



## **Interference Management for Spectrum Liberalisation**

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## **1.0 Introduction**

This is in part a response to Ofcom’s recent consultation documents<sup>1</sup> which is based on 8 years of successful operation by FuturePace Solutions with a method of interference management for self-managed spectrum liberalisation and trading that is currently applied only in Australia. In Australia<sup>2</sup> the term “spectrum licensing” subsumes both spectrum liberalisation and trading.

Australia faced the ‘crunch implementation issues’ for change of use head on between 1994 and 1996, establishing rules that not only successfully dealt with interference but more importantly maintained the “quality” of the spectrum asset. These important attributes are born from a **spectrum space focus** rather than the traditional focus on equipment standards. This is a completely new method of interference management. A spectrum space focus offers simplicity, maximum flexibility and certainty<sup>3</sup> – see Figure 1.

This paper provides a general introduction to the new interference management method.

Importantly, the National Regulatory Authority (NRA) no longer authorises the use of equipment – the responsibility for technical evaluation and authorisation being fully outsourced and self-managed by industry.

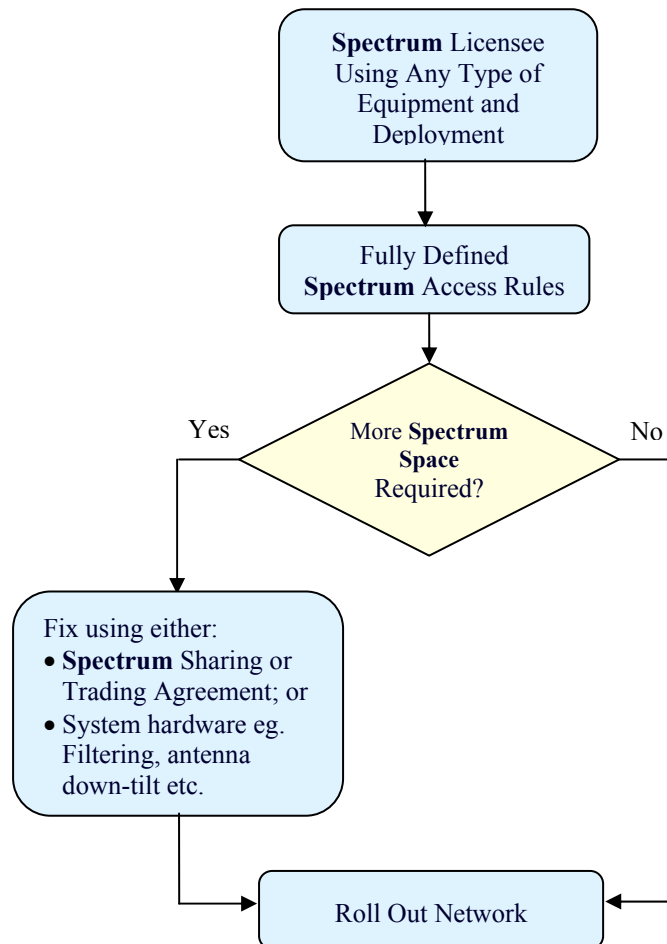
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<sup>1</sup> Spectrum Framework Review (23/11/04) and Implementation Plan (13/1/05), A Statement on Liberalisation and Liberalisation Guidelines (26/1/05)

<sup>2</sup> Ofcom has only just recently also started using the term “spectrum licensing” in its consultation documents, however it is not yet clear if Ofcom is using it to describe a fully defined interference management framework designed for self-management of spectrum under change of use conditions as is currently described in Australia by that term.

<sup>3</sup> The Australian NRA’s observation is that, as a general rule, spectrum licensing has been preferred by industry for the higher value, higher risk and newer applications as it offers longer guaranteed tenure and minimises risk to the licensee because of its high degree of technology and trading flexibility.

**Figure 1. The Simplicity of Self-Managed Spectrum Licensing when using a Spectrum Space Focus**



FuturePace fully appreciates the real difficulties in translating Australia’s technical success into the political reality of the UK, and that the geo-political issues are magnified when a pan-European solution is contemplated. However, the science of this new interference management method is relevant to the UK and Europe.

