Comparison of transmit power between UWB and other technologies



7.2.1 APPLICATIONS OF ULTRA WIDEBAND

UWB technology was originally developed for 'non-civilian' usage such as military radar and communication services. More recently, new applications such as commercially available data communication services, as well as 'civilian' radar systems and safety applications have been introduced globally.

7.2.2 UWB AND CURRENT REGULATORY ARRANGEMENTS

The Australian radiocommunications licensing arrangement that is best suited for short range devices is that of class licensing[40]. Existing class licences currently support the operation of a number of types of conventional short-range devices. Although some applications may require licensing under other arrangements, it is ACMA's view that the majority of UWB applications could be accommodated in the current class licence arrangements provided they do not cause unacceptable interference to other services

Under current arrangements, s138 of the Act precludes the issuing of a class licence authorising the operation of radiocommunications devices in a part of the spectrum that is designated or declared for spectrum licences[41]. In other words, ACMA is not able to issue a new class licence in a spectrum licensed band, even if it had the agreement of all the spectrum licensees in the frequency band[42].

Legislative amendments to the Act would be required to allow ACMA to consider the inclusion of class licences in spectrum licence space. This issue is beyond the scope of the current paper.

A further regulatory challenge relating to UWB technologies relates to the significant bandwidth that this technology typically occupies. The significant bandwidth employed by UWB

40 CEPT regulates short range UWB devices under its current framework short range devices. This framework allows users to operate a range of standards compliant devices without the need for an individual licence.

41 This issue was discussed in the following ACMA discussion paper, *"Proposal to amend the Radiocommunications Act 1992"*, 2005, http://www.acma.gov.au/WEB/STANDARD/pc=PC_100494#radcom

42 In areas and frequency bands that are not spectrum licensed, the ACMA is able to issue both apparatus and class licences.

technologies may span radiofrequencies that are allocated to other service types in the *Australian Radiofrequency Spectrum Plan*. For example, a 24 GHz UWB transmitter with 50 MHz bandwidth may span frequencies used for other services allocations, such as microwave fixed links, space research, radio astronomy, amateur radio and satellite communications, respectively.

Issues for comment

5. ACMA welcomes comment from industry regarding possible new technologies, including sharing issues, safeguards, etc., which may impact the development of spectrum licence technical frameworks into the future.

8 Summary

This paper is intended to facilitate and inform discussion on a number of issues relating to technical frameworks used for spectrum licensing. Comment is sought on the issues raised in this paper (outlined below) and any others considered relevant. Responses to this paper will be employed in any future development of detailed strategies for future spectrum licensing technical frameworks.

From its internal evaluation, ACMA has formed views on the following points:

- the current methodology that Australia employs in the development of spectrum licence technical frameworks is consistent with international framework methodologies and is appropriate for Australian requirements;
- consultation with an industry working group is the most appropriate forum for creating a technical framework;
- the current method for specifying technical conditions, known as core conditions, is appropriate for Australian requirements;
- the current method for managing interference using the s.145 determination is appropriate for Australian requirements;
- in lower frequency bands, the deployment of transmitters within 30 km of a geographic spectrum boundary is restrained by current specifications in the s.145 determination;
- the current method for managing interference using the s.262 determination is appropriate for Australian requirements; and
- the creation of future technical frameworks will require underlay and overlay technologies to be considered.

8.1 Issues for comment

ACMA welcomes industry and government comment of the discussion raised in this paper. A summary of the issues raised for comment is provided below.

Chapter 3 – Technical Frameworks Background

1. ACMA welcomes comment from industry in relation to the following issues:

    - the value of the industry working group process in the development of technical frameworks for spectrum licences;
    - the clarity and effectiveness of current Applicant Information Packs, and how they could be improved;
    - the types of issues that ACMA should consider in the development of technical frameworks for spectrum licences that are coming up to expiry; and
    - the flexibility and effectiveness of the development process for technical frameworks, and how it could be improved.

Chapter 4 – Core Conditions

2. ACMA welcomes comment from industry in relation to the following issues:

    - the effectiveness of the current process undertaken by ACMA to develop geographic areas for spectrum licences;
    - the value of the regional licence area model for allocating spectrum licences in areas of rural and remote Australia; and
    - the effectiveness of the current processes applied by ACMA in specifying the core conditions for inclusion in the technical framework, or how it could be improved.

Chapter 5 – Device Boundary Criteria

3. ACMA welcomes comment from industry in relation to the following issues:

    - the effectiveness of the current method used to specify the device boundary criteria, and how it could be improved;
    - the effectiveness of the current method used to specify deployment constraints, and how it could be improved; and
    - the effectiveness of the current device registration process, and how it could be improved.

Chapter 6 – Advisory Guidelines

4. ACMA welcomes comment from industry in relation to the following issues:

    - the effectiveness of the current approach in developing Advisory Guidelines to protect spectrum licensed receivers, and how it could be improved.
    - the effectiveness of the current approach in developing Advisory Guidelines to protect existing services or transmitters, and how it could be improved.
    - whether s.262 (the Registration of Devices Advisory Guideline) is a useful tool for

interference management.

- whether formal criteria should be developed regarding the application of guard space for particular spectrum licensed bands. If so, how should the criteria be developed; and who should be involved in determining their development.

Chapter 7 – Future Considerations

5. ACMA welcomes comment from industry regarding possible new technologies, including sharing issues, safeguards etc., which may impact the development of spectrum licence technical frameworks into the future.