Establishing an Interference Management Framework for Spectrum Licensing in Australia

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ABSTRACT Australia is at the forefront of developing spectrum management techniques for the provision of flexible access to radio communications spectrum under a new form of licensing called "spectrum licensing." Spectrum licenses have already been issued in the 500 MHz band, and auctions are being held in 1998 for spectrum lots in the 800 MHz and 1.8 GHz bands. Licensees manage their own spectrum space defined in terms of a frequency band and a geographic area for a fixed license term. The Regulator maintains a level of regulation just sufficient to keep significant levels of emission within those licenses so that spectrum utility is not reduced by either an unacceptable rate of interference or fear of litigation. No channeling plan is employed, and the spectrum may be used for any type of radio communications service. New terms such as "horizontally radiated power," "device boundary," and "level of protection" have been coined to describe fresh approaches to interference management that take advantage of the capabilities of geographic information systems. The interference management framework is dynamic, and designed to evolve on the basis of both practical experience and requirements of licensees.

In January 1997, the Australian Communications Authority auctioned parcels of spectrum space in the 500 MHz band [1]. After the auction the spectrum lots were aggregated and issued as spectrum licenses for the first time in Australia.

Spectrum licensing is a way of providing access to radio frequency (RF) spectrum where spectrum space, described in terms of a geographic area and a frequency band, is preserved for sole use by the licensee. No channeling plan is employed, and the spectrum may be used for any type of radio communications service. The space is protected from in-band unwanted signals from adjacent licenses with license conditions that create emission buffer zones along both the area and frequency boundaries of licenses. In addition, transmitter deployment and other constraints manage intermodulation interference across frequency boundaries.

Spectrum licensing is very different from the traditional form of licensing, called *apparatus* licensing, where access to spectrum is provided by an authorization to operate a single radio communications device. Operation of the device is managed by selecting a frequency for its operation using coordination procedures and frequency selection strategies that take account of nearby services. Frequencies are assigned to devices on a first-come first-served basis.

This article mainly provides an overview first of how spectrum space is specified for spectrum licenses in Australia, and second how the technical framework maximizes spectrum utility and manages interference between the licenses. The technical framework developed for the 500 MHz band is used as an example.

BENEFITS OF SPECTRUM LICENSING

Spectrum licensing has been introduced to achieve economic efficiency in the use of spectrum and involves the repeated sale of spectrum after fixed periods, delivering a stream of recurrent revenue to the government. The revenue is viewed as a resource rent tax paid by licensees to the community for the use of a valuable natural resource. Auctions are used to sell spectrum so that its correct current market value may be established. Licenses are created from aggregations of spectrum lots, which are in turn made up of aggregations of indivisible basic units of spectrum space. Spectrum is sold using a simultaneous multiple-round auction, designed expressly for this purpose and allowing bidders to acquire, subject to competition rules, the correct amount of spectrum for their differing commercial and technical purposes. Because the bidders pay market rates for spectrum, they have a strong commercial interest in extracting maximum utility from it. Competition between licensees ensures that they provide the community with rapid access to the latest in radio communication facilities, with the major cost and risk borne by licensees.

Licensees take responsibility for both spectrum planning and interference management within their spectrum, thus reducing the administrative burden on government. Licensees can trade surplus spectrum after the auction, creating new license area shapes and bandwidths, thus allowing continued optimization of spectrum use over time. Economic optimization can only occur when licenses supporting differing technical and spectrum space needs are able to be purchased and traded.

DEFINING SPECTRUM SPACE

A spectrum license provides a licensee with access to a parcel of spectrum space defined in terms of a geographic area and frequency band. In Australia, licensees purchase and trade spectrum space measured in terms of aggregated standard trading units (STUs). An STU has bandwidth and geographic dimensions which cannot be further divided.

The minimum frequency band for any spectrum license would have a width of one STU bandwidth. In the 500 MHz band the STU bandwidth is 12.5 kHz.