### *1.1 Australia's Political Situation Allowed a Technically-Optimum Solution to be Found*

Understandably, given the geo-politics, there is significant concern in Europe at both the political and industry level about the introduction of spectrum liberalisation and trading. Australia also experienced a level of negativity in the beginning mainly concerning implementation issues. Because Australia does not have complex cross border issues or a major manufacturing sector the Government was able to proceed quickly to full liberalisation and industry self-management.

The Australian interference management method internalises into licence conditions many issues that are prominent in Europe. Where they occur, cross border issues are solely a technical problem with a clear technical solution. Experience here suggests that cross border issues could be managed just as either:

- area-adjacent spectrum licences are now managed; or
- apparatus licensed devices outside spectrum licences are now coordinated.

This is not in any way to minimise the difficulties in obtaining agreement between a number of countries about the details of such a solution, though there are undoubtedly current agreements on such matters which would form a basis for such arrangements. The ease with which Australia has been able to apply a consistent technical framework throughout a country the size of Europe is admittedly a great benefit.

From the technical perspective Ofcom's long term vision<sup>4</sup> is already concrete in Australia.

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<sup>4</sup> The Ofcom Spectrum Vision: **A.** Spectrum should be free of technology and usage constraints as far as possible. Policy constraints should only be used where they can be justified; **B.** It should be simple and transparent for licence holders to change the ownership and use of spectrum; and **C.** Rights of spectrum users should be clearly defined and users should feel comfortable that they will not be changed without good cause.

## **1.2 Important to Minimise Level of Necessary Negotiation**

Given the level of policy concern surrounding the introduction of spectrum liberalisation and trading in Europe, Ofcom may see short term advantage in a step-by-step approach “*In the medium to longer term we expect the effect of this to be that Ofcom increasingly withdraws from managing the radio spectrum.*”

On the other hand, the Australian experience demonstrates it would be possible for Ofcom to withdraw immediately from management of at least, certain frequency bands by providing ab initio a more cost-effective fully defined framework under which industry can self-manage interference. The issues confronting Ofcom are serious and will set the agenda of UK and in some cases, European, communications for years to come. FuturePace believes it could be difficult for Ofcom to extricate itself from the initial centralised negotiation process it plans to set up (coupled with trading or spectrum awards with a partially defined technical framework), to manage change of use. The likely result is a legal and technical framework built on ad hoc spectrum access rights with ambiguous spectrum boundaries which will not provide the necessary level of both legal and technical certainty industry needs for efficient and cost effective operation in either short or long term. The economic benefits of liberalisation are only released as the level of uncertainty is reduced.

Another problem with Ofcom’s step-by-step approach is that there appears to be an intention<sup>5</sup> to conduct a live experiment with commercial systems in order to gain experience for the next step in the process.

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<sup>5</sup> “But it may take longer to assess whether they will cause excessive interference to other legitimate users” From Ofcom’s Statement on Spectrum Liberalisation, 26 Jan 2005

## **2.0 Full Upfront Definition Preferable to “Better” Definition over Time**

Ofcom suggests that *“Liberalising to a sufficient degree that simple change of use is possible will require:*

- *Better definition of spectrum usage rights. One of the major blocks to widespread trading in Australia has been identified as spectrum usage rights that are tailored to particular applications, making change of use difficult;”*

This issue is a complex one. However, the above reference to the Australian technical solution is not correct and would be an unfortunate basis on which to dismiss it. Certainly, the laws of physics are immutable and Australia’s technical solution for interference management under change of use conditions is readily applicable in the UK, or elsewhere.

### **2.1 The Only Impediment to Trading in Australia**

The only impediment to trading of spectrum licences in Australia is the marketplace impact of two non-communications issues, notably the definition of assets by the Australian Taxation Office and the power of the individual Australian States to impose Stamp Duty on transactions involving sale of commercial assets.

These policies can make trading between spectrum licences costly. Despite the matter being raised at the Productivity Commission Inquiry in 2000 by a number of industry participants it has yet to be resolved and remains an “unintended consequence” of the original policy. In any event, Australian industry has found its own way around the policy impasse.

