CONTEMPORARY SPECTRUM MANAGEMENT IN AUSTRALIA

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ABSTRACT

The already intensive use of the radiofrequency spectrum for wireless communication systems continues to increase. The success of wireless communications and the integral part they now play in our modern society is, in part, due to effective spectrum management. As a result, an understanding of spectrum management is important in the consideration of any radiocommunication system. Spectrum management is a discipline that, if done well, is practically transparent to the user. However, if ineffective, it has the potential to have a major negative impact on the entire community.

In this paper we will provide a brief overview of some aspects of spectrum management in Australia. The international foundation of spectrum management will be outlined, along with some of the contemporary challenges and opportunities.

INTRODUCTION

Spectrum management can be considered as the technical and regulatory foundation for the efficient and effective use of the radiofrequency spectrum – in practice, it is an extensive discipline covering a unique blend of engineering, regulation, economics, policy and international politics. A comprehensive overview of all these aspects is clearly beyond the scope of this paper.

Accordingly, this paper concentrates on a general outline of two key components of spectrum management, spectrum planning and licensing. These aspects perhaps have the greatest day to day impact on users of the radiofrequency spectrum.

SPECTRUM MANAGEMENT OVERVIEW

The radiofrequency spectrum is a finite natural resource, resulting in competing demand for its use. Unlike most other natural resources, spectrum is non-depletable. This means that spectrum can be re-farmed between users and services as situations change.

Spectrum is also inhomogeneous, meaning that due to technical and economic reasons, some parts of the spectrum are better suited to certain uses than others. This results in an uneven demand on some parts of the spectrum.

In certain circumstances, and if properly managed, spectrum can be simultaneously shared by multiple users. In other cases, due to the physics involved or the requirements of the users, spectrum cannot be shared and arrangements must be developed that provide isolation between users of the spectrum. This isolation between users can be as simple as frequency or geographic separation to complicated arrangements that apply technical and operational constraints on spectrum use.

INTERNATIONAL SPECTRUM MANAGEMENT FRAMEWORK

To a certain extent, spectrum management is inherently an international activity. The peak international spectrum management body, the International Telecommunication Union (ITU), is a United Nations specialised agency headquartered in Geneva, Switzerland. The role of the ITU is varied and covers three main areas: telecommunications, radiocommunications and telecommunications development.

The Radiocommunications Sector of the ITU, often referred to as the ITU-R, is the primary area of the ITU concerned with spectrum management.

The mission of the ITU-R is, inter alia, to ensure rational, equitable, efficient and economical use of the radiofrequency spectrum by all radiocommunication services, including those using satellite orbits, and to carry out studies and adopt recommendations on radiocommunication matters [1].

The primary ITU-R output is the *Radio Regulations* which is a binding international treaty-level instrument governing use of the spectrum. The Radio Regulations specifies, among other things, the Table of Frequency Allocations which segments the spectrum in distinct bands where various services can operate.

Further to the table of frequency allocations, the Radio Regulations also outline technical and operational arrangements that facilitate shared access to the radiofrequency spectrum.

The Radio Regulations are reviewed and updated by World Radiocommunications Conferences (WRCs) approximately once every fours years.

A further important role of the ITU-R is achieved by a number of *Study Groups* established to consider specific technical issues and to develop *ITU-R Recommendations*. The current structure consists of seven study groups focussing on separate, but related, areas of radiocommunications.

Recommendations address specific issues (often of a technical nature) with the aim of identifying mutually agreeable methods and processes relating to spectrum management. As the name suggests, ITU-R Recommendations are generally not mandatory and are intended to provide guidance only. Nevertheless, ITU-R Recommendations have become very important and often form the basis for defacto world-wide standards on a broad range of spectrum management related topics.

AUSTRALIAN DOMESTIC SECTRUM MANAGEMENT FRAMEWORK

Australian spectrum management is the responsibility of the Commonwealth Government, through the Australian Communications and Media Authority (ACMA). The ACMA came into being on 1 July 2005 from the merger of the Australian Communications Authority (ACA) and the Australian Broadcasting Authority (ABA).

In addition to spectrum management and radiocommunication functions, the ACMA is also responsible for the regulation of broadcasting, telecommunications and online content.

The *Radiocommunications Act 1992* (the Act) forms the basis for the ACMA's spectrum management functions. The object of the Act provides a succinct overview of the aims of spectrum management in Australia:

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

- *maximise, by ensuring the efficient allocation and use of the spectrum, the overall public benefit derived from using the radiofrequency spectrum;*
- *encourage the use of efficient radiocommunication technologies so that a wide range of services of an adequate quality can be provided.*

Et al [2]

Spectrum Planning Framework

To achieve its spectrum management responsibilities the ACMA and its predecessors have established various technical and regulatory frameworks. At the highest level is the *Australian Radiofrequency Spectrum Plan (ARSP)*.

