Comment on the Productivity Commission's Radiocommunications Draft Report

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1.0 About FuturePace Solutions

Spectrum Management International Pty Limited, trading as FuturePace Solutions, is a private company operating since 1997 and headquartered in Canberra, Australia. Michael Whittaker, now a FuturePace Director, was principally responsible for designing the Australian 500MHz, 800MHz, 1.8GHz, 3.4GHz and 28/31 GHz spectrum licensing technical frameworks.

2.0 Our Previous Submissions

Our earlier submissions (18, 34, 59) to the Productivity Commission regarding the review of Radiocommunication Acts and of the market based reforms and activities undertaken by the Australian Communications Authority discussed a number of important issues related to the implementation of spectrum licensing in Australia.

In particular we:

- Argued strongly against introduction of a new "single more flexible licensing system" because of the unnecessary cost to industry considering the flexibility in licensing arrangements already available in the Act and already used by the ACA for necessary product differentiation;
- Expressed our disappointment that the progressive evolution of spectrum licensing towards the economic benefits given by technology neutrality and greater certainty had been set back by the 2 GHz spectrum framework;
- Proposed use of an apparatus-based spectrum licence when an apparatus type (prescriptive) licence, but with a term longer than 5 years, is required for economic efficiency reasons

- Explained the core technical problems that have been solved in spectrum licensing – defining clear benchmarks for in-band and out-of-band interference using:
    a) For in-band interference, any-time transmitter emission rights; and
    b) For out-of-band interference, first-in-time coordination using the national centralised on-line data base as well as a fully defined notional receiver.
- Cautioned against Australia adopting the European concept of "spectrum harmonisation" because it is effectively made redundant by the provision of generic or open standards through spectrum licensing and has already led to unnecessary constraints on competition in Europe;
- Warned that an apparatus licence term longer than 5 years would lead to a complex and costly requirement for compensation;
- Proposed the introduction of private spectrum administrators (band managers) with appropriately conditioned spectrum licences to out-source the current ACA task of managing an apparatus licensed band, especially for point to point services;
- Provided information concerning the 2.3 GHz Conversion Plan "affair" where the true market value of spectrum had not been realised;
- Advised against including additional device details for spectrum licensing arguing that present technical details have been carefully selected by an industry based consultation process to create an efficient balance between data necessary for reasonably accurate coordination and the cost of gathering and recording that data;
- In answer to criticisms that the "device boundary" concept should be abandoned, we listed nine significant reasons why, where necessary[1], use of the device boundary in spectrum licensing provides an optimal balance between operational flexibility and certainty for managing in-band interference. We also questioned whether, in proposing that it be abandoned, the proposer had devised a new method and could demonstrate that it further improved on those benefits; and

[1] The device boundary concept is not used at 28 GHz because there is no need for it at such high frequencies.

- Explained the situation surrounding the origin, limitations and dangers of the process used by the ACA to currently record a very limited number of device details for GSM900 services rather than the full details that have been supplied to the ACA by carriers.

We have read the Commissions' draft report and we wish to thank the team for their assessment of this very large and complex field. We are gratified that some of our suggestions have been incorporated into the Commissions draft. FuturePace is impressed with the grasp of spectrum licensing issues displayed by the Commission, however, there are a few areas in the document which we believe are either inaccurate or could be developed towards a more positive outcome. FuturePace believes that, with a little more clarification, some of the outcomes could become more progressive. So we have commented at length on several issues which we believe are critical to the continuing success of spectrum licensing in Australia and for which the Commission has made a request for additional information.

We have also responded briefly to a number of the Commission's draft finding and recommendations. These are contained in Attachment A.

For this round of comments we have decided to submit two separate sets of comments, one for publication and a further confidential submission dealing with commercially sensitive material.

3.0 Causes of Confusion

Whenever there is a paradigm shift in management methods, initial attitudes and managerial responses tend to be a mix of the old and the new. This can lead to confused responses. A good example was the initial use of area-based apparatus licencing. FuturePace particularly supports the Commissions' draft recommendation that all area-based apparatus licences be converted to spectrum licences. However, the technically biased nature of existing area-based licences will require some rather creative solutions

considering that, in the conversion process, the Act requires that the spectrum licences, so far as is practicable, authorise the operation of devices to the same extent as, or to a greater extent than, they are authorised under the apparatus licence to be replaced. Hopefully 'so far as is practicable' will support the necessary limitations.

When the Commission has encountered confused views, the conclusion it has drawn is an honest "we just don't know", and we applaud the honesty of this approach. However, we are concerned that the transit from "don't know" to "no" is often a fairly fast segue. That which is not readily understood is often negated.

Many confused views contained in submissions are caused by their authors continuing to think in terms of apparatus licensing (coordination of devices) rather than spectrum licensing (coordination of spectrum spaces). We previously noted this in our submission 59.

3.1 Managing Space Rather Than Devices

The fundamental difference between spectrum and apparatus licensing is that the conditions of the spectrum licence primarily seek to manage space rather than devices. The Government policy is to sell space and therefore, it was thought that by reason, the space should be maintained reasonably free of encroachment by devices operated outside that space. This is precisely why the device boundary has been designed to operate in its present manner. A proper understanding of the device boundary construct requires an equal understanding of the technical and policy objectives of spectrum licensing.

If the objective was to simply manage the existing and new devices on a first come first served basis without any consideration given to, for example, spectrum denial caused by receivers operating just outside the spectrum space of a licence, then certainly, the device boundary construct would not be required. However, the certainty provided by the device boundary would also

be lost, as would the elegance of coordination capability around new apparatus licensed devices.

Of course, if the space was managed completely on a first-come first-served basis, the first thing that could happen in practice, is that it would be open to spectrum licensees to register receivers all around the boundaries of their licences as well as at all high sites within their licence. The effect of this would be to severely restrict the ability of their neighbours to operate transmitters. The absence of a device boundary concept would make inefficient management of spectrum inevitable and create major diseconomies in spectrum usage. The not perfect, since no solution is ever perfect, but most appropriate solution, is to first provide a licensee with transmit rights, irrespective of receivers outside the space, and then allow for negotiation between licensees in the small number of situations when those rights do not produce the optimum outcome. It is important to minimise the requirement for costly and uncertain negotiation. The cost of the device boundary calculation was also minimised by the ACA supplying most of the necessary software for $300. This is how the Australian system is presently, and effectively, operating.

3.2 Limits to the Analogy of Property Rights

It should be made clear that, while the analogy of a property right in radio spectrum is useful, and there is some comfort in describing the register of radiocommunications licenses as being rather like a property register, the actual rights gained, notwithstanding their description as “quasi property rights” are in fact rights limited by licence conditions. Despite its convenience, the analogy is false. The ACA has been assiduous in ensuring that licensees are aware that there is no property right and that the asset cannot be used in ways which would be usual were it a property right, for example, in the raising of mortgage funds.

The Commission has made a request for further information and we are responding to that request because we believe it important to maintain Australia's now internationally recognised and impressive lead in the field of spectrum management.

4.0 Overseas Recognition of Australia's Reform of Traditional Spectrum Management Methods

The recently published report of the UK Independent Spectrum Management Review, led by Professor Martin Cave, says about the Australian spectrum licensing technical framework:

- Page 81 "The (Australian) framework is an innovative variation on conventional interference management techniques and divides interference into two kinds: in-band and out-of-band....."

- Page 98 "A number of other national authorities, including Australia, Canada, New Zealand, and the USA, have begun to introduce a more generic approach to licensing access to radio spectrum, motivated by the desire to enable flexibility and innovation in spectrum use. Of these, the Australian approach is the most fundamental reform of traditional spectrum management methods."

Market based reforms have required the reform of spectrum management methods. If we go back to the reasons why reform was required for spectrum licensing, and these are contained in another a paper[2] reviewed by academic peers and recently published by the IEEE in the USA, then it is obvious that Australian spectrum licensing has been developed to avoid pitfalls now, which either are, or will gradually become, obvious elsewhere. Spectrum is more than a one-line entry in a business case. If the spectrum requirements of a

[2] See pages 148 and 149 of the paper "Shortcut to Harmonisation with Australian Spectrum Licensing" M Whittaker, FuturePace Solutions, Australia, IEEE Communications Magazine, January 2002

project are incorrectly or inadequately defined before auction then the business case on which they rest has also the potential for failure.

The reasons for spectrum management reform, taken from our paper, are to design legally robust licence conditions that would provide a clear description of the product to be sold in order to create certainty and encourage confidence in a spectrum auction by:

a) protecting the purchaser (the licensee) who would know exactly to what use the product could be put;
b) protecting the seller (the Government) by having a clear boundary drawn between licensee and Government responsibilities;
c) protecting incumbent (apparatus) licensees for a short re-allocation period after spectrum sale so that they might either trade their right to operate during the re-allocation period with spectrum licensees for the cost of re-location or use it while they found alternative spectrum or other means of maintaining their operations;
d) protecting existing adjacent apparatus licensees which may wish to continue to operate just outside both the geographic and frequency boundaries of a spectrum licence;
e) having clearly defined and consistent spectrum access rights over the full term of the licence in order to enable a bidder to establish the correct price for spectrum including ensuring that subsequent adjacent apparatus licensed services do not encroach on the spectrum;
f) managing interference between devices operated under adjacent spectrum licences with minimum requirement for costly and uncertain negotiation between licensees;
g) maximising flexibility by allowing all types of equipment and systems to operate (rather than biasing the licence conditions towards a 'likely-use' and as a consequence requiring relatively more space for other types of services) and enabling the real value of the spectrum space to be based on the most economically efficient use available; and
h) incorporating trading or sharing of all or part of the spectrum to allow efficient licence shapes and sizes to evolve over time to support the

operation of anything from narrowband short-range to wideband long-range services.

Essentially, the product to be sold has to be fully defined **before the auction** to protect the Government, the purchaser and incumbent services. And, as we will explain later, full definition does not have to mean technical prescription.