Regardless of these two non-technical impediments, trading in spectrum licences in Australia continues to take place whenever a licensee can see benefit (see the ACA website, [www.aca.gov.au](http://www.aca.gov.au) for the latest details).

Trading in spectrum licensed space is also undertaken by entering into third party spectrum sharing agreements and this is done frequently, simply, and all of it without the direct involvement of the Australian NRA which minimises delay and cost.

## ***2.2 Too much Focus on Trading under the Australian Solution is Inappropriate***

Using market trading of multiple apparatus licences as the means by which a company would obtain contiguous spectrum for a new network is rather difficult because of the practical difficulties associated with resolving negotiation with multiple entities. Hence, the Australian Government has avoided this approach<sup>6</sup>. The exception is for the experiment with Conversion Plans in the 500 MHz prototype spectrum auction, where it was found that the task of fully defining spectrum usage rights when there were many incumbent licensees would be impossibly complex. After this experience, the ACA realised the best solution was to offer apparatus licence incumbents a period of time which they could use to either trade with the incoming spectrum licensee for assisted relocation or continue to operate.

The period is a form of compensation and the length of the time reflects the value of that compensation.

In Australia, the most important “trade” is performed by the transfer of management rights from the Government to private management when it reallocates spectrum to the use of spectrum licensing. Therefore, while it has been possible for licensees to trade in spectrum licences since 1997, except for a few isolated cases no spectrum has been purchased specifically to trade. Trading in apparatus licenses is normal practice in Australia, the two

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<sup>6</sup> Ofcom appears to have also come to the same conclusion, see implementation plan regarding spectrum awards, “Ofcom considers this type of approach is preferable as it is more likely to lead to an optimal use of the radio spectrum and to do so more quickly.”

regimes being managed separately. This has allowed the Australian Government to focus on the technical demands of implementing spectrum licensing without being locked into using old interference management methods.

Spectrum is the medium for network deployment, and a spectrum licence, whether acquired at an auction or through any other process designed to provide a purchaser with the flexibility to properly dimension the licence, should not require trading. There is a legitimate perspective from which the need to trade under the Australian solution could be seen as a planning failure on the part of either the spectrum licensee or the auction designer. Correct dimensioning of the spectrum asset, including its quality, prior to purchase, by use of the purchasing rules and auction design options means that only the necessary amount of spectrum is acquired. Most licensees are in this situation and because licence periods are for 15 years, the second major trade for them will occur at the end of that period. Trading would naturally increase if perpetual licences were introduced.

Too much focus on the level of trading in Australia<sup>7</sup> elevates a secondary issue to unreasonable prominence and simultaneously downplays the overall technical success of Australian spectrum licensing.

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<sup>7</sup> *“It is still a concern that very little trading happens at all as has been the case in Australia..., says (Professor William) Webb”* PolicyTracker, Dec 2004.

### **2.3 Specific and Restrictive Usage Rights – Where is this Leading?**

Ofcom illustrates what it calls specific and restrictive usage rights by describing two types of equipment having different levels of out-of-band emissions. Ofcom suggests these two types of rights will improve flexibility.

Australia has a single generic definition for out-of-band emissions for two very good reasons:

- For increasing certainty with change-of-use self-management, thereby increasing industry efficiency and removing the NRA from the position of impeding or facilitating (“picking winners” for) industry rollout; and
- For increasing certainty by informing frequency adjacent licensees ab initio what levels of interference they will have to contend with at any time over the 15 year licence term, rather than a “movable feast” which will be the consequence of specific and restrictive usage rights.

If Ofcom’s endpoint is to have industry self-management, then being involved in authorising multiple sets of out-of-band emission limits over time is not the answer. Neither is the answer continuous involvement by Ofcom in the traditional NRA’s task of management by allocation of spectrum to specific equipment standards. The strength of the Australian technical solution is operational certainty. The Australian spectrum licensee has the benefit of clearly defined operational certainty<sup>8</sup> from licence issue to the end of the licence period.

Ofcom’s proposal is similar to the current manner of interference management in the USA. Coordination between devices operated under FCC licences is based on a TIA/EIA document TSB-84A. That same document states that “*use of traditional coordination leads to non-reciprocal spectrum access for dissimilar equipment standards*”. Traditional coordination alone, under

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<sup>8</sup> See Annex A for a single exception at 2 GHz

change-of-use conditions **does not work**<sup>9</sup>. Spectrum liberalisation is a new management concept requiring new tools.