The ARSP divides the Australian radiofrequency spectrum into a number of frequency bands and specifies the general purposes for which the bands may be used.

This process is referred to as the allocation of frequency bands to radiocommunications services. These Australian allocations are based on the arrangements in the ITU Radio Regulations (Article 5) which outlines frequency allocations on a world wide basis.

The ARSP is the first planning document that should be consulted regarding spectrum arrangements in Australia. However there are a number of other technical elements in addition to the ARSP that are used to provide further layers of detailed planning.

Depending on the situation these additional elements can include *Band Plans*, *Radiocommunications Assignment and Licensing Instructions (RALIs)* and *Spectrum Embargoes*.

Band Plans provide detailed instructions on the use of specific parts of the spectrum. Band Plans are divided into two types, Frequency Band Plans, which are legal instruments, and (non-statutory) Administrative Band Plans.

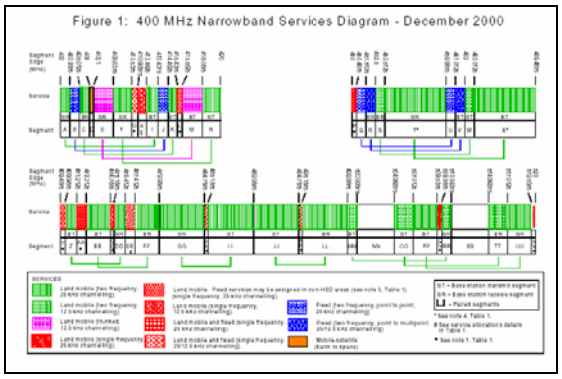

Figure 1 Channel arrangements included in the 400 MHz Band Plan (Administrative). *Source:* ACMA

Radiocommunications Assignment and Licensing Instructions (RALI) are a further important tool in Australian spectrum management and provide detailed guidance on specific spectrum access arrangements.

To facilitate the frequency planning process it is necessary from time to time to place Spectrum Embargoes on certain parts of the radiofrequency spectrum. Embargoes place restrictions on frequency assignments for apparatus licensed services in certain frequency bands and geographic areas.

Developments in Spectrum Planning and Assigning

Tools used to plan and assign spectrum have improved dramatically over recent years. Traditionally frequency planning and assignment have been, by necessity, fairly conservative and deterministic in nature. However, the ready availability of complex modelling software that automatically takes into account factors such as terrain allows increasingly more accurate assessments to be achieved.

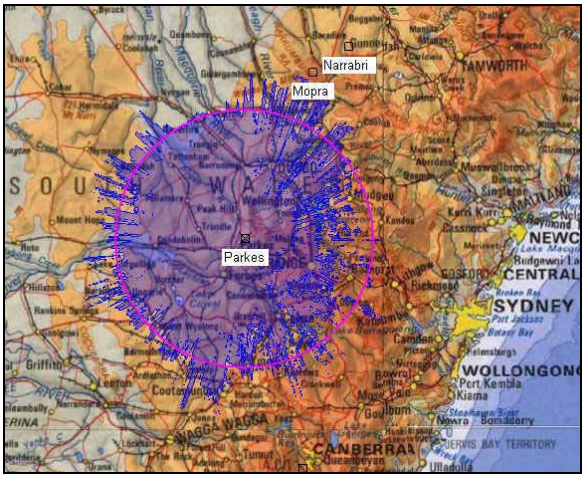

Figure 2 Example spectrum planning assessment using computerised modelling software. *Source:* ACMA

Participation in International Processes

The ACMA has overall responsibility for coordinating Australia's day to day international involvement (primarily with the ITU and APT) on radiocommunications issues. To support this involvement, a domestic framework has been developed that encourages stakeholder participation in the Australian preparatory processes for international activities.

Preparation for international meetings involves the ACMA overseeing extensive industry and stakeholder consultation,

through the ACMA's International Radiocommunications Advisory Committee (IRAC), its preparatory groups (PGs) and the Australian Radiocommunications Study Groups (ARSGs).

Australian industry and stakeholder involvement is essential in ensuring that developments are in Australia's best interests. ARSGs are typically chaired by industry representatives, but are managed and coordinated by the ACMA. There are seven ARSGs, which mirror the work of the ITU-R Study Groups discussed above.

Licensing Framework

Consistent with the requirements of the Act, all users of radiocommunication devices in Australia must be licensed. All transmitters are devices unless otherwise specified by the ACMA and all receivers are not devices unless determined by the ACMA.

The ACMA currently has three distinct licensing options available to authorise access to the radiofrequency spectrum:

- Class licensing;
- Apparatus licensing; and
- Spectrum Licensing.