Full definition allows the purchaser to know the business and technical capacity and potential profitability of the asset being purchased. The purchaser is then in a position to agree, on the basis of a developed business case, to be bound by the licence conditions. Obviously, defining the product in terms of what may or may not be able to be negotiated with adjacent licensees, often your competitors, sometime after the purchase of the spectrum and without pre determined technical parameters, as happened[3] to a degree at 2GHz in Australia, is not the way to achieve any level of certainty.

5.0 A Trick Question?

The attainment of operational and technical certainty requires the definition of a benchmark spectrum utility that effectively limits all the possible ways in which use of spectrum may be denied to a licensee through different types of interference. The Commission has asked the question: "*What are the implications of adopting generic boundary conditions that would allow licensees to negotiate among themselves on the most appropriate arrangements*?".

Submission 18 to the Commission's inquiry explained that the space of a licence is defined not only in terms of geographic area, bandwidth and time (the core conditions, a term used by the Act), but most importantly and often

[3] This requirement is set out in a Note in a guideline but its significant ramifications are not explicitly explained in the Marketing Plan.

overlooked, through all the other licence conditions that limit access to the spectrum for devices (the so-called access conditions); and

a) Assuming that by '*generic boundary conditions'* the Commission means conditions like the access conditions used for the Australian 3.4 GHz spectrum licences where a 'likely-use' was not assumed;

b) Noting that, for a fully defined framework which forms a basis for negotiation, the core conditions may already be negotiated; and

c) In practice, the access conditions have already been worked around using a number of methods, where necessary, by the negotiation of spectrum sharing arrangements;

d) Our answer to the Commission's question is "what is the purpose of the question?".

FuturePace shares the Commissions' view that there is a need for a more active market in spectrum in Australia. But we are not convinced that the objective is achieved by the long term implications for industry of any push for a fast-fix of partially defined technical frameworks as a supposed means of getting product quickly to market. We suspect the purpose of the Commission's question is to find a way around an obstacle that really does not exist. We wish to assure the Commission that the time to develop a technical framework for a band is **not** a significant impediment to spectrum release.

In the case of the 3.4 GHz auction, the total time from Draft Re-allocation recommendation (19/6/98) to the Auction Close (24/10/00) was 28 months. The TLG meetings began on the 2/11/98 and finished before Christmas 98 having dealt with all the licence conditions except those involving coordination between apparatus and spectrum licensed devices (3 out of 5 usual papers). This was 2 months! Following the incredible urgency by the ACA to get

industry agreement by Christmas 98 the framework development then lapsed into the doldrums because of ACA leave requirements and the resolution of unrelated but confidential issues involving the Minister which drew out the process considerably. But industry consultation and framework development can move rapidly when necessary.

And, as Table 11.4. of the Commission's draft report demonstrates, the by now traditional 5 papers were produced for the 2GHz auction in the period 25/7/00 to 17/8/00 a total of 1 month and the revised papers were provided by 19/9/00. The technical framework for the 2 GHz auction took 2 months out of the total 2 years!

On balance there is not much difference in the time spent on the 3.4 GHz framework, which is fully defined and the 3G framework, which is not. But the disbenefit to industry from the 3G framework will, unless the licensees act to remedy the technical shortfalls in the license conditions, be a thorn in the side of industry, which has after all the responsibility to manage the spectrum, potentially throughout the life of the licences.

There are a couple of policy development facts which may serve to ameliorate some apparent criticisms of the ACA especially in relation to the delay between the legislative permission for spectrum licensing in 1992 and the first auction in 1996.

In the intervening period all the work of technical design for spectrum licensing as well as the complete development and design of the auction system had to be set in place. There was certainly no lack of activity in designing and packaging the initial product for market.

6.0 Device Registration Details

The Commission has asked "Whether there are benefits in narrowing the list of device registration details to reduce the burden of spectrum licensees?".

In our submission 34 we explained to the Commission: "*the present technical details for spectrum licensing have been carefully selected by an industry based consultation process to create an efficient balance between data necessary for reasonably accurate coordination and the cost of gathering and recording that data*".

Those devices that have no demonstrably valid spectrum management reason for registration, usually those having low effective radiated power, are exempt.

We are at a loss to understand the Commissions' concern because the present list of technical details for spectrum licensing were carefully selected by an industry based consultation process in 1995-6 to create an efficient balance between the data necessary for reasonably accurate coordination to manage interference and the cost of gathering and recording that data.

That agreed list was reflected in a Determination which established the essential data against which licensees and accredited persons have now set up their software management systems. It was agreed that the data set was would remain constant so that industry could develop efficient and cost effective software tools, the basics of which would remain standard across all spectrum licensing band releases. Entering the complete data from such a system into the national database was to provide clear and accurate data against which coordination, especially across the frequency boundary could be effected. We explained in our first submission that for efficiency reasons, out-of-band interference occurring between devices operated under adjacent spectrum licences is managed through frequency coordination. The management of out-of-band interference will become essential when licensees wish to use devices, for example, that do not comply with a 'likely-use' upon which the ACA has based the 2GHz framework.

The important role of a centralised properly managed national database to facilitate industry self-management cannot be over emphasised.

We strongly question whether a data set established through consultation with, and agreed by industry, can reasonably be seen as a burden on that industry. Nor, when we examine the submissions of the major spectrum licensees, do we see that they are seeking variations to the dataset.

With reference to Box 11.2 of the draft report, the Commission has listed 23 device registration items for spectrum licensing. Of these items 16 are technical. However, since the relevant ACA ID for location represents 4 of the 16, the ACA ID for the antenna represents another 4 of the 16 and it is fairly easy to differentiate between a transmitter and a receiver, in practice, there are no more than 9 separate items to be collected for any device (noting that under spectrum licensing it is not mandatory to register receivers):

1. Site ID
2. Antenna ID
3. Antenna polarisation
4. Antenna Azimuth
5. Antenna Height
6. Emission Centre Frequency
7. Emission Designator
8. Effective Occupied Bandwidth
9. Radiated Power Pattern

FuturePace does not accept that omission of any of these parameters would advance the economic efficiency of spectrum management, in fact omission of any one of them would significantly reduce efficiency, the data set represents a minimalist approach to data collection and was derived in consultation with and supported by industry.

Industry has agreed with Government the data that is essential for managing their spectrum licences, because it defines the level of accuracy with which any coordination may take place. Importantly, the data set is part of the definition of utility of the spectrum which a licensee has purchased. Therefore, the agreed data set is part of the definition of the product that the Government has sold to industry.

If the previously agreed data set is 'narrowed' then inaccurate notional or short-from data will have to be used for frequency coordination. Any attempt to narrow the data is also an attempt, albeit possibly inadvertent, to reduce the value of a licensee's spectrum. This is of doubtful benefit, and undoubtedly would cause an increase, rather than a decrease, in their 'burden'. Which is precisely why industry agreed to this data set as part of its agreement to the introduction of spectrum licensing. We apologise, the argument is necessarily an ellipse.

The cost of including one or more data items in a file that is automatically created from a client's network design software and subsequently automatically processed and registered in the ACA's on-line data base, is insignificant when compared not only with the cost of a base station but also the cost of the spectrum that would be wasted by using notional information.

Perhaps the Commission may have heard that when devices are in the so-called 'middle' of the space they do not require the same level of coordination and data accuracy as applies when they are near the boundary? This statement is a nonsense because the frequency boundary of a spectrum licence exists everywhere within its geographic area and needs to be managed by coordination everywhere, even when the geographic area consists of the entire Australian mainland.

And of course if a spectrum licence is divided as part of a future trade, then that device which is in year one, in the middle, may in the outyears become the boundary of a traded spectrum entity. FuturePace considers that short-

term considerations are inappropriate when dealing with a fully tradeable asset having a 15 year life. If the Commission is serious about perpetual licensing, and we see no reason why they should not be, then these considerations become even more important. Data integrity and the maintenance of a fully documented and accurate National Database with clearly defined and consistently applied rules are central to such a concept.

Spectrum Engineering Australia (sub 30) has argued for the inclusion of additional registration details for spectrum licensing. Our experience is that the existing data set is more than adequate to manage coordination requirements.

The Commission may wish to note that apparatus licensing, in fact, requires more details, significantly more than the 23 for spectrum licensing (see Attachment B for a list of 14 additional details required under apparatus licensing, in excess of those required for spectrum licensing). Interestingly enough, the ACA have, very recently, further increased the number of details required for apparatus licensing as a result of industry consultation on point to point services[4].

In researching the differences we also discovered that the Register Determination contains an error for apparatus licensing by not requiring the identification number of the accredited person who issued a Frequency Assignment Certificate when that occurs. However, we believe the ACA currently collects this data.

If the ACA have found it necessary to require a much greater number of items for the effective management of spectrum administered by them, why seek to impose on industry a reduction in the already low number of details they have established as minima for efficiently managing their spectrum licences?

[4] See page 67 of "Microwave Radio Spectrum Trends: Accommodating the Demands of Growth, New Technologies and Relocation" ACA Radiofrequency Planning Group, February 2000.

7.0 Care Required when Allocating Spectrum to Licence Exempt Services

While FuturePace can see some benefit in allocating spectrum for use as 'public parks', that is licence exempt services, there is a need for care when this is done. Licence exempt services generally work because interference is managed through their quite low power, and hence, very limited geographical coverage. It is not practical to allow wide-area services in 'public parks' because, for technical efficiency, they need to be managed and recorded on an individual basis. While this is one serious limitation for the types of services that are possible in such public parks, there are also 'tragedy of the commons' issues that require management, that is, eventual reduction in spectrum utility through harmful interference caused by overuse. However, the limited geographical coverage of licence exempt services normally results in 'within premises' coverage so that the building manager may be able to regulate interference. Alternately, users may decide between licence exempt and licensed spectrum use, depending on the grade of service they require. An often ignored limitation, continuing with the rustic theme, is the ramification for spectrum 're-farming'.

FuturePace has recently successfully negotiated with the Australian Communications Authority and the Australian Broadcasting Authority for the experimental licensing of Motorola iDEN equipment in TV Ch 69 (base receivers) and CT2 (base transmitters) spectrum. Australia allocated licence exempt spectrum to CT2 services. This is a 'public park', where wireless devices self-assign their channel based on detecting nearby interference until most the channels are in use and service reliability deteriorates unacceptably. A similar situation applies in the UK. However, in the UK there is currently a phased withdrawal of CT2 services because they have been a commercial failure in the UK, and also, for that matter, in Australia.

While it is possible to coordinate iDEN with the Ch 69 TV transmitters, thereby providing reliable interference free access to spectrum that would otherwise lie fallow, the ACA may be understandably reluctant to licence the under-utilised CT2 spectrum for iDEN base transmitters, except on a very limited scale. One reason is that licence exempt services are not recorded in the Australian national data base and therefore cannot be located for coordination purposes. If the few CT2 services had been recorded in a data base it would have been possible to coordinate around them. One of the usual benefits of licence exempt services is the 'simplicity' of their exemption from registration. However, 'simplicity' often leads to loss of flexibility. In this case it can prove to be a serious long term dis-benefit and limit more appropriate future use of spectrum. The superficially 'simple' is not always long term effective.

It is important to appreciate that whenever spectrum is allocated to low power licence exempt services, while the Regulator can get a rough idea from import records, there is no clarity as to how many of the devices are operating in the 'public park' because the details of each device are not recorded. These low power devices would suffer a reduction in capacity if higher radiated powers were nearby. Nor can the short range services be worked around because their location is not recorded. This usually means that the spectrum can be left to lie fallow for a long period.

FuturePace recommends licence exempt spectrum be subject to periodic review to determine whether or not there has been a commercial failure of the service. In the case of failure (CT2) we would recommend that a short period for re-allocation be stipulated (2 years). As long as this policy is declared up-front, there should be no cause for complaint from industry or from users considering that no fees are paid for use of this spectrum.

The future limitations created by 'public parks' need to be carefully considered before allocating spectrum to licence exempt services.

8.0 Principles for the Settlement of Interference Disputes

The Commission considers that dispute resolution guidelines could provide valuable assistance to both licensees and the ACA and has requested further information on their potential content. The Commission prefers guidelines that emphasise economic efficiency rather than arbitrary first-in-time rules, but recognises that such guidelines may be difficult to implement.

FuturePace wishes to direct the Commission's attention to an ACA guideline *Radiocommunications Advisory Guidelines (Managing Out-of-band Interference in Receivers Operating in Spectrum Licensed Space.3.4 GHz Band) 2000.* A copy is supplied at Attachment D. This guideline is intended to be used for both the development of coordination procedures and settlement of interference for devices operating under frequency-adjacent spectrum and apparatus licences. It also provides policy for the settlement of in-band interference.

The guideline was developed in consultation with industry and published to establish clear principles that would apply to interference dispute resolution. The guideline provides certainty for users and assists parties to resolve disputes among themselves. As the Commission has anticipated, the common law principle of first-in-time is relied upon, however it also provides for the use of more economically efficient solutions when they are possible. For example, part of the extensive interference settlement guideline states:

First-in-time registration and interference settlement

3.2 (1) The ACA intends to support the use of coordination procedures based on first-in-time registration by varying the details of the most recently registered device to remove interference—unless the other devices are not operating in accordance with their licence conditions. In some instances it may be more appropriate both technically and economically for the first service to have changes made at the expense of the later service operator, provided these arrangements do not degrade the service performance requirements of the first service.

Although we have not mentioned it in previous submissions, because we needed to bring the Commission's attention to what we believe are much more important issues concerning the continuing economic efficient operation of spectrum licensing, these interference settlement guidelines, which were part of the continuing improvement of spectrum licensing before the 2 GHz auction, were not included in the 2 GHz technical framework. This is another example of the partial definition of that framework about which we continue to be concerned.

We believe the Commission has made an error in its statement in relation to first-in-time interference settlement that "Favouring prior uses could impede new uses that offer greater social benefits." This statement is more to do with re-allocation than interference settlement. And the quoted DCITA comments have more to do with spectrum planning than interference settlement.

We encourage the Commission to read the attached ACA guideline in order to obtain a better feel for our comments on the need to balance a number of objectives in any interference settlement process.

9.0 Achieving True Technology Neutral Spectrum Licences

It is obvious from our statements to the Commission and our other publications that FuturePace was disappointed with the design techniques used for the Australian 3G spectrum licences at 2 GHz. They represented a retrograde step in the evolution of spectrum licence design. They were not technology neutral in that the spectrum access conditions were biased towards use of a particular 'likely-use'. In addition, the licences were not fully defined to provide a basis upon which licensees may establish the utility (and hence value) of their spectrum or negotiate with adjacent licensees for modified conditions or interference settlement. We have attached a paper, "*True Technology Neutral Spectrum Licences*" at Attachment C, which not only clearly describes the mistakes Australia made at 3G but proposes a solution. The ACA in commenting on our paper, have said that in their view

consultation was adequate, they have not however, challenged the accuracy and veracity of our comments about unnecessary technology bias and partial definition of the framework.

The Commission states in its draft report that "*It is difficult for the Commission to assess whether the technical prescription that has crept into spectrum licensing was a pragmatic and necessary response to an unworkable concept or the capture of the reform process by a conservative industry"*.

FuturePace does not accept that spectrum licensing, as envisioned by the Act, is conceptually or practically unworkable. Nor do we accept that the process was captured by a conservative industry, industry in fact are keen on the concept and are creatively using the additional flexibility provided by spectrum licensing. We do however feel that there is scope for a more open arrangement in relation to the administration of spectrum licensing.

As we said to the Commission at its hearing in Canberra in October last year, spectrum licensing is no longer a black art and it is not so complex that only a few people can understand it. However, like any other science, it requires study and application.

FuturePace invites the attention of the Commission to our attached paper before making decisions about the practicality of technology neutral licences. We certainly agree with the Draft Report that the Act envisages true technology neutrality and we reiterate there is no reason why this can not be provided.

And technology neutrality is absolutely essential if perpetual licences are to be issued at any time in the future.

Attachment A.

Findings, Recommendations and Requests for Information for which FuturePace Offers Comment

Chapter 5 Spectrum allocation

DRAFT FINDING 5.1
Although there are overall benefits from adhering to the international spectrum plan to minimise the potential for international interference, Australia's geographic location gives it some flexibility to depart from the International Telecommunications Union plan for Region 3.

FuturePace Comment - For many frequency bands and services there is little benefit in adhering to the international spectrum plan irrespective of the location in the world. Spectrum Plans based on technical prescription have been formerly used to simplify the task of coordination between individual devices and provide equity of spectrum access for adjacent countries. Unfortunately, the ITU standardisation process has also often been captured by industry to limit competition. Spectrum licensing can simplify coordination between spectrum spaces and devices without using technical prescription, provide equitable spectrum access as well as open up competition and Australia's geographic location does not provide any additional benefit in this regard. We recommend that the Commission amend this finding to read:

> "Although there are some benefits from adhering to the international spectrum plan to minimise the potential for international interference, Australia's economic growth will often be enhanced by using spectrum licensing to depart from the International Telecommunications Union plan for Region 3"

We ask the Commission to consider our proposal carefully because the present draft finding is likely to send an incorrect message to overseas countries that spectrum licensing will only work in Australia when that is definitely not the case. Australia would then miss out on the benefits which could derive from exporting the technology, rather than inadvertently managing it out of existence.

Chapter 6 Licensing

DRAFT FINDING 6.3
There are few advantages and likely disadvantages from introducing a single licence type compared with retaining the current licence types in the Radiocommunications Act 1992.

FuturePace Comment – We agree strongly as argued in our previous submissions.

DRAFT FINDING 6.4
The practice of using a market-based approach only when there is excess demand for a band may unnecessarily restrict the issue of spectrum licences. From an efficiency perspective, it may be beneficial to sell spectrum licences even when there is only one prospective buyer.

DRAFT RECOMMENDATION 6.1
The Australian Communications Authority should issue spectrum licences in bands even if only one party is interested in using that bandwidth. To establish the level of demand, the Authority should call for expressions of interest and allow a suitable period for responses.

FuturePace Comment – We agree. It is more important to have spectrum licences in the market than to wait until it is possible to determine how much they are worth using a competitive bidding process.

DRAFT FINDING 6.5
Competition limits imposed under sections 60 and 106 of the Radiocommunications Act 1992 are not necessary given the application of section 50 of the Trade Practices Act 1974.

DRAFT RECOMMENDATION 6.2
Those parts of sections 60 and 106 of the Radiocommunications Act 1992 that impose competition limits should be repealed.

FuturePace Comment – We agree, competition limits have mostly been used to generate competition in the auction rather than competition in the marketplace.

DRAFT RECOMMENDATION 6.5
Section 130 of the Radiocommunications Act 1992 should be amended to specify that apparatus licences generally will be renewed unless:
• licensees have failed to comply with licence conditions; and/or
• spectrum re-allocation declarations affect the licences.

FuturePace Comment – We agree.

DRAFT FINDING 6.6
Given that apparatus licences are akin to short-term permits to access a public resource, it is not appropriate to provide compensation to apparatus licensees whose licences are cancelled or not renewed as a result of spectrum re-allocation.

FuturePace Comment – We agree.

DRAFT RECOMMENDATION 6.6
Section 82 of the Radiocommunications Act 1992 should be amended so that, if it re-issues spectrum licences to the same persons, the Australian Communications Authority is required to publish its reasons and the fees paid.

FuturePace Comment – We agree, with the proviso that there should be an open process for the assessment of likely competition and alternate usage of the spectrum and the decisions should be challengeable at law if there is significant industry disquiet with the decision as was the case with the 2.3GHz re-allocation. And where there is interest in the spectrum from parties in addition to the incumbent there should be an open market place process, such as an auction to determine future use. The 2.3 GHz experience suggests that picking winners is not a suitable activity for Government.

DRAFT FINDING 6.8
The conversion process has been hampered by technical and legal complexities as well as legislative impediments.

FuturePace Comment – Our comments on the 2.3 GHz conversion apply here. There are principles set out in the Act but the lack of an open and reviewable process can lead to the appearance of 'mates' deals and possible misapplication of the law, as well as a denial of competition. For example anyone buying spectrum at 3.4GHz would have had an interest in competing for the 2.3GHz spectrum because of the availability of equipment at 2.3GHz. In conversion, the 2.3 GHz spectrum was biased towards one way services when through re-allocation and auction it might have been designed to be technology neutral to accommodate two-way services. And of course the price at which the spectrum was sold was significantly lower than the same spectrum realised at private sale shortly after (anecdotal evidence suggests possibly before) completion of the conversion. Which means that neither spectrum management excellence nor economic efficiency, if that is defined by revenue augmentation, were achieved.

DRAFT RECOMMENDATION 6.7
The Radiocommunications Act 1992 should be amended to allow the conversion of a designated band to spectrum licences while allowing for certain apparatus licences to remain in that band.

FuturePace Comment – We agree. However, we do not believe there is any need for amendment of the legislation because as far as we are aware,there is currently no limit on the maximum re-allocation period, which could be for the life of the licence.

DRAFT RECOMMENDATION 6.8
Where it is cost-effective to do so, the Australian Communications Authority should convert wide area apparatus licences into spectrum licences.

FuturePace Comment – We agree.

DRAFT RECOMMENDATION 6.9
The conversion process in the Radiocommunications Act 1992 should be amended to allow the Australian Communications Authority to offer — where practicable — a spectrum licence for the same frequency range in cases where an apparatus licensee operates on different frequencies in contiguous geographic areas.

FuturePace Comment – FuturePace is aware that the current Act includes a 'where practicable' allowance for conversion, and the Commission may be suggesting the only practicable solution for the conversion of fixed link spectrum.

Chapter 7 Secondary markets

DRAFT FINDING 7.5
The technology and site specific nature of apparatus licences severely restricts the potential for trade in these licences.

FuturePace Comment – We do not agree. The potential for trade of apparatus licences is not restricted by their utility, rather we feel it is the ready availability of equivalent licences direct from the ACA that affect trading between licensees. Trading in apparatus licenses is likely to be promoted by the introduction of private band managers, though there may be an ongoing need for the ACA to retain management of some areas, especially where international, security and other safety-of-life considerations apply.

DRAFT FINDING 7.7
'Use it or lose it' provisions generally are not warranted as supplementary conditions in radiocommunications licences because of the protection afforded by the Trade Practices Act 1974.

FuturePace Comment – We agree. 'Use it or lose it' clauses are difficult to define and even more difficult to monitor.

Chapter 8 Managing interference

DRAFT RECOMMENDATION 8.1
The Australian Communications Authority should not be able to refuse registration of a device where an accredited person certifies that the device will not breach spectrum licence core conditions.

FuturePace Comment – We agree else we, like the Commission, can see the danger of contributory liability arising for the ACA in the settlement of future interference cases.

DRAFT RECOMMENDATION 8.2
In the case of 'lawful' interference, the Australian Communications Authority should recover the costs of interference investigation according to the cost recovery arrangements for indirect costs.

FuturePace Comment – We agree.

DRAFT RECOMMENDATION 8.3
In the case of 'unlawful' interference, the Australian Communications Authority should endeavour to recover the reasonable costs of interference investigations from the person making the unlawful transmissions.

FuturePace Comment – We agree.

Chapter 9 Charging for spectrum

DRAFT RECOMMENDATION 9.1
The Australian Communications Authority should assess the advantages of combinatorial auctions over simultaneous ascending auctions in the light of any forthcoming overseas evidence. If combinatorial auctions prove superior, following consultation, the Authority should consider this format for the future auctioning of spectrum licences.

FuturePace Comment – The definition of 'prove superior' concerns us. In addition, our experience with consultation does not reassure us that all issues will be weighted correctly especially when final decisions are unreviewable and reasons not often provided. In this case, agreement within industry would be a minimum requirement, because so much has been spent in the development of existing industry based auction management systems. Significant added economical efficiency, considering all its contributions, would need to be satisfactorily demonstrated noting that, while ideas often work well in the confines of a laboratory, they often end up being unpredictable in the field. FuturePace is concerned that fashion or academic ambition rather than practicality and economy may be the driver for these demands, which we see not coming from industry but from auction designers. In any event we understand that the ACA already has this matter under constant review as part of its routine consultations with industry. We suggest it pursue the matter if there is sufficient general industry push for uptake.

At this point in time we feel that the Draft Report has provided insufficient rationale for the Commission to elevate this matter to the level of a Recommendation.

DRAFT FINDING 9.1
Spectrum auctions appear to have met the objectives assigned to them by the Government, namely efficient allocation of spectrum, accurate pricing of the resource, increased competition and revenue raising.

FuturePace Comment – We agree.

DRAFT RECOMMENDATION 9.4
The Australian Communications Authority should implement a more transparent and flexible model for calculating the apparatus licence Spectrum Access Tax. In particular, it should ensure that all the elements required for the calculation of fees are given to licensees, and that fees vary in a continuous — rather than a discrete — fashion.

FuturePace Comment – We do not necessarily agree that fees should be continuous, rather that the steps should result in a more equitable and common sense result. We also believe that fees should be based on the occupied bandwidth of a transmitter and not the channel width. Having a 'continuous' fee designed for a few discrete channel widths would not, in our view, solve the existing problem.

Chapter 10 Managing spectrum for non-commercial and broadcasting services

DRAFT RECOMMENDATION 10.1
The Commission recommends that:
• section 31(1b) of the Radiocommunications Act 1992 should be repealed, transferring responsibility for the broadcasting services bands of the spectrum to the Australian Communications Authority, to be managed under the provisions of the Act;
• licences granting access to spectrum should be separated from content-related licences that grant permission to broadcast, and the spectrum access charges should reflect the opportunity cost of the spectrum used; and
• the Australian Broadcasting Authority should retain responsibility for issuing licences to broadcast and for determining the number of non-commercial broadcasting licences in a licence area. It also should retain responsibility for regulating content, enforcing codes of practice and monitoring ownership.

FuturePace Comment – We agree.

Chapter 11 Operations of the Australian Communications Authority

DRAFT FINDING 11.1
Spectrum licensing, as introduced by the Spectrum Management Agency/Australian Communications Authority, provides greater flexibility of use than the concept originally envisaged by the Bureau of Transport and Communications Economics, but it is more prescriptive than was potentially provided for in the Radiocommunications Act 1992.

FuturePace Comment – We agree and we have proposed a solution in Attachment C.

DRAFT FINDING 11.2
The current arrangements introduced by the Australian Communications Authority governing interference impact certificates for registration of spectrum licence devices are not inappropriate.

FuturePace Comment – We agree, however we recommend that the Commission amend the wording to read “The current arrangements introduced by the Australian Communications Authority governing interference impact certificates for registration of spectrum licence devices are appropriate.”

DRAFT FINDING 11.3
The deployment of spectrum licences has proceeded more slowly and has been applied in far fewer bands than was envisaged in 1995.

FuturePace Comment – We agree.

DRAFT FINDING 11.4
The design and implementation of spectrum auctions by the Australian Communications Authority has followed — and, in some cases, set — world's best practice. Nonetheless, the possibility exists that it has set reserve prices too high in some auctions.

FuturePace Comment – The Commission may have read our comment on the FuturePace web site pertaining to the 2 GHz auction where we show how the ACA very accurately predicted the eventual price paid for the spectrum with its setting of reserve prices. In fact, so accurately that we briefly entertained the view there might be no further need for auctions.

Requests for information

The Commission seeks inquiry participants' views on the advantages and disadvantages of holding auctions a specified period (for example, three years) before spectrum licences expire.

FuturePace Comment – We agree that the auction should be held 3 years before expiry rather than license expiry being the time when auction preparations begin. Generally we do not support a melange of situations where spectrum may be auctioned or licenses extended, we support open market based processes.

The Commission seeks inquiry participants' views on the advantages and disadvantages of selling 'encumbered' spectrum licences.

FuturePace Comment – We agree that the selling of permanently encumbered spectrum licences could be beneficial, especially in remote areas and as part of the introduction of private band managers.

The Commission seeks inquiry participants' views on whether there are benefits in narrowing the list of device registration details to reduce the burden for spectrum licensees.

FuturePace Comment – We do not support any narrowing of the list of device registration details for spectrum licensing and emphatically dispute that there is a 'burden' for spectrum licensees. See body of our submission for further details.

The Commission requests more information from interested parties on the following:
a) How binding are boundary conditions?
b) Are current arrangements allowing licensees to negotiate changes to boundary conditions adequate?
c) What are the implications of adopting generic boundary conditions that would allow licensees to negotiate among themselves on the most appropriate arrangements?

FuturePace Comment – FuturePace:
a) understands that the core and access conditions are binding under law;
b) has practical experience of negotiating spectrum sharing agreements using the several methods already provided by technical frameworks including composite licensing; and

c) has seen no evidence that would support the development of a technical framework after spectrum licences were issued. Furthermore, we have described a method for the design of technology neutral spectrum licences. We also caution against any removal of the present device boundary construct until it has be clearly demonstrated that some other mathematical device significantly improves on all the current benefits. See body of our submission for further details.

Attachment B

Additional Device Related[5] Details for Apparatus Licences

Registration of apparatus licenses requires details equivalent to spectrum licensing plus the following:

1. the callsign;
2. the ship station name (where applicable);
3. the carrier frequency (as opposed to assigned frequency which is also required);
4. the lower frequency limit;
5. the upper frequency limit;
6. the status (that is, whether approved or not);
7. if the operation of the device is related to a geographic area-that area;
8. whether the coverage is by means of a low power apparatus within the meaning of the Transmitter Licence Tax Determination No. 2 1995;
9. the registration number allotted by the International Frequency Reservation Board.
10. the transmitter power (as opposed to EIRP which is also required);
11. the International Frequency Reservation Board power indicator;
12. the antenna tilt relative to the perpendicular.
13. whether the site is within a high density geographic area, a medium density geographic area or a low density geographic area, within the meaning of the Transmitter Licence Tax Determination No.2 of 1995;
14. the site elevation above sea level.

[5] Note that for a proper comparison, devices operated under a single apparatus licence have a licence number, call sign, licence type etc., which applies to each device operated under the licence. These are also device related properties.

Attachment C.

True Technology Neutral Spectrum Licences

A TECHNICAL PAPER BY:

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DATE:

FEBRUARY 2002

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1.0 Introduction

When Australian spectrum licences were first auctioned in 1996 the Government encouraged industry to embrace a new system of spectrum management which would provide 15 years of operational certainty against clearly defined licence conditions for the deployment of any type of radiocommunications equipment. Fine print revealed that such deployments had to meet the conditions of the licence.

Until the recent auction of 3G licences at 2 GHz for a total of $1.17 billion, licence design techniques had been progressively augmenting an appropriate balance of flexibility and certainty, as both industry and government slowly came to grips with the science of spectrum licensing. The 3G auction marked a retrograde step. Following a design technique more attuned to traditional apparatus licensing, these licences were deliberately biased towards the use of a particular equipment standard, WCDMA. They were also partially defined, opening the door to costly and uncertain negotiation with adjacent licensees for interference management when other equipment is operated.

The Marketing Plan released prior to the 3G auction did not clearly state the likely impact of the failure to define certain aspects of the technical rules and many licensees may still be unaware of the full implications for future network deployment. Licensees assuming policy continuity would be well advised to closely examine their licences.

2.0 What does a spectrum licence offer?

A spectrum licence provides a means of authorising the use of radiocommunications devices within a defined spectrum space. The space is defined not only in terms of geographic area, bandwidth and time (the core conditions), but also through all the other licence conditions that limit access to the spectrum space for devices (the access conditions).

The access conditions incorporate levels of receiver protection from interference caused by neighbouring transmitters in either a direct or indirect manner and generally ensure equitable spectrum access on both sides of the area and frequency boundaries. Access conditions significantly affect the level of utility of the spectrum. If access conditions are biased towards a particular type of equipment it often means that it is more difficult to operate other types. This subsequently reduces the value of the spectrum for those other types.

The combination of core and access conditions does not directly manage interference, rather it creates a basis for the design of coordination rules by the licensee for the self-management of interference. The licensee coordinates with existing devices that are just outside the area and frequency boundaries of a licence and registered in the ACA's national on-line centralised data base. Registration of receivers grants priority for their continued operation when interference occurs. Australia leads the world in the development and maintenance of its national publicly available data base.

3.0 What is interference?

There are two main types of interference that must be managed by spectrum licensees:

- In-band interference; and
- Out-of-band interference.

3.1 In-band Interference

In-band interference can be caused over large distances by co-channel (same frequency) emissions from transmitters operated under area-adjacent apparatus or spectrum licences. Licensees manage this interference, by knowing, because it is specified in the licence conditions, the maximum level allowed to be radiated from any specified site in an adjacent area. Licensees then determine on a risk assessment basis, how far their receivers must be

set back from the area boundary in order to cope with that allowed maximum level.

In-band interference may also be caused over short distances by the out-of-band emissions (emissions outside the nominal channel width) which are incidental to the use of a frequency adjacent spectrum or apparatus licence. A properly designed and fully specified spectrum licence will usually state the limits for the allowed levels of these radiated emissions. Spectrum licensees then manage this interference by determining the isolation requirements for their receivers with regard to the limits and the likelihood of the presence of transmitters operated under frequency-adjacent licences. Interference of this type, which is steady and continuous, can reduce the useable range of received signal levels, which in turn, for example, affects the maximum communication distance of mobile services. Interference of this type, which is transient in nature, can reduce the communication capacity of a system by the loss and re-transmission of data.

3.2 Out-of-band Interference

Out-of-band interference occurs when transmitters and receivers operate close together in terms of the two main variables that determine their degree of isolation from each other: distance and/or frequency separation. Out-of-band interference may be caused over short to medium distances when there is insufficient isolation. This interference is not directly caused by co-channel emissions, but by having the energy of emissions at other frequencies transferred to co-channel frequencies through a number of special mechanisms[6]. As can be imagined, the management of out-of-band interference presents the major difficulty in designing licence conditions.

[6] ***out-of-band interference*** means interference:

(a) relating to selectivity, blocking, intermodulation immunity and spurious response immunity; and

(b) caused by emissions at frequencies outside the frequency band of the spectrum licence;

This definition of out-of-band interference relates to specific interference mechanisms and should not be confused with 'out-of-band emission', a term used in apparatus licensing to refer to emissions at frequencies outside a channel.

4.0 How access conditions are biased

Spectrum licences are most often sold in a paired configuration consisting of upper and lower frequency bands separated by a large gap. This follows traditional spectrum planning methods, the intention, in the case of a mobile system, being for one band to be used by base transmitters and mobile receivers and the other by mobile transmitters and base receivers in what is called a two-frequency duplex system (FDD), with both signal paths able to communicate simultaneously. By using two very separate bands the base transmitters may be sufficiently isolated from co-located base receivers utilising frequency separation. This reduces the likelihood of out-of-band interference to acceptable levels. Spectrum licence access conditions have sought to mimic this type of use with transmitter deployment and radiated power constraints that are different in the upper and lower bands. These constraints tend to bias the access conditions towards a 'likely use' configuration.

Another form of biasing occurs when out-of-band emission limits are also chosen with regard to a 'likely use'. These levels are usually in accord with rather generous regulatory bench performance allowances. They are quite high, sometimes making it difficult to operate other equipment configurations in frequency-adjacent spectrum. Regulatory out-of-band emission masks are often not realistic and measurements of actual equipment usually outperform these masks by a significant margin. In practice, additional high quality filtering is also usually employed on transmitters which reduces the actual levels of emission substantially. Therefore, regulatory masks should not be copied directly into spectrum licence technical conditions. When they are copied, the need to consider that the licence conditions allow high levels of out-of-band emission militates against use of any other configuration. Obviously it is better to provide an initial high spectrum utility based on low levels of emission taking into account actual performance, operational practicality as well as theoretical models. Licensees may then increase those levels, if they so desire, biasing spectrum use through spectrum sharing

agreements, but this should be a commercial consideration, not a technical limitation of the licence.

5.0 What is wrong with designing licence conditions around a 'likely use'?

Access conditions have been biased towards a single likely use in all previous auctions except for 1.8 GHz remote areas and 3.4 GHz. Unfortunately, use of frequency bands is often not the same around the world, European and USA spectrum allocations often differ substantially. For example, the lower band of the recently sold Australian 3G spectrum at 2 GHz is paired even lower with the 1.8 GHz band in the USA. Also, frequency bands are subject to re-planning in the longer term. Likely use today will often be unlikely tomorrow.

There are many other types of services for which biased FDD access conditions are not appropriate, for example, same-frequency operation (time-domain duplex (TDD)) where a base transmitter/mobile receiver communicate for a period and then stop while the mobile transmitter / base receiver communicate, same-frequency repeater stations and point to point services. The constraints are also often not appropriate for other band pairing arrangements.

Any bias towards one service type means that additional spectrum space will usually be required to operate other types. This creates inequities in the isolation demanded by the access conditions for different types of services. Therefore, biased access conditions lead to inefficient use of spectrum for certain equipment.

Biasing may also be viewed as simply another way in which a government can 'pick technological winners' even though the Australian Government have clearly stated that its policy is not to do so. It can also follow that, because of the technical complexity of the issue, some areas of government may not realise they are being led to a technically biased solution which may favour

one company or technology over others. But there are implications for government which mean that a lack of such an awareness can lead to policy and cost aberrations. Owners of biased licences can sometimes lever an assumed right to limit competition from a government decision to bias licences. For example, the very high prices paid for the UK 3G IMT-2000 licences may have ramifications for policy development for 3G services in other bands in the UK well into the future. Governments can avoid these situations by providing unbiased access conditions.

There is no need for governments to take risks by biasing access conditions. Instead, spectrum licences can and should be designed upon a basic framework of true technology neutrality. After this is established, any decision to bias spectrum use, for whatever reason[7], may be left to industry. After the government establishes the basic neutral conditions, the decision to bias could then be taken according to industry consensus either before an auction, or spectrum sharing agreements negotiated between successful bidders after an auction. This would clearly differentiate between the basic neutral framework and added elements of technology bias and remove any in-built bias from the fundamental operation of the access conditions initially provided by government. A neutral framework reference would then assist industry in self-managing the evolution of its spectrum use over the full 15 year licence term, or permanently if perpetual licences are to be issued at some time in the future.

6.0 Achieving True Technology Neutrality

To achieve true technology neutrality, the access conditions must be designed without any bias towards an assumed likely use and therefore, be identical for both upper and lower bands. Simple access conditions and out-of-band emission limits based on mimicking a likely use would not be used. However, the conditions would still need to be capable of managing out-of-

[7] Usually to minimise the amount of spectrum used for guard bands.

band interference for receivers and transmitters operating close in terms of both frequency and distance separation.

This can be achieved using *guard space* techniques.

Guard space methods are not new. They are commonly used to manage discontinuities in spectrum planning between different types of services such as:

- the division between CDMA base transmitters and GSM base receivers at 890 MHz;
- the division between PHS and 3G TDD systems at 1.9 GHz; and
- the division between DECT and DCS-1800 systems at 1.88 GHz.

7.0 How does guard space work?

Guard space, consisting of both guard *band* and/or guard *area*, may be created by spectrum licensees deliberately not using their own spectrum space. A guard *band* may be created by not operating transmitters on frequencies that are near the frequency boundaries of licences. The objective of creating this internal guard *band* is to allow a frequency-adjacent licensee to utilise it for the operation of the roll-off of a filter they would need to protect their receivers. The objective of creating a guard *area* is to allow an area-adjacent licensee to utilise it to help isolate their receivers that are located at high sites near their area boundary. Note that it is also possible to design access conditions that require guard space to be shared with, or even fully provided by, an adjacent licensee. Shared guard space would obviously be the most equitable solution.

The amount of guard space required for a specific situation may be estimated on the basis on a fully defined minimum receiver performance (or notional receiver). This usually includes a full description of the RF and IF selectivity (receiver input filtering) together with a compatibility requirement defined as the likelihood of a maximum unwanted power spectral density at the receiver

input. In the past, reasonably concrete models have been used. However, there would be no difficulty in stripping away the physical model to its simpler more mathematically abstract form. The receiver model, together with models for in-band and out-of-band interference mechanisms, are then used by a licensee to calculate the minimum guard space requirements for a particular transmitter. Similarly, the minimum necessary additional internal guard space requirements for the operation of a receiver that does not operate better than the minimum receiver performance may also be calculated when licensees wish to operate those types of receivers.

8.0 Guard Space in Practice

Minimum guard band and guard distance for the co-existence of dissimilar 2 GHz cellular systems based on managing transmitter wide band noise and receiver blocking[8] is discussed in reference [1]. Given sufficient guard band, the respective base stations can be co-located as long as vertical antenna separation is used to achieve the necessary additional isolation.

Unfortunately, many guard band studies have used inappropriate equipment models, for example, the high levels of regulatory emission masks discussed earlier, and usually propose a larger guard band than actually necessary. Other equipment models can also be inappropriate, for example, models for handset power at a cell edge, handset sensitivity and propagation in the near field all need to be accurately modelled [2] to arrive at real guard band requirements. Guard band requirements between two adjacent CDMA operators is examined in [5].

In the case of asymmetric services with high data throughput in one direction, for example, video on demand, only one band of a FDD service would be required, hence utilising TDD in FDD spectrum could potentially double the spectrum utility. A true technology neutral spectrum licence would allow TDD operation in so-called FDD spectrum and fully define the conditions under

[8] Intermodulation effects can also be the limiting form of interference.

which it would be allowed to occur. Studies [3] show that TDD and FDD base stations operating in adjacent bands can be co-located if the amount of power reaching the receiver, due to imperfections in physical implementation of the transmitter and receiver, is more than 70 dB below the total transmitter power. This power ratio is referred to as the Adjacent Channel Interference Ratio (ACIR). Reference [4] recommends an increase in ACIR above a proposed 30 dB to ensure that data capacity is not reduced through interference when competitors operate in adjacent spectrum. The full definition of the minimum receiver performance for a spectrum licence is central to the value of ACIR.

9.0 What is wrong with the Australian 3G licences?

Unfortunately, the Australian 3G access conditions do not include the necessary full definition of the minimum receiver performance. Given that the concept of a fully defined notional receiver applies in traditional apparatus licensing it is difficult to understand the reasoning behind its excision from the 3G framework, unless the rush to auction to allow the predicted $2.6 billion input to the Revenue was the catalyst. In the event both the technical rigour of the licences and the budget predictions were unmet expectations. Instead of providing 15 years of operational certainty, the 3G licences potentially allow for 15 years of negotiation. Especially if, as equipment and technology develops, a licensee wishes to deploy something other than WCDMA. And this is highly probable in a highly creative industry dedicated to the creation of new and better technical solutions.

The decision to provide biased and partially defined access conditions will inevitably create difficulties. Importantly the resolution of interference problems will now be problematical without a clear indication of exactly which carrier is at fault and which needs to act and at what cost. Now that the spectrum has been sold a solution is likely to require the agreement of all licensees. However, any 3G licensee not yet ready to use its spectrum could, by drawing out negotiations, act in the market place to deliberately impede competitors wishing to be first in the marketplace.

10.0 True Technology Neutrality in Practice

If access conditions are defined on the basis of guard space, to achieve a fully defined benchmark of true technology neutral utility, licensees could negotiate additional spectrum sharing arrangements, as they do now, to bias the access conditions taking advantage of any new overseas developments as they occur but without the complexities caused by in-built bias. A decision to bias spectrum use would then be in the hands of industry rather than government. And, any bias would also have been reversible by industry without government involvement. This would represent a change in the state of the art of licence design, and significantly add to an increasingly self-regulated communications sector.

As more and more spectrum is managed under spectrum licensing, true technology neutrality would enable a licensee to use band pairing consisting of one band from a current auction and another from a previous auction. This will be an essential requirement for industry if perpetual licences are to be issued at some time in the future.

11.0 References

[1] *Sathyendran A., Murch A., Shafi M.* 'Study of Inter-System Interference between Region One and Two Cellular Systems in the 2GHz Band' Vehicular Technology Conference, 1998. VTC 98. 48th IEEE, vol. 2 , 1998 Page(s): 1310 -1314 vol.2

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[3] *Miao Qingyu; Wang Wenbo; Yang Dacheng; Wang Daqing* 'An Investigation of Interference between UTRA-TDD and FDD systems' Communication Technology Proceedings, 2000. WCC - ICCT 2000. International Conference, Volume: 1, 2000 Page(s): 339 -346 vol.1

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[5] *Park et al* 'Frequency Coordination Between Adjacent Carriers of Two CDMA Operators' IEEE Vehicular Technology Conference 1996, pp1456.

About FuturePace Solutions

Spectrum Management International Pty Limited, trading as FuturePace Solutions, is a privately owned company operating since 1997 and headquartered in Canberra. FuturePace has two Directors, Michael Whittaker who was principally responsible for designing the Australian 500MHz, 800MHz, 1.8GHz, 3.4GHz and 28/31 GHz spectrum licensing technical frameworks and Barbara Phi who handles business development and administration.

The company specialises in the certification of RF regulatory compliance and EMR risk hazard management following the out-sourcing by the ACA of much of their liability in relation to their certification function. FuturePace has a long-term commitment to professional research and the development of general and cost effective spectrum solutions for network, regulatory and public interest matters. They may be reached at www.futurepace.com.au or by e-mail at futurepace@bigpond.com.

Attachment D.

Commonwealth of Australia

Australian Communications Authority

Radiocommunications Act 1992

Radiocommunications Advisory Guidelines (Managing Out-of-band Interference in Receivers Operating in Spectrum Licensed Space—3.4 GHz Band) 2000

The AUSTRALIAN COMMUNICATIONS AUTHORITY makes the following guidelines under section 262 of the *Radiocommunications Act 1992*.

Dated 17 July 2000

R Horton
Acting Chair

G W Luther
Senior Executive Manager
Radiocommunications

Australian Communications Authority

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PART 1 - INTRODUCTION

Title

1.1 These Guidelines are called the *Radiocommunications Advisory Guidelines (Managing Out-of-band Interference in Receivers Operating in Spectrum Licensed Space—3.4 GHz Band) 2000*.

Commencement

1.2 These Guidelines commence on 17 July 2000.

Purpose of these Guidelines

1.3 These guidelines provide a compatibility requirement to be complied with by transmitters for the management of out-of-band interference in certain receivers that are operated in spectrum licensed space in the 3.4 GHz band. The compatibility requirement is intended to be used as the basis for both the development of coordination procedures and settlement of interference for devices operating under frequency-adjacent licences.

Interpretation

1.4 (1) In these Guidelines, unless the contrary intention appears:

Act means the *Radiocommunications Act 1992.*

blocking means a measure of the ability of a receiver to receive a wanted signal, in the presence of a high level unmodulated signal, that:

(a) is at the frequency offsets set out in Schedule 1 (but excluding the characteristic frequencies relating to spurious response immunity); and

(b) increases the non-linearity of the receiver's pre-amplifier;

without the receiver's grade of service falling below the compatibility requirement.

compatibility requirement means a receiver grade of service based on the conditions for wanted and unwanted signal levels at the receiver's input, as set out in Schedule 2.

in-band means:

(a) for a transmitter operated under a spectrum licence, the frequencies within the frequency band to which the licence relates; and

(b) for a receiver operating in the space of a spectrum licence, the frequencies within the frequency band to which the licence relates; and

(c) for a transmitter or receiver operating under an apparatus licence, the frequencies between the lower frequency limit and the upper frequency limit of its spectrum access.

[Note: For an apparatus licence, the lower frequency limit and the upper frequency limit of its spectrum access are published by the ACA on the Register of Radiocommunications Licences CDROM. The bandwidth contained by those limits often appears on the licence as the 'chargeable bandwidth'.]

in-band interference, for a receiver, means those levels of emissions from a transmitter that are permitted under the conditions of the licence under which it operates and:

(a) if the receiver is operated in the space of a spectrum licence, the emissions at frequencies within the frequency band of the spectrum licence; or

(b) if the receiver is operated under an apparatus licence, the emissions at frequencies between the lower frequency limit and the upper frequency limit of the spectrum access of the apparatus licence.

[Note: When interpreting 'in-band interference' it is important to keep in mind that 'those levels of emissions from a transmitter that are permitted under the conditions of the licence' relate to in-band as well as out-of-band emissions.]

incumbent, for a device, means a device:

(a) that operates under an apparatus licence; and

(b) that had part of the band comprising the frequencies between the lower frequency limit and the upper frequency limit of its spectrum access, and its location, within the re-allocation of the 3.4 GHz band when that band was re-allocated.

intermodulation immunity, for a receiver, means 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 signals with a specific amplitude and frequency relationship to the wanted signal frequency.

Marketing Plan means the *Radiocommunications Spectrum Marketing Plan (3.4 GHz Bands) 2000.*

out-of-band interference means interference:

(a) relating to selectivity, blocking, intermodulation immunity and spurious response immunity; and

(b) if the receiver is operated in the space of a spectrum licence, caused by emissions at frequencies outside the frequency band of the spectrum licence; or

(c) if the receiver is operated under an apparatus licence, caused by emissions at frequencies outside the band that is between the lower frequency limit and the upper frequency limit of the spectrum access of the apparatus licence.

[Note: This definition of out-of-band interference should not be confused with 'out-of-band emission', a term used in apparatus licensing to refer to emissions at frequencies outside a channel.]

RALI LM8 means the Radiocommunications Assignment and Licensing Instruction No. LM8 issued by the ACA, as in force from time to time, copies of which are available from the ACA.

selectivity means a measure of the ability of a receiver to discriminate between wanted and unwanted signals according to the IF and RF response set out in Schedule 1.

spurious response immunity means a measure of the ability of a receiver to receive a wanted signal at its operating frequency, in the presence of an unwanted signal at characteristic frequencies at which the receiver responds that are greater than 3 MHz from the receiver's operating frequency, without the receiver's grade of service falling below the compatibility requirement.

section 145 determination means the *Radiocommunications (Unacceptable Levels of Interference—3.4 GHz Band) Determination 2000.*

3.4 GHz band means the following frequency bands:

(a) 3425MHz – 3475 MHz (the 3.4 GHz Lower Band);
(b) 3475 MHz – 3492.5 MHz (the 3.4 GHz Upper Band A);
(c) 3542.5 MHz – 3575 MHz (the 3.4 GHz Upper Band B).

[Notes: 1. The following terms, used in these advisory guidelines, are defined in the *Radiocommunications Act 1992* and have the meanings given to them by that Act:

core condition	Register
frequency band	interference
ACA	spectrum licence
transmitter.	

2. The following terms, used in these advisory guidelines, are defined in the section 145 determination and have the meanings given to them by that determination:

device boundary	emission centre frequency
effective occupied bandwidth	groups of receivers
effective antenna height	effective occupied band]

Background

1.5 (1) The conditions of spectrum licences (and in a related manner, the conditions of apparatus licences) are designed to keep significant levels of emission within the geographic and frequency space of the licence and in doing so tend to manage in-band interference. For spectrum licences, the main conditions managing in-band interference are:

(a) the core condition about emission limits outside the area; and
(b) the device boundary criterion; and
(c) the core condition about emission limits outside the band.

If protection from in-band interference is required at levels that are above the intrinsic levels provided by these conditions then receivers operated under spectrum

licences (or under apparatus licences issued after[1] the date of the Marketing Plan) must be operated in ways which provide that additional protection.

(2) Emissions causing in-band interference do not normally[2] need to be reduced. The management of in-band interference is left to the operator of the receiver, who would need to consider:

(a) the likelihood of transmission from popular sites; and

(b) the levels of emission in the direction of the receiver that are allowed by relevant licence conditions.

The operator of the receiver would need to take precautions to protect the receiver from the possibility of these emissions for the full term of the relevant licence.

(3) Out-of-band interference is managed differently (see clause 1.7). Out-of-band interference refers to a number of non-linear types of interference that may occur across the frequency boundaries of licences. For example, receiver intermodulation may occur when a receiver is in the presence of two or more unwanted signals at frequencies outside the bandwidth of the receiver.

(4) The likelihood of out-of-band interference depends on the proximity, in terms of both frequency and distance, of transmitters and receivers and, therefore, requires special consideration at communal sites. Out-of-band interference:

(a) may be caused by transmitters operating at frequencies that are many MHz from the operating frequency of a receiver; and

(b) is related to the quality of the receiver as well as the levels of transmitter emissions.

(5) The emission limits of spectrum licences are not designed to manage out-of-band interference. It is not practical to manage out-of-band interference (for example, receiver intermodulation) with transmitter emission limits because that type of interference increases much faster than changes in the level of the signal causing it and, therefore, any limits would have to be very low. Low limits throughout the entire geographic area of a licence (the frequency band limits of a spectrum licence exist throughout the entire area of the licence) would be unreasonable when mostly only communal sites require that level of protection and then only in certain situations. Out-of-band interference is more efficiently managed through coordination procedures based on a defined compatibility

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[1] The holders of pre-existing apparatus licences issued before the date of the Marketing Plan are provided with protection based on the compatibility requirements of the *Radiocommunications Advisory Guidelines (Managing Interference to Apparatus Licensed Receivers—3.4 GHz Band) 2000.*

[2] Except where compatibility requirements for pre-existing apparatus licences and a defined Level of Protection for receivers operating in the space of spectrum licences are not met. A Level of Protection is defined for 500 MHz spectrum licences because a small bandwidth standard trading unit STU is allowed for the trading of spectrum. A Level of Protection will not be defined for 3.4 GHz spectrum licences because the minimum aggregation of bandwidth STU's is large and the operating frequency of devices may be varied to work around cases of interference caused by anomalous propagation.

requirement. This approach maximises spectrum utility and flexibility and provides equitable spectrum access for devices operating near frequency boundaries.

Managing in-band interference

1.6 (1) Although these Guidelines are directed towards the protection of receivers operated within the space of spectrum licences, it is helpful to present the general policy for management of interference to receivers in any situation.

(2) In-band interference is considered to be acceptable if the interfering transmitter complies with all the conditions of the licence under which it operates. This policy applies equally to apparatus and spectrum licences, and is designed to provide certainty for licensees by allowing them to continue to operate radiocommunication systems in accordance with the emission limits of a licence for the full term of the licence. In the case of spectrum licences, this certainty also extends to emission limits relating to the device boundary criterion. For apparatus licensing, the re-use distance provides a similar guarantee. It is only when emissions create out-of-band interference that additional management is required. This is the purpose of these Guidelines.

(3) In-band interference caused by apparatus licensed transmitters licensed before the date of the Marketing Plan to receivers operating in the space of spectrum licences, is managed by the conditions of the apparatus licence. Spectrum licensees must accept that interference:

(a) if the transmitter is non-incumbent, for the licence term; or

(b) if the transmitter is incumbent, for the relevant re-allocation period.

Before a Marketing Plan is made, the frequencies of apparatus licences are usually assigned without regard to future spectrum licences.

(4) In-band interference caused by apparatus licensed transmitters licensed after the date of the Marketing Plan to receivers operating in the space of spectrum licences is usually managed by assigning frequencies to apparatus licences using coordination procedures identical to the device boundary criterion in the relevant s.145 Determination. This process ensures that the receivers do not experience higher levels of in-band interference than they would if the adjacent spectrum was managed under spectrum licensing.

(5) In-band interference caused by spectrum licensed transmitters to non-incumbent and incumbent apparatus licensed receivers licensed before the date of the Marketing Plan is managed in accordance with the compatibility requirements described in the *Radiocommunications Advisory Guidelines (Managing Interference to Apparatus Licensed Receivers—3.4 GHz Band) 2000*. These compatibility requirements apply:

(a) if the receiver is non-incumbent, for the licence term; or

(b) if the receiver is incumbent, for the relevant re-allocation period.

For these purposes, receivers that communicate with incumbent transmitters are to be treated as incumbent.

(6) In-band interference caused by spectrum licensed transmitters to apparatus licensed receivers licensed after the date of the Marketing Plan is managed by the conditions of the spectrum licence. Those receivers must accept that interference from the time when the transmitter is first registered.

Managing out-of-band interference

1.7 (1) Out-of-band interference is managed through a coordination procedure using devices that are selected on a first registered basis to meet a compatibility requirement, as follows:

(a) the operator of a transmitter need only take account of receivers already registered when the transmitter is registered; and

(b) the operator of a receiver need only take account of transmitters already registered when the receiver is registered.

(2) A receiver will not be afforded protection unless its details are in the Register.

PART 2 - USE OF THE COMPATIBILITY REQUIREMENT

When the compatibility requirement is used

2.1 (1) The compatibility requirement is used to manage out-of-band interference occurring in receivers operating in the space of a spectrum licence that is frequency-adjacent to either apparatus licences or other spectrum licences. These situations may commonly occur:

(a) across the frequency boundaries 3425, 3442.5, 3475, 3492.5, 3542.5 and 3575 MHz, when caused by transmitters operated under apparatus licences; and

(b) across the frequency boundary 3475 MHz, when caused by transmitters operated under spectrum licences having effective occupied bands containing frequencies above 3475 MHz.

(2) The ACA intends to take the compatibility requirement into account when settling interference disputes between apparatus and spectrum licensees under Part 4.3 of the Act. Therefore, the compatibility requirement is intended to be used as a basis for the development of coordination procedures used to assign transmitter frequencies.

(3) The compatibility requirement may also be used to guide the settlement of interference between frequency-adjacent spectrum licensees.

PART 3 - RECEIVERS TO WHICH THE COMPATIBILITY REQUIREMENT APPLIES

When the compatibility requirement applies

3.1 The compatibility requirement does not apply to all receivers operating in spectrum licensed space. It will only apply if the receiver:

(a) is registered before any of the transmitters causing the interference (first-in-time registration); and
(b) has a level of performance equal to or better than the level specified in Schedule 1; and
(c) is operated or authorised to operate by the licensee; and
(d) is of a type specified in clause 3.5; and
(e) is deployed as set out in clause 3.6, having regard to the band in which it is operated, the effective antenna height and the beamwidth of the antenna.

First-in-time registration and interference settlement

3.2 (1) The ACA intends to support the use of coordination procedures based on first-in-time registration by varying the details of the most recently registered device to remove interference—unless the other devices are not operating in accordance with their licence conditions. In some instances it may be more appropriate both technically and economically for the first service to have changes made at the expense of the later service operator, provided these arrangements do not degrade the service performance requirements of the first service.

(2) If the operating conditions of a transmitter or receiver are later varied so as to increase the likelihood of interference, the effective date of registration for interference settlement purposes is:

(a) the date at which the variation was made; or
(b) if the operator reverts to the original registration details—the original registration date.

(3) The likelihood of interference to a varied transmitter or receiver increases whenever:

(a) for a transmitter operated under a spectrum licence:
  (i) the device boundary expands; or
  (ii) the effective occupied band expands outside the original frequency band; or
(b) for a receiver operated in the space of a spectrum licence:
  (i) the antenna gain for any azimuth increases; or
  (ii) the receiver's deployment changes so that the compatibility requirement is applied when previously it was not applied; or
  (iii) the location is changed; or
  (iv) the effective occupied band of the transmitter communicating with the receiver expands outside the original frequency band; or
(c) for a transmitter operated under an apparatus licence:
  (i) the radiated power for any azimuth increases; or
  (ii) the location is changed; or

(iii) the antenna height is changed; or
(iv) the lower frequency limit of its spectrum access decreases or the upper frequency limit of its spectrum access increases.

(d) for a receiver operated under an apparatus licence:
(i) the antenna gain for any azimuth increases; or
(ii) the location is changed; or
(iii) the lower frequency limit of its spectrum access decreases or the upper frequency limit of its spectrum access increases.

(4) The early registration of devices at the network design stage is encouraged by the ACA as an aid for licensees who wish to check the coordination work of adjacent licensees.

Receiver performance levels

3.3 (1) The degree of out-of-band interference to a receiver depends to an extent on the interference susceptibility of the receiver. Emission levels from transmitters should not have to be reduced when poor performance of the receiver is to blame. Therefore, when establishing a compatibility requirement for receivers, it is necessary to also establish a minimum receiver performance. The receiver minimum performance level is set out in Schedule 1.

(2) Transmitter emission levels will be judged against the receiver minimum performance. Note that, under spectrum licensing, a licensee may choose to operate a receiver of any performance level. The protection given by the compatibility requirement is not available to receivers with a performance level below the minimum level. However, if transmitter emission levels are excessive in relation to the minimum receiver performance then action would normally be required to reduce them to the necessary level.

(3) The ACA proposes that, because the desired outcome is equity in the use of adjacent spectrum, the minimum receiver performance level should be similar throughout the entire 3.4 GHz spectrum licensed bands.

Receivers operated or authorised to operate by the spectrum licensee

3.4 (1) The compatibility requirement applies only to a receiver operated by the licensee (or a receiver authorised to operate by the licensee):

(a) in the geographic area and frequency band of the relevant spectrum licence; or
(b) as described in subclause (3).

(2) A receiver is operating in the frequency band of a spectrum licence when the effective occupied bandwidth of the transmitter communicating with the receiver is within the frequency band limits of the licence. Broadly speaking, this occurs when the receiver's IF bandwidth stays within the spectrum licence limits. In practice, the IF bandwidth of a receiver may be slightly broader than the effective occupied bandwidth and this must be taken into account by the operator of the receiver.

(3) Where a transmitter is registered under a spectrum sharing agreement and its effective occupied bandwidth overlaps the frequency bands of two or more licences, the receiver is taken to be operating within the space of a spectrum licence having a frequency band equivalent to the combined frequency bands of the shared licences.

Types of receivers

3.5 (1) The compatibility requirement does not apply to mobile[3] devices operating under any type of licence because the mobility of the devices prevents the use of a practical coordination procedure for managing out-of-band interference.

(2) Except for a group of fixed receivers located near a central point[4], the compatibility requirement does not apply to receivers that are registered in a simplified manner using the concept of group of receivers.

Receiver deployment

3.6 (1) When a transmitter is certified as complying with the relevant section 145 determination and is registered, it means that it satisfies certain conditions about the deployment of transmitters (deployment constraints). Receiver compatibility requirements are assigned in a manner complementary to the transmitter deployment constraints, to provide immediate spectrum access for the most common equipment configuration without loss of spectrum utility from out-of-band interference. This is one aspect of the operational certainty offered by Australian spectrum licences. It is not acceptable for a successful bidder either to risk the ability to negotiate, or to pay the additional cost of negotiation, with an adjacent licensee about the management of out-of-band interference. Deployment constraints remove a substantial amount of negotiation costs that would otherwise be necessary.

(2) While a licensee is allowed to operate any type of receiver at any location, the provision of a compatibility requirement depends on the beamwidth of the antenna, the band in which it operates and its effective antenna height. If a compatibility requirement does not apply to a receiver, a licensee would normally take account of the risk of interference in some other manner, for example, by some agreement with the manager of a communal site or by using guard space within the spectrum licence space.

(3) The compatibility requirement is provided to receivers:

(a) that communicate with a transmitter that has its effective occupied band totally within the 3.4 GHz Lower band; and

(b) that use an antenna with a beamwidth greater than 5 degrees; and

[3] It is not expected that mobile devices will operate at 3.4 GHz, however, the Advisory Guidelines should consider all possibilities over a maximum 15 year licence term.

[4] See the s.145 determination for an explanation of group of fixed receivers located near a central point.

(c) that operate at high sites, that is, above an effective antenna height for any segment 1, $he_1(\phi_n)$ greater than 20 metres[5].

This is because wide beamwidth transmitters are usually kept below an effective antenna height for any segment 1, $he_1(\phi_n)$ of 10 metres in that band.

(4) The compatibility requirement is provided to receivers:

(a) that communicate with a transmitter that has its effective occupied band totally within the 3.4 GHz Upper band A or 3.4 GHz Upper band B; and

(b) that use an antenna with a beamwidth greater than 5 degrees; and

(c) that operate at low sites, that is, below an effective antenna height for any segment 1, $he_1(\phi_n)$ of 10 metres.

(5) The compatibility requirement is not provided to receivers:

(a) that communicate with a transmitter that has its effective occupied band partly within the 3.4 GHz Lower band and 3.4 GHz Upper band A; and

(b) that use an antenna with a beamwidth greater than 5 degrees.

(6) The compatibility requirement is provided to receivers using an antenna with a beamwidth less than or equal to 5 degrees irrespective of their effective antenna height and the band in which they operate.

(7) The deployment constraints for the compatibility requirement provide operational certainty for hub receivers at high sites in the 3.4 GHz Lower Band. However, it is possible for transmitters that operate at high sites in this band to be registered if internal or shared guard space is provided. In these cases, the guard band should provide the necessary frequency separation for the management of out-of-band interference, if necessary, through the use of filters.

PART 4- MINIMUM RECEIVER PERFORMANCE AND COMPATIBILITY REQUIREMENT

Minimum level of receiver performance

4.1 (1) A minimum level of receiver performance is set out in Schedule 1.

(2) The minimum level of receiver performance relates to:

(a) selectivity;

(b) intermodulation immunity;

(c) blocking; and

(d) spurious response immunity.

[5] See the section 145 determination for an explanation of $he_1(\phi_n)$. The choice of 20 metres is based on maintaining a satisfactory vertical distance separation between transmitters and receivers operating in the same band. The effective antenna height takes account of terrain height. While there is no guarantee (and no requirement) that hub receivers will be above the 20 metre criterion, the deployment constraint seeks to ensure that the overall rate of actual interference remains acceptable.

Compatibility requirement

4.2 The compatibility requirement is set out in Schedule 2.

Receiver selectivity

4.3 (1) The selectivity of a receiver affects its susceptibility both to in-band and out-of-band interference.

(2) In the case of out-of-band interference, by specifying an IF and RF bandwidth shape, the power falling within it may be calculated from a knowledge of the power spectral density of an off-channel unwanted signal. The interference is assumed to be noise-like within the IF and generally created through reciprocal mixing with the local oscillator of the receiver.

Receiver intermodulation immunity

4.4 (1) Models for out-of-band interference related to receiver intermodulation immunity are available (see RALI LM8) and are based on the RF selectivity of a receiver and a conversion ratio. The interference power may be calculated from knowledge of these parameters and compared with the compatibility requirement.

(2) Models for the conversion ratios for various intermodulation types are based on the non-linear characteristics of a semiconductor and are usually a very good approximation to actual receiver performance. Two-signal third order, two-signal fifth order and three-signal third order intermodulation interference scenarios are normally checked in a co-ordination study.

Receiver blocking

4.5 (1) Out-of-band interference caused through receiver blocking usually results from a change in the operating point of the RF-amplifier or mixer stages when overloaded.

(2) This type of interference is not the same as that involving receiver selectivity, although both effects can sometimes occur simultaneously for small frequency offsets.

(3) The interference power is not easily modelled and a minimum blocking performance is specified in Schedule 1.

Receiver spurious response immunity

4.6 (1) Spurious response immunity is largely a function of the selectivity of the RF stages and local oscillator spectral purity.

(2) The power for this type of interference is not easily modelled and a minimum spurious response immunity ratio is specified in Schedule 1.

SCHEDULE 1

Receiver minimum level of performance

1. Table 1 sets out the minimum IF selectivity for a receiver. The frequency offsets are specified for the upper and lower limits of the effective occupied bandwidth of the transmitter communicating with the receiver.

Frequency Offset (MHz)	Loss (dB)
0	0
0.32	3
0.45	10
0.62	20
0.84	30
0.97	40
1.25	50

Table 1. Receiver IF filter Characteristics

2. The minimum RF selectivity for a receiver (between the antenna and receiver input) is:

(a) $2 + 60*\text{Log}_{10} [1 + (\text{FreqOffset}/13)^{1.6}]$ dB for FreqOffset ≤ 64 MHz; and

(b) 70 dB for FreqOffset > 64 MHz;

where FreqOffset is the separation in frequency from the upper or lower limits of the frequency band of the spectrum licence in whose space the receiver operates.
[Note: The symbol * represents the operation of multiplication.]

For a receiver operating under agreement in the shared space of more than one licence, FreqOffset is specified for the minimum lower and maximum upper limits of the shared licences.

3. Table 2 sets out the minimum conversion ratios for the three main intermodulation types.

Intermodulation Type	Conversion Ratio (dB)
Two-signal Third-order (2A±B)	11
Two-signal Fifth-order (3A±2B)	28
Three-signal Third-order (A±B±C)	5

Table 2. Receiver Intermodulation Conversion Ratios

SCHEDULE 1 *(continued)*

4. (1) The minimum level of performance for a receiver in relation to interfering signals from transmitters with frequency offsets based on the upper and lower limits of the effective occupied bandwidth of the transmitter communicating with the receiver is:

(a) a blocking level of greater than or equal to 80 dB for frequency offsets greater than 2.5 MHz from the wanted signal; and
(b) a spurious response immunity performance of greater than or equal to 65 dB.

(2) All levels are referenced to the antenna connector of the equipment.

(3) The minimum level of performance of an antenna system for a receiver is a gain of 10dBi in all directions and a feeder and combiner loss of 2 dB.

SCHEDULE 2

Compatibility requirement

The compatibility requirement is:

- an output quality equivalent to a wanted to unwanted signal level ratio that is not less than 15 dB for more than 1% of the time in any 1 hour period;
- with the wanted signal never less than -111 dBm; and
- when measured as mean power within a 30 kHz rectangular bandwidth that is within the frequency band of the spectrum licence.