**“Spectrum liberalisation is a new management concept requiring new tools.”**

Multiple usage rights based on multiple standards constitute ad hoc interference management, a continuation of traditional spectrum management, and considering the complications and uncertainty it will bring to industry, a costly process.

While Ofcom is proposing multiple sets of out-of-band emission limits, it is important to know that in 8 years of industry experience with change of use in Australia there has not been a single instance when equipment could not be authorised under the single generic set of out-of-band emission limits and supporting framework.

#### **2.4 Harmonisation of Spectrum Access Rules, Not Frequency Bands**

*“Spectrum licensing is able to break the nexus between the equipment standardisation process and obtaining regulatory approval to access spectrum, avoiding delays and effectively harmonising spectrum use”<sup>10</sup>.*

Given the present capabilities of frequency agility, including reconfigurable antennas<sup>11</sup>, harmonising spectrum use no longer requires the harmonisation of specific frequency bands.

<sup>9</sup> Ofcom seems to continue to ignore this USA evidence - “We have concluded for reasons set out below that this can be achieved through existing TFAC and coordination procedures with the SQB embedded in them and will use these as a key criterion when deciding whether or not to allow a requested licence variation and in investigating interference complaints.” From Ofcom’s Statement on Spectrum Liberalisation, 26 Jan 2005

<sup>10</sup> Whittaker M. “Shortcut to Harmonisation with Australian Spectrum Licensing” IEEE Communications Magazine, January 2002.

<sup>11</sup> This is not beam forming in the spatial domain but reconfiguring the array in spectral and angular domains to recently achieve, for example, operation at 4.1 and 6.5 GHz. See Cetiner et al

**“Harmonising spectrum use no longer requires the harmonisation of specific frequency bands”**

While the marketing success of GSM is obvious, it is inappropriate to pin that success on either frequency band harmonisation or choice of technology<sup>12</sup>. The guarantee of available spectrum certainly led to the technology but as tri-band handsets now demonstrate, the initial harmonisation could have also delayed the development of frequency agile services.

Certainly, Ofcom’s statement that, *the GSM band would be always available for GSM whether or not the respective right holder decides to use it for GSM*, is encouraging. FuturePace also agrees wholeheartedly with Ofcom’s intention to balance its duty to avoid unnecessary restrictions in the licences it grants, with its duty to promote the European internal market. It is harmonisation of **spectrum policy (spectrum access rules)** rather than harmonisation of frequency bands that is required for spectrum liberalisation.

### 2.5 *Out-of-Band Emission is not the Major Problem*

The primary challenge of spectrum licensing is not the management of out-of-band emission but the management of **out-of-band interference**. This is interference that can be caused by **high level emissions well outside** the frequency band of a spectrum licence. This type of interference results from implementation imperfections in the licensee’s receiver, that is: RF and IF selectivity; intermodulation immunity, blocking and spurious response immunity. Ofcom will need a technically rigorous process which manages this major type of interference. The current proposal gives UK industry little

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“Multifunctional Reconfigurable MEMS Integrated Antennas for Adaptive MIMO Systems” IEEE Communications Magazine December 2004.

<sup>12</sup> It is a mistake to base the correctness of the EU decision to mandate the GSM standard in 900 MHz bands, on the current relative number of GSM and CDMA subscribers especially when all 3G technologies are now CDMA-based. Certainly this is another VHS/Beta type situation where marketing strength rather than technical excellence is the determinant of market position, and policy focus.

comfort as to how this ubiquitous problem will be managed through the proposed use of multiple usage rights.

The potential of out-of-band interference to degrade spectrum utility was the most difficult concept to explain to both legal and economic professionals during the design of the Australian system from 1994 to 1996. The Ofcom approach seems to provide an economist's and administrator's solution to a problem for which the solution lies in engineering and physics. If the physics is correct the economic outcome will follow, as will the administrative and industry efficiencies.