The choice of which licensing framework the ACMA utilises depends on the situation and usually involves a public consultation process.

Class Licensing (spectrum commons)

Class licensing is sometimes referred to as the 'public park' approach to licensing as it authorises users to operate devices in designated spectrum on an uncoordinated, shared basis with no requirement for individual licensing.

Users to not have to apply to the ACMA to operate in class licensed bands and no fees are payable. However, devices do not receive interference protection and are not coordinated in terms of location and numbers of devices. This results in great flexibility for users but provides no assurance as to the integrity of the access to spectrum in terms of inference protection.

Class licensing is often used when the devices in question have a low interference potential and will be deployed in large numbers on an uncoordinated basis.

Radio Local Area Networks (RLANs) such as the IEEE 802.11 family is representative of the types of technologies that operate in Australia under a class licensing regime.

Apparatus Licensing (command & control)

Under the apparatus licensing system individual devices are authorised by dedicated licenses. As each device is individually licensed and generally coordinated with other spectrum users, this method is sometimes referred to as the 'command and control' technique.

Individual licensees must pay fees to the ACMA for apparatus licenses. However because each device's access to the spectrum is generally coordinated with other spectrum users, a quality of service can often be assured. This is on contrast to the class licensing system where the quality of the spectrum access can not be guaranteed.

Apparatus licences can be issued for periods up to five years and are generally issued on an over the counter, 'first come, first served' basis.

Spectrum Licensing (private spectrum)

Spectrum licensing is a mechanism where use of a specified frequency band in a certain area, is licensed exclusively to a single user. Other than abiding by the technical framework and any other conditions of the licence, a spectrum license holder can utilise the spectrum in any way it sees fit.

Spectrum licenses can be issued for periods of to 15 years and are generally distributed by way of a priced based allocation method, usually an auction.

Spectrum licensing has been traditionally favoured primarily by large operators, such as telecommunications companies for the deployment of such services as mobile phone systems.

SPECTRUM MANAGEMENT CHALLENGES AND OPPORTUNITES

Spectrum Demand

Perhaps the most fundamental challenge is the simple equation of demand exceeding supply. The radiofrequency spectrum is a finite resource with the most valuable parts experiencing increasingly high demand.

As Australia's spectrum manager, the ACMA must remain conscious of this demand tension and determine the most appropriate mechanisms for ensuring the best use of the spectrum resource is achieved.

There also continues to be tension between government use of the spectrum and the wider community. Like all spectrum users, government users (in particular the Department of Defence) require access to the radiofrequency spectrum to achieve their goals. It is the challenge of the spectrum manager to continue to recognise the special requirements of government spectrum users while providing appropriate access to the Australian community as a whole.

Australia as a Technology Adopter

Australia is generally an adopter of radiocommunications technology rather than a developer. Much of the most widely deployed technology in Australia is designed overseas, often with only limited consideration of Australian specific requirements.

This is a double edged sword, while it allows Australia access to the extremely important benefits of economies of scale from much larger international markets, it does mean that these systems are generally engineered to exist in foreign spectrum management frameworks. In most cases Australia can adopt mechanisms similar to that used overseas to support these technologies, but this can on occasions represent a challenge.

There is an increasing international trend for standardising the spectrum access requirements of radiocommunications technologies. A good example is the international effort, primarily by the ITU, to standardise the spectrum access characteristics of 3G mobile telephony systems.

While these international efforts are positive and supported by Australia, it is likely that spectrum management in Australia will always needs to be a delicate balance between different overseas influences.

Emerging Technologies

There are an increasing number of technologies that have the potential to offer major spectrum management benefits. Technologies such as software defined radios, smart antennas, mesh networks and cognitive radios are set to allow a new paradigm to be applied to spectrum management which can offer significant improvements in spectrum efficiency.

Cognitive radios in particular offer unique spectrum efficiency benefits.

The essential element of cognitive radio technology is that the system is aware of its surrounding spectrum environment and can modify its behaviour accordingly. This ability sees cognitive radios modify transmission parameters such as frequency, power and modulation characteristics to permit far more efficient use of the limited spectrum resource.

Cognitive radio offers, among other things, the possibility of using intelligent frequency agility to allow other users to utilise the spectrum when not being used by its 'primary' user.

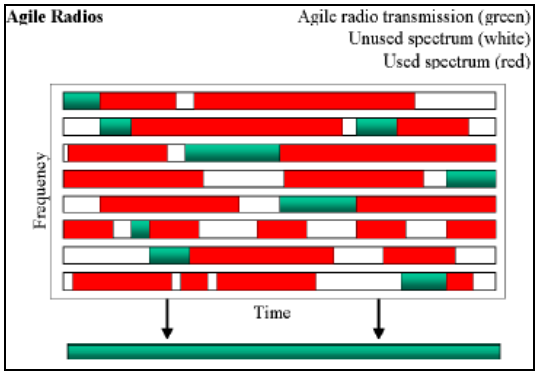

Figure 3 Illustration of the concept of cognitive radios utilising agility to make more efficient use of the spectrum. *Source:* ITU [5]

While at first inspection it may appear that cognitive radio technology is almost a spectrum management panacea, there are a number of technical and regulatory challenges that must be addressed to support the introduction of such technology.

Despite the challenges, the technical benefits to spectrum efficiency offered by these technologies are obvious; however, it will require a major rethink of established spectrum management practices to gain the most these technologies have to offer.

This combined opportunity and challenge is being accepted by many spectrum mangers around the world. The Office of Communications (Ofcom), the United Kingdom spectrum manager has undertaken a comprehensive effort to, among other things, identify, understand and further emerging technologies such as cognitive radio [6].

Some international spectrum managers such as the Federal Communications Commission (FCC) in the United States, have already mandated the use of contention based protocols to improve spectrum efficiency in the 3650-3700 MHz band recently released to support wireless broadband [7].

In Australia, the ACMA is also eager to take advantage of the benefits offered by these emerging technologies. It is likely that in the near future the ACMA will also mandate the use of intelligent techniques that are inherently more spectrum efficient.

CASE STUDY – ULTRA WIDEBAND

Ultra wideband (UWB) technology involves the radiation, reception and processing of very wide bandwidth radiofrequency emissions. Consequently, these emissions typically occupy a portion of the spectrum spanning a number of bands allocated for different purposes. This results in a significant spectrum management challenge to national administrations and traditional spectrum management methodologies.

UWB technology has the potential to be applied to a wide range of applications, ranging from highly specialised ground penetrating radars with a relatively small potential installed base, to ubiquitously deployable personal communications equipment and short range vehicular radars that could conceivably be deployed in the millions. With the increasing interest in UWB technology from a number of countries, the associated spectrum management issues are being intensively studied by many national spectrum management authorities and the ITU

ITU UWB considerations have been intense with established, traditional service based stakeholders wary of the technology. Not only does the wide bandwidth, albeit generally low power, emission characteristics of UWB technology cause concern, but also the potentially huge deployment numbers of devices using this technology. The ubiquitous deployment characteristics of some UWB applications are seen by some as mitigating the generally very low interference potential of an individual device.

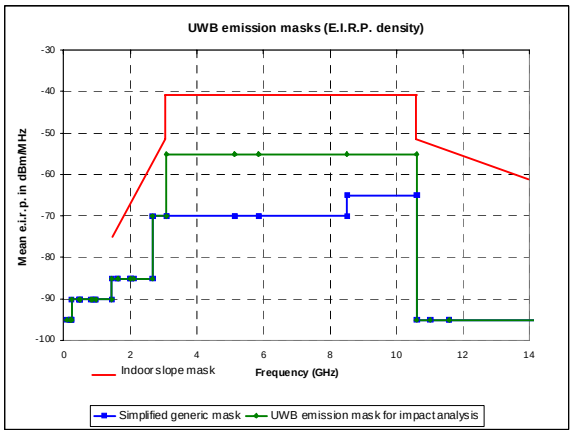

Figure 4 Emission mask used in the ITU for impact analysis of indoor UWB.
Source: ITU [8]

Many national administrations have been closely following the ITU deliberations, and to some extent, waiting until they were completed before making definitive decisions within their national jurisdictions.

This has largely been the case in Australia, with the ACMA and the ACA before it closely monitoring and participating in the ITU considerations on UWB.

However, prior to the completion of ITU studies on the matter, Australia had already authorised the interim use of devices utilising UWB technology in a limited number of circumstances.

The ACMA is currently developing definitive arrangements to support vehicle mounted short range radars (SRRs) that utilise UWB technology around 24 GHz. The low interference potential and ubiquitous deployment nature of these devices means that a class licensing approach is likely to be adopted in Australia. A public consultation process on proposed arrangements is expected in 2006.

The licensing approach for other UWB technologies will depend on a number of factors, including interference potential to other services and the likely spread of deployment. However, a class licensing framework is likely to be the most suitable for many UWB applications.

CONCLUSION

Efficient, effective and flexible spectrum management is essential to support the ongoing development of new wireless technologies that are becoming increasing essential to modern life. The widespread success of technologies such as mobile telephones and RLANs has been in part due to good spectrum management.

With the continuing demand for mobile applications that can only be provided via wireless technologies, spectrum management will remain a challenge for both regulators and industry alike.

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