The minimum geographic area for any spectrum license is a single cell of a spectrum map grid. The spectrum map grid covering Australia is shown in Fig. 1, and consists of cells of varying resolution depending on their location. Cells of size 3° of arc, 1° of arc, and 5 min of arc are used depending on the population density. A cell is a curvilinear trapezoid with a side measured in degrees by reference to a spheroidal coordinate system. A cell of 5 min in Australia varies in length between 7 and 9 km depending on its latitude. Larger areas can only be made up of aggregations of cells. The cell sizes are sufficient for the definition of spectrum lots and the later trading of spectrum. The cell size determines the resolution for calculations involving propagation loss. Better resolution is not warranted considering the spectrum space requirements of licensees and the accuracy of propagation loss prediction. The geographic area was not defined in terms of statistical local government areas because these areas change over time and do not allow the definition of licenses that take full advantage of terrain shielding.

The 500 MHz auction spectrum lots consisted of 17 areas of about 10,000 km^2 each and two bands, 501–505 MHz and 511–515 MHz, each divided into 27 subbands with bandwidth varying from 12.5 kHz to 1 MHz. The areas were chosen with regard to population distribution, terrain shielding, and known prime transmitting sites. The boundaries were located in areas of low population. After the auction and subsequent aggregation of the lots, about 230 spectrum licenses were issued.

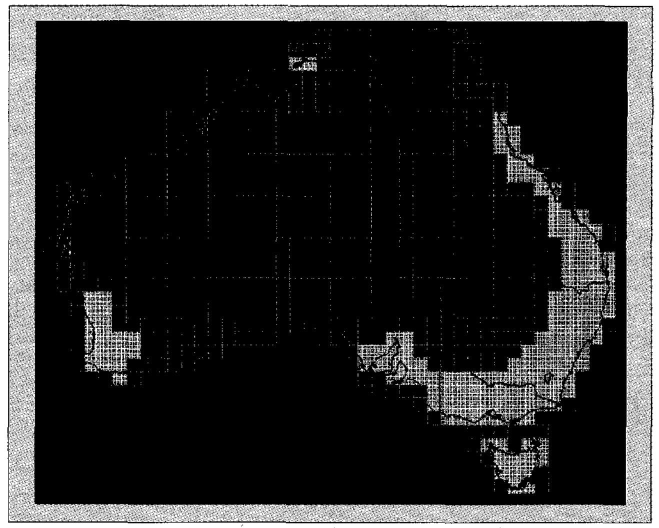


Figure 1. *Australia's spectrum map grid.*

Interference Management Framework

In Australia, the interference management framework for spectrum licensing is a fully defined baseline structure that allows the operation of different types of services. The framework clearly specifies the rights and responsibilities of each licensee. Full disclosure of the license conditions enables bidders to correctly estimate the value of each spectrum lot. The framework does not allow licensees to do whatever they like, nor does it require licensees to settle interference problems through litigation. It operates at a broad management level, the detailed management of the spectrum being left to licensees who plan the use of their spectrum within the broad design criteria provided by the framework.

The framework for spectrum licensing for 500 MHz is able to accommodate:

- All types of digital and analog modulation
- Narrowband and broadband services
- Frequency or time domain (in certain deployment configurations) duplexing
- Mobile or point-to-multipoint service areas of up to 40 km radius in urban areas
- Point-to-point services in remote areas
- Narrowcasting services with negotiated increases in maximum emission levels when a licensee provides an acceptable guard band
- Mobile transmitters with high radiated power

A Caution

As a note of caution, it is often very difficult for people to grasp the concept of multidimensional space. It is often helpful when discussing the management of interference within the space of spectrum licenses to be continually aware that the frequency boundaries of a spectrum license exist everywhere within the geographic area of the license.

Types of Interference

There are two types of interference the framework must manage, in-band and out-of-band.

In-band interference is caused by unwanted signals at frequencies that are within the frequency band of a communication channel. A single transmitter is capable of causing in-band interference over long distances with the emission within its communication channel (co-channel interference), or over short distances with broadband noise or steady-state or transient spurious signals at frequencies outside its channel. In addition, a number of closely located transmitters are capable of causing in-band interference over short distances through the mechanism of intermodulation, where signals are created at various arithmetic combinations of the transmitter frequencies. Receiver intermodulation is usually the dominant type of interference for closely located devices and occurs when new signals are created from nonlinearities in a receiver's input.