## *2.6 Types of Interference to be Managed*

For the sake of absolute clarity in this matter, there are **three** types of interference that a receiver can respond to and for which there must be specific licence conditions to manage (see Figure 2):

### Linear-Type Interference Response

- A)** In-band interference – Same Band – Adjacent Area (for example, in-band emissions radiated from “co-channel<sup>13</sup>” services);
- B)** In-band interference – Same Area – Adjacent Band (includes out-of-band emissions radiated from adjacent “channel” transmitters as well as intermodulation products re-radiated from non-linear devices which have radiated signals coupled to them, such as:
  - corroded metallic joints in towers;
  - bi-metallic junctions in multi-couplers and antennas; and
  - transmitter PA stages;

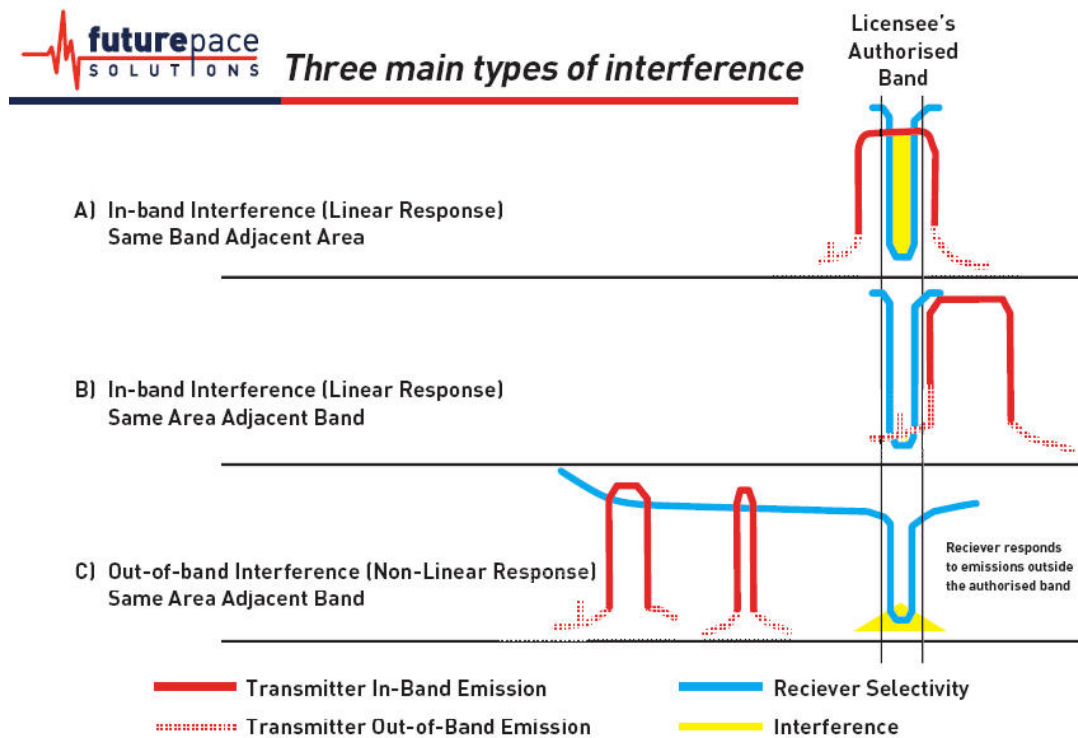
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<sup>13</sup> There are no channel plans under Australian spectrum licensing.

Non-Linear-Type Interference Response

**C) Out-of-band interference** (for example, intermodulation products created within receiver input stages - the result of receiver implementation imperfections in the presence of high level in-band emissions from frequency adjacent services).

The individual methods by which these three main types of interference are managed must be fully defined under both steady state and transient conditions in order to achieve industry certainty of operation under any form of spectrum liberalisation.



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Ofcom's proposal to utilise a "Spectrum Quality Benchmark" taken from frequency assignment criteria as the key criterion in deciding whether or not to allow the removal or reductions of restrictions and as a reference for Ofcom in

resolving interference complaints<sup>14</sup> is an oversimplification of the three different consequences resulting from these three different forms of interference which, and we are most concerned, based only on the information Ofcom has so far released, can not possibly lead to efficient spectrum management.

A single benchmark<sup>15</sup> level of receiver protection is actually unnecessary, effectively being just another method of operating under 'worst-case' conditions. Ofcom also see their proposed 'key' parameter as a potential liability<sup>16</sup>.

### *2.7 The Major Type of Interference Not Often Discussed*

Interference types **A** and **B** are simple to illustrate and discuss. They are the types usually used by administrative, legal and economic specialists in their arguments about spectrum management. Unfortunately, interference type **C**, which can be both many times the power level and likelihood of linear type interference in RF dense areas, is the one that makes spectrum usage rights **highly interdependent** and simple property and land analogies inappropriate. This interference type is hardly ever mentioned<sup>17</sup> by these specialists. Non-linear, out-of-band interference (C) is the most difficult interference to manage in a technology flexible environment.

The development of spectrum licensing in Australia required the development of new terminology to describe managerial and technical concepts.

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<sup>14</sup> Thought it is difficult to see how SQBs will be used to settle an interference dispute when Ofcom provides "no guarantee for users that interference will not exceed the level implied by the SQB".

<sup>15</sup> "Ofcom will apply spectrum quality benchmarks (SQBs) as a key criterion in deciding whether or not to agree to a requested licence variation. SQBs will be based on existing technical frequency assignment criteria (TFAC) or, for some services, on existing coordination requirements" From Ofcom's Statement on Spectrum Liberalisation, 26 Jan 2005

<sup>16</sup> "However, we cannot give a guarantee that we will never allow any variation that reduces spectrum quality below a benchmark." From Ofcom's Statement on Spectrum Liberalisation, 26 Jan 2005

<sup>17</sup> Note that some technical commentators also use the term incorrectly, such as "clear spectrum property rights" when they are actually referring to a complete set of spectrum access parameters that underpin the development of technology-flexible coordination procedures.

Understanding of specific terminology used in the Australian technical solution is essential to a complete understanding of its benefits. A clear grasp of the use of the term “out-of-band interference” is critical to understanding how and why the Australian technical solution is successful.

**“Non-linear, out-of-band interference (C) is the most difficult interference to manage in a technology flexible environment.”**

## 2.8 All spectrum use is “Tailored”

Ofcom mentions that “*in countries where single sets of spectrum usage rights have been used there is recognition that true technology neutrality has not been achieved because the spectrum usage rights tend to favour particular technologies or applications*”. It is not correct to say that true technology neutrality has not been achieved because multiple sets of usage rights have not been used.

**“It is not correct to say that true technology neutrality has not been achieved because multiple sets of usage rights have not been used.”**

The favouring of certain technologies does not occur with the setting of out-of-band emission limits but through the application of **deployment constraints** for receivers and transmitters. They are applied to manage out-of-band interference and optimise spectrum productivity for certain technologies.

They are a practical reality of good spectrum management. Ofcom will necessarily be required to also apply deployment constraints to manage interference and therefore, tailor the spectrum use to particular technologies or applications.

Given Ofcom later says in the consultation document “*Because most users of similar services and technologies are placed together in neighbouring bands, and because similar technologies are less likely to interfere with each other, far less restrictive rights than these can normally be used in practice*” Ofcom is obviously aware of this spectrum productivity loss, but ambiguity in the consultation document certainly confuses levels of out-of-band emission with deployment constraints.

There is a logical impasse created by a description of Ofcom’s usage rights that will not be tailored to particular applications in one paragraph and then benefit by being tailored to particular applications in another. This might be due to a lack of full appreciation for the constraints that have to be imposed on any spectrum access right to manage out-of-band interference.

Ofcom then proposes to “*allow users to modify their rights provided they have agreement with all the affected third parties.*” This will not necessarily provide “better” usage rights, especially when Ofcom intends over time to apply additional specific usage rights, which would, presumably, undo previous industry negotiation.

## ***2.9 The Major Issue - Minimising the Cost and Uncertainty of Negotiation***

The major issue in providing for change of use is not whether spectrum is “tailored” but whether the technical framework offered by Ofcom can provide sufficient flexibility to accommodate change of use in a manner that gives quick market access as well as ongoing marketplace and regulatory certainty.

Australia realised the necessity to minimise negotiation very early, especially the pivotal role of absence of negotiation in creating industry self-management without high costs and expensive delays to industry. This requires upfront definition of the complete interference environment, if only to

determine who indeed are the “affected licensees” in a negotiation process. Obviously, a competitor who is “affected” by the proposed rollout of another network is unlikely to agree to anything in a hurry. And without full upfront definition a competitor may feel it commercially expedient to claim to be “affected” whether they are or not. A count of the number of “if”s and “might”s used in change-of-use examples provided in the Ofcom consultation documents illustrates the high likelihood of wireless networks being held up by unresolved negotiation. For example, Ofcom suggests “*a cellular operator might agree with all of those who hold spectrum within  $\pm 10\text{MHz}$  of its assignment to modify its rights*”. Surely it is equally likely that an aggressive competitor might not agree to anything. The Australian technical solution has been specifically designed to minimise negotiation and therefore maximise operational certainty for the total period of the licence.

It is inevitable that UK industry will not wish to spend months in round table discussions about change of use, especially where new equipment and innovative technologies are involved. Generally, industry likes to surprise its competitors, not signal innovation and development plans in a process where competitors have ample opportunity to de-rail innovation and reduce competitor profitability.

The needs of industry are not met by long bureaucratic processes for consultation, especially consultation which exposes technical parameters of equipment, or commercial directions to competitors.

Such processes, especially those defining interference criteria, which can involve bleeding of IP and confidential information between licensees, are difficult for industry to countenance and are also costly as they often involve measurement and laboratory work which is expensive and time consuming.

### 2.10 Change of Use is Simple in Australia

Change of use in Australia requires **no** involvement by the NRA and is simple rather than difficult, as long as the licensee or accredited person authorising the change is fully conversant with the flexibility provided under the regime. FuturePace has had no trouble authorising new equipment in spectrum licensing bands, if necessary, through the alternate certification procedure known as “internal or external guard-space” and this happens usually within a 48 hour turnaround on device registration (see Annex A for why Ofcom might think change of use is difficult in Australia). As an example of the ease of change of use in Australia, it has always been possible since 1997 for a licensee/accredited person to authorise the operation of 3G **TDD** services in **any** band administered under spectrum licensing. In discussions on liberalisation there needs to be less emphasis on technology neutrality and more on the level of technology flexibility that is being offered.

**“....there needs to be less emphasis on technology neutrality and more on the level of technology flexibility that is being offered.”**

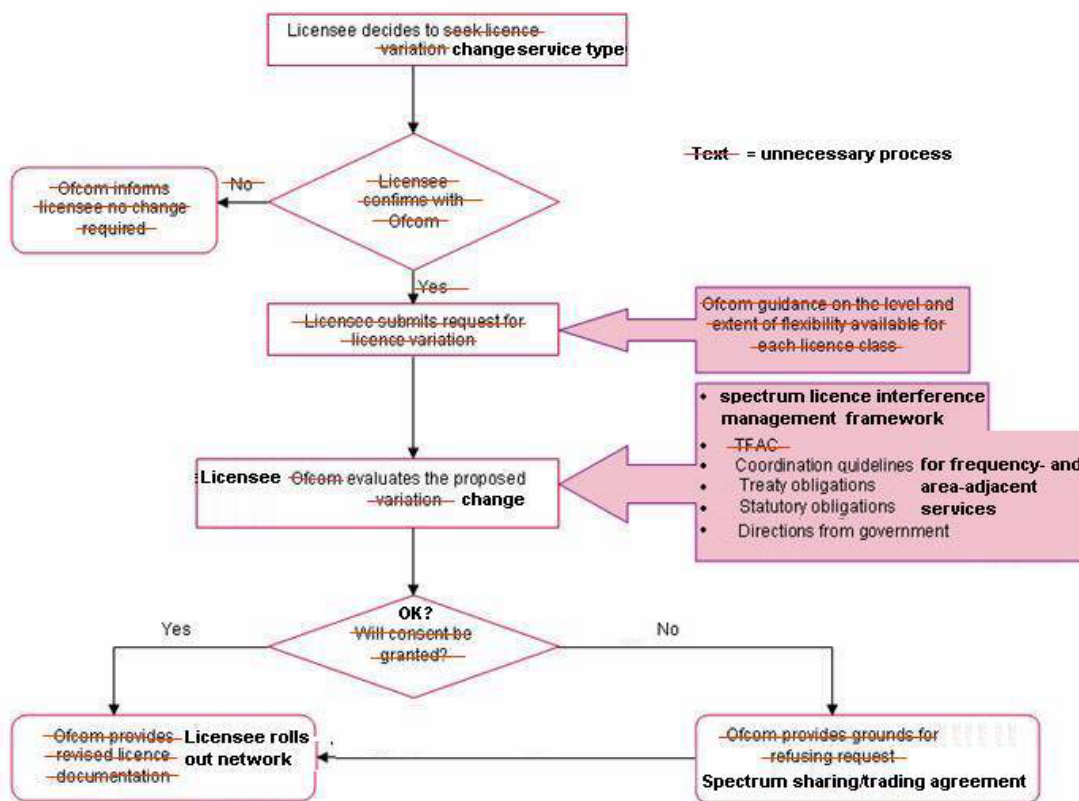
### 3.0 Fully Divesting Central Control

Ofcom is proposing to “*work with licence holders to assess what their de-facto rights are and modify their licences to these rights during the period that spectrum usage rights are rolled out.*” As Australia found with defining Conversion Plans in 1996, if Ofcom wants to do this in a full technology-flexible manner to enable the easy aggregation and division of spectrum, it will be presented with an impossibly large task establishing these rights.

While Ofcom’s stated long term position is to move to industry self-management, the proposed initial phase is very much central control. See

Figure 3. for how often Ofcom is central in the decision process for change of use and as a comparison, how unnecessary it is in Australia. There is an imbalance between Ofcom’s stated public policy objectives and the methodology proposed for their execution.

**Figure 3. Ofcom’s Proposed Change of Use Process compared with Australia’s**



What is certainly made clear is that UK industry is to shoulder the burden of implementation - see the following published by Ofcom on 26 January 2005:

- *“It is therefore important that applicants for licence variations carry out their own due diligence into the effects on neighbouring assignments instead of relying solely on Ofcom’s predictions that spectrum quality in neighbouring assignments will be above the SQB”.*

- *“Liberalisation involves empowering spectrum users to take more decisions on how spectrum is used but, with this added freedom, comes greater responsibility”*
- *“Where a change is particularly novel we may require a greater amount of information, which might include technical studies on the interference impact of the proposed change. Applicants may also choose to carry out their own technical checks to verify that the spectrum they intend to use is of sufficient quality for their proposed service and also to satisfy themselves that their proposal will not reduce neighbouring assignments’ spectrum quality below the SQB but Ofcom will not require them to do so.”<sup>18</sup>*
- *“It is your responsibility to check that the actual spectrum quality of your assignment is adequate for your purposes. As stated above, actual spectrum quality may differ from that predicted by Ofcom’s assignment models. Moreover, spectrum quality can also be affected by sources outside Ofcom’s control.”*
- *“It is possible for a variation to be allowed that has a greater than predicted effect on third parties’ spectrum quality. If this happens, we will investigate and try to resolve the situation by negotiation and agreement. But, ultimately, we reserve the right, following investigation and consultation, to make further changes to your licence, possibly with immediate effect, in order to protect third parties from an unacceptable reduction in their spectrum quality.”*
- *“It should be noted that interpretation of monitoring data is complex and usually requires a degree of technical expertise. Ofcom provides data in good faith but does not accept responsibility for the use made of them. Before using the data, you should take technical advice from a suitably qualified person.”*

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<sup>18</sup> But at a practical level they will have to carry out their own technical checks to ensure their network will not cause interference to frequency and area adjacent licensees.

In Australia, Ofcom's "suitably qualified person" is the "accredited person". The accredited person system has been the fundamental cause of the removal of the command and control aspects of Australia's old spectrum management regime. The accredited person not only performs Ofcom's proposed tasks more quickly and cost effectively but more importantly accepts liability. Who accepts the liability associated with technical evaluation is more important to UK industry than who performs the evaluation.

**"Who accepts the liability associated with technical evaluation is more important to UK industry than who performs the evaluation."**

### *3.1