Out-of-band interference is caused by unwanted signals at frequencies outside the frequency band of the communication channel. A single transmitter is capable of causing out-of-band interference over short distances by overloading the input circuits of a receiver.

Interference is managed by maintaining sufficient isolation between transmitters and receivers. Isolation may be achieved through propagation loss (distance), frequency-selective

Definitions of Terms

True Mean Power:
- If an unmodulated carrier is present — the mean power measured while the unmodulated carrier is present; and
- If an unmodulated carrier is not present — the mean power measured while transmitted information is present.

Mean Power: The average power measured during an interval of time that is at least ten times the period of the lowest modulation frequency.

Maximum True Mean Power: The true mean power measured in a specified rectangular bandwidth which is located within a specified frequency band such that the true mean power is the maximum of true mean powers produced.

Horizontally Radiated Power: The radiated maximum true mean power, within the frequency band of the license authorizing the operation of the device, summed over all polarizations and measured in units of dBm EIRP in a direction referenced from, and in the horizontal plane containing, the phase center of the antenna used with the device.

Peak Power: The average power during one radio frequency cycle at the crest of the signal envelope measured in a specified rectangular bandwidth that is located within a specified frequency band.

devices (filtering), or limiting radiated power. Because there are many ways in which interference can occur over short distances, transmitters are not normally located near receivers when the frequency separation between them is small. In addition, because there are usually a limited number of transmitting sites, two-frequency operation, where a base station transmits and receives on different and widely separated frequencies, is necessary for maximizing spectrum utility. The wide frequency separation allows isolation to be achieved through filtering.

Managing Interference with a Blend of Policy and Technical Rules

Traditionally, spectrum management is a mix of art and science. It is with good reason that the FCC broadcast frequency assignment rules were originally described as "taboos." In situations where interference cannot be practically managed with emission limits, it is managed through policy. Spectrum licensing in Australia uses a blend of policy and technical rules to achieve a balance between managing interference and maximizing spectrum utility.

This blending makes it very difficult to compare the efficiencies of interference management frameworks adopted by different national administrations. For example, the author has been told by a prominent FCC official, in connection with the high level of negotiation required for the management of interference in the personal communications services (PCS) bands, that in the United States "interference is managed through the mutual greed of the licensees." Australia does not require a high level of negotiation for interference management, and, while greed may be a valid instrument of policy, it is difficult to translate into rates of actual interference and levels of spectrum utility for comparison purposes.

The interference management framework for spectrum licensing in Australia can only be understood when viewed as a complete system of policy and technical rules applied in the form of emission limits, deployment constraints, and interference settlement responsibilities.

One important policy relates to the delegation of responsibility for interference settlement. When there is little isolation between transmitters and receivers (e.g., they are co-sited), interference mechanisms become highly nonlinear, and emission limits cannot be used to manage interference without placing an unreasonable level of constraint on the use of devices. Therefore, under the framework for 500 MHz, a licensee (usually through a site manager) is made responsible for the settlement of all interference caused within 200 m of each transmitter (see "Responsibilities for Interference Settlement" later). This policy allows a licensee to take local conditions into account and have flexible use of the spectrum at sites. Other policies relating to deployment constraints may also affect a licensee's decisions regarding spectrum use at sites.

Under the deployment constraints for 500 MHz, a transmitter may only radiate high power when it is at certain heights which depend on the band in which it operates.

In the lower band (501–505 MHz) transmitters must have an effective antenna height of more than 30 m to radiate maximum power (49.2 dBm/12.5 kHz). Below 30 m the maximum power drops linearly, until at 15 m it remains at 23 dBm/12.5 kHz.

In the upper band (511 to 515 MHz) transmitters must be kept below an effective antenna height of 5 m to radiate maximum power. Above 5 m the maximum power drops linearly until at 15 m it remains at 23 dBm. No significant levels of radiated power are allowed above 30 m. These deployment constraints, including the definition of effective antenna height, are established by considering usual system requirements and economically viable antenna placement scenarios.

While a receiver may be used at any height, it only has protection under the framework when it is located at certain heights, chosen with respect to the heights where transmitters are allowed to radiate high power. The heights are chosen so that, in practice, the resultant propagation losses between transmitters and receivers are large enough for receiver intermodulation to occur mainly within a 200-m radius. In order to have this level of propagation loss, a high site–low site propagation model is used as the basis of the framework. In this case, a licensee becomes almost entirely responsible for managing interference caused by receiver intermodulation. For the 500 MHz band, receivers only have protection in the lower band when their effective antenna height is less than 10 m and in the upper band when their height is greater than 20 m.

In situations where a receiver is not provided protection under the framework, a licensee can either accept a low level of risk (e.g., when these receivers are used in remote areas) or negotiate with adjacent licensees for necessary protection.

If trading of spectrum at a fine level is provided under the framework (e.g., spectrum licenses with frequency bandwidths down to 12.5 kHz), deployment constraints must be used to manage interference through receiver intermodulation. When a fine level of trading is not allowed, intermodulation interference between spectrum licenses is managed by simply maximizing the frequency band of licences and minimizing the number of spectrum licenses that are available.

Selecting a Propagation Model for the Framework

The 200 m receiver intermodulation zone can only be achieved by using a high site–low site propagation path model for the derivation of emission limits. This type of model has other benefits. The path model used for 500 MHz is based on Okumura [2] and is a fundamental component of the interference management framework for spectrum licensing because it:

- Manages receiver intermodulation
- Maximizes spectrum use by minimizing the width of the emission buffer zone between the area boundaries of licenses
- Provides a practical solution to the problem of calculating the spectrum space required for a single device — its "device boundary" (see "Calculating a Device Boundary" later) — to ensure that it fits within the space of the license

When two band segments are being auctioned, there is a choice between allowing high levels of emission at high sites in either both segments or only one segment. If large mobile service areas are required, in one of the segments receivers must be given a good level of protection at high sites. This means that high levels of emission are not possible in that band at high sites. If, on the other hand, large mobile service areas are not required, transmitters may have high levels of emission at high sites in both band segments. This latter situation is likely to occur in bands above 1 GHz and in country areas.

Using Emission Limits to Manage Interference

In-band interference between devices that are not closely located may be managed with emission limits. There are two core limits: one manages emission levels outside the geographic area, and another manages levels outside the frequency band of the license.

Emission levels outside the geographic area are managed by establishing emission limits for power radiated in the direction of the geographic area boundary. The limits are based on the propagation model, the distance of the device from the boundary, its effective antenna height, and the benchmark level of protection (see "Level of Protection for Receivers" later).

Emission limits outside the frequency band of the license are based on the management of in-band interference to frequency-adjacent services. Both limits create emission buffer zones along the frequency and area boundaries of the license. The emission buffer zones act to reserve the total spectrum space free from encroachment by the devices operated under neighboring licenses.

MANAGING EMISSION LEVELS OUTSIDE THE AREA

The management of emission levels outside the area is related to the management of interference caused by emissions that are within the frequency band of the license. The emission levels are measured in terms of "horizontally radiated power" (see "Definitions of Terms"). The introduction of spectrum licensing and the flexibility it provides has meant that either new terminology or a broadening or clarification of traditional terms was required to accurately describe the radiated power of transmitters using different modulation schemes.

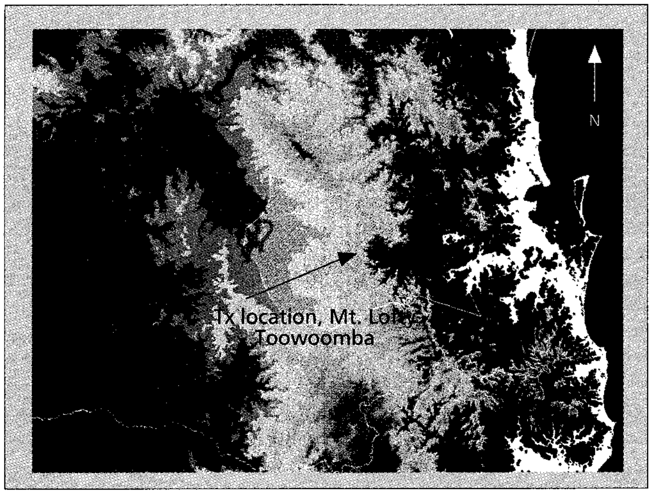
Calculating a Device Boundary — Emission levels outside the geographic area of a license are considered to be acceptable if the device boundary of each transmitter lies within the geographic area. Device boundaries may be also calculated for receivers for any given level of protection.

The calculation of a device boundary for a transmitter under the 500 MHz framework involves establishing the distance from the device along 36 radials, taken every 10°, which is required for emission levels to drop below a benchmark level of protection for receivers. The distance along each radial is calculated using the propagation model.

Terrain is taken into account in a simple manner by changing the antenna height of a device according to its height above average terrain (called its effective antenna height) for each distance increment (5 min in length) along each radial. The terrain is averaged in areas that have the shapes of 5 min segments of 10° sectors. An area average is appropriate because it provides a modeled emission level along a boundary, as opposed to a profile, which would only establish a level at one point on the boundary. Although each averaged area is considered in isolation and the effect of any previous terrain blocking is not taken into account, the method works very well in practice without any significant loss of efficiency.

A device boundary for an omnidirectional transmitter with a horizontally radiated power of 49.2 dBm/12.5 kHz located at Mount Lofty, Toowoomba, Queensland, is shown in Fig. 2. The device boundary is not to be viewed as a service area for the transmitter; instead, it establishes the spectrum space used by the transmitter under the framework when based on a high site–low site propagation model. The site is located on a mountain at the edge of a plateau that looks east. There are even higher sites to the north and south. The calculated space takes in the low sites (but not the higher sites) in accordance with the high site–low site propagation model framework.

If a high site–high site propagation model was used for the framework, device boundaries would consist of an extremely large inner area surrounding the device plus additional outer areas covering faraway mountaintops. This would not be a practical solution to the problem of calculating a device boundary.



■ **Figure 2.** *A device boundary for a transmitter at Mount Lofty, Toowoomba, Queensland.*

When spectrum is traded, some device boundaries may no longer fit inside the space of the resulting licenses, and their operating characteristics would need to be varied.

MANAGING EMISSIONS OUTSIDE THE BAND

Emission limits outside the frequency band of a license need to manage in-band interference over short distances. The limit for 500 MHz is chosen with regard to using adjacent channels in a service area of up to 40 km radius, and is 50 dB below the maximum power [3], or –1 dBm/12.5 kHz. This limit could be much higher than –1 dBm/12.5 kHz if wide-area services were not required under the framework. Transient unwanted emissions (e.g., transient emissions caused by a carrier being switched on or off) are managed by specifying the limit as peak power. At greater frequency separations from the frequency band of the license, the limit falls to –46 dBm/12.5 kHz, and the power is then specified as radiated maximum true mean power (see "Definition of Terms").

Traditionally, emission limits outside the band may be specified in either absolute power levels or power levels relative to the transmitter power. In order to promote the flexibility inherent in spectrum licensing, emission limits are specified as absolute power levels. This allows a licensee to trade the maximum radiated power of a device with its out-of-band performance.

Because the limits are to be maintained under all environmental conditions, a licensee may trade emission bandwidth against frequency stability. In this case, frequency stability is specified indirectly by the emission limits outside the band.

In order to satisfy the peak power requirements of the emission limit, the rise time of a transmitter must be limited as a function of its carrier frequency offset from the upper or lower frequency limit of the license. For example, a spectrum license with a frequency band of 12.5 kHz requires rise times greater than about 1500 μs to comply with the limit. A spectrum license with a frequency band of at least 400 kHz would be required before a licensee could use equipment operating with a rise time of about 1 μS; that is, 200 kHz separation is required from the frequency boundaries of the spectrum license to ensure that the emission limits are maintained.

Licensees also need to take account of the likelihood of transient interference to the receivers they wish to operate. Transient interference increases as the necessary bandwidth of a receiver increases. The peak level of a switching transient increases by 6 dB for each doubling of the necessary bandwidth.

Level of Protection for Receivers

When trading of spectrum at a fine level in the frequency dimension is allowed, it is necessary to introduce a level of protection (LOP) for receivers. This is necessary because if a licensee is permitted to own a spectrum space with a bandwidth of, for example, 12.5 kHz, the total spectrum may be made useless by a case of anomalous propagation from an adjacent license. In that case, the licensee cannot shift frequency to avoid the interference, and the only solution is to reduce the radiated power. Therefore, the Regulator must impose license conditions that enable it to make further reductions in radiated power even when a transmitter already satisfies the emission limits. The Regulator can make those reductions through the provision of an LOP.

For 500 MHz, the level of protection for a receiver is a mean power level expressed in units of dBm per 12.5 kHz:

- That causes the device boundary of the receiver (calculated in a manner similar to that for a transmitter) to be as near as possible to the boundary of the geographic area of the license while remaining within that geographic area
- Is never better than a benchmark level of protection.

The benchmark level of protection for 500 MHz is –139 dBm per 12.5 kHz. This value is based on a noise floor of –129 dBm and a 10 dB reliability margin that takes account of 90 percent of locations.

LOPs are used to specify the maximum level of interference a licensee may have to accept when operating a receiver. Transmitters are often considered the main users of spectrum space because they fill the space with emission. However, the fact that the space contains emission in no way prevents another transmitter from emitting power into the same space — the transmitter only denies spectrum space to receivers. On the other hand, receivers also use spectrum space because they deny it to transmitters through the application of compatibility checks.

The LOP is defined in a manner that prevents licensees using spectrum space outside their license. Receivers are required to accept higher levels of interference as they move closer to the boundary of the geographic area of the spectrum license under which they are operated. In addition, receivers in these situations are required to accept still higher levels of interference as their effective antenna height increases. This arrangement manages receiver spectrum denial.

LOPs allow the regulator to investigate interference in a direct manner by checking emission levels at receivers. If an LOP is not defined, interference may only be investigated in an indirect manner by checking levels of emission at transmitters. Direct interference investigation is not always required. In bands intended for large telecommunications systems where the spectrum licenses usually have large frequency bands, and a significant degree of self management expected, the LOP may be left unspecified, that is, set to a constant high value for all receivers.

What the Level of Protection Means in Practice

The level of protection would normally be taken into account during interference settlement. In that case, the level of in-band emission from a transmitter operating under a license, measured at a receiver operating otherwise than under that license, must be, for up to and including 99 percent of the time in any one hour period, not greater than the level of protection for that receiver plus 20 dB. The figure of 20 dB takes account of location variability and in normal circumstances means that the level of protection is being maintained for about 99 percent of locations.

The level of emission measured at the receiver is the level of radio emission received by a notional antenna with a gain of 0 dBi in any direction and located as if its phase center is located at the phase center of the antenna used with the receiver. The emission level is measured as mean power in units of dBm per 12.5 kHz at the terminals of the notional antenna. The level of protection is applied only within the spectrum license and only within the IF bandwidth of the receiver and the same level of protection is provided to a receiver regardless of either the gain of its antenna or the bearing of the interfering transmitter.

Measurement of levels of emission at receivers down to -120 dBm/12.5 kHz, is often unreliable because of, for example, internally generated spurious signals or overload problems in the measuring equipment caused by nearby transmitters. In some cases, the interference mechanism is determined by a process of applying remedies to suspected causes rather than by direct measurement. When emission levels cannot be reliably measured, interference settlement may be effected by providing an acceptable protection ratio between the wanted and unwanted signals, taking account of necessary fading and operating conditions. In addition, operating problems in the absence of a wanted signal, which can be removed by fitting signal gating systems such as Continuous Tone Coded Squelch (CTCSS), would not normally be considered interference. LOPs for mobiles are arbitrarily set to a single high value because it is not practical to measure interference levels at mobiles.

Effective Mobile Locations and Groups of Transmitters

The framework takes special account of the interference potential of high-powered mobile transmitters (about 25 W). In order to simplify their management, groups of identical transmitters are treated as one logical device, and that one logical device may operate in a number of effective locations. Effective mobile locations for major towns are defined as the circumference of circles whose radii are based on the position and size of built-up areas for the towns. Reference lists of effective mobile locations are published, and the radii of the circles are used to further expand the device boundary in a manner that takes into account the roaming of a mobile transmitter.

When the degree of simultaneous transmission by transmitters in a group is low (less than 5 percent of the time), the radiated power for the group is taken to be the highest radiated power of any individual transmitter. When the degree of simultaneous transmission is high, the radiated power for the group is taken to be the maximum allowed under the framework.

Irregular Pairing of Bands

Both paired and unpaired bands may be obtained through the auction and later trading, and bands may be paired without regard to either their separation or the size of the bandwidths. This is acceptable because it does not increase the likelihood of interference from intermodulation. Intermodulation interference occurring between two band segments used to support a number of send-return configurations is primarily managed by both the intersegment gap and the deployment, at adjacent prime sites, of transmitters and receivers. The deployment of frequencies at adjacent prime sites is random whether or not the bands are paired in a particular manner. Therefore, pairing bands with constant separation (the traditional method) does not reduce the likelihood of intermodulation interference.

Special Device-Specific Coordination Procedures

In some cases, devices managed under apparatus licensing may be adjacent to spectrum licenses in an area sense, and those services may not comply with the high site–low site design of the framework. Whenever this occurs, a device-specific coordination procedure, in addition to the framework, is necessary to manage interference.

At 500 MHz, there are point-to-multipoint services in remote areas that are area-adjacent to spectrum licenses. In a few cases these services may be affected by devices operated under spectrum licenses because their receivers do not comply with the deployment constraints. A high site–high site propagation model is used to maintain compatibility with these services.

Compatibility with frequency-adjacent services was achieved at 500 MHz by making the out-of-band emission limits for the spectrum licenses identical to those of the adjacent services.

Modifying the Framework

Licensees may propose modifications to the framework, and, if they can show that the modifications would not increase the overall rate of interference between spectrum licenses, the framework may be varied and all licensees then operate under the new conditions.

In addition, if two or more adjacent licensees have either common frequency or common geographic boundaries, they may negotiate between themselves about the management of interference along those common boundaries. They may, for example, operate devices that have device boundaries outside their geographic area. If the device is later involved in a case of interference, the licensees are fully responsible for settling that interference. The private agreements would, in effect, reduce the size of the emission buffer zone between the licenses or remove it completely — but only along the common boundaries.

Responsibilities for Interference Settlement

As the size of a spectrum license increases, the licensee's level of responsibility for interference settlement also increases. In cases where the size of the spectrum license is small, a small level of interference settlement responsibility is imposed on the licensee because there is a corresponding reduced number of options to work around interference.

In all cases, licensees are responsible for managing interference:

- Between devices operated under their spectrum licenses
- Between a device operated under their spectrum licenses and devices operated in accordance with other licenses and caused by:
  - Co-sited devices (located within 200 m of the first device)
  - The first device being a receiver and having a performance worse than a notional level of performance established under the framework
  - The first device being a receiver with a level of interference below its LOP plus 20 dB for up to and including 99 percent of the time in any 1 hr period

Conclusion

Spectrum licensing is an old concept that has waited a long time for implementation. Australia has successfully introduced spectrum licensing in the 500 MHz band using a blend of policy and technical license conditions derived from a basic understanding of interference mechanisms applied to a local legislative framework. Interference is managed in a way that achieves maximum flexible use of spectrum and minimizes the need for negotiation between adjacent spectrum licensees. Technical frameworks have also been developed for 800 MHz and 1.8 GHz PCS bands, with an auction in 1998. Other countries are now wishing to use economic-based spectrum management techniques to maximize economic efficiency in use of their spectrum.

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Biography

Michael Whittaker (mwhittak@aca.gov.au) has worked in spectrum management for the Australian government since 1984, pioneering automated frequency assignment systems. He is now involved with providing the engineering basis and software design for the introduction of spectrum licensing. He received a B.App.Sc. (physics) from the University of Southern Queensland in 1971 and managed the nuclear magnetic resonance (NMR) service facility at the Research School of Chemistry (Australian National University) for 10 years, co-authoring several papers on NMR research topics. He received a Grad.Dip. in electronics in 1983 from the University of Canberra, and has authored a number of papers dealing with frequency assignment automation and the electromagnetic compatibility aspects of spectrum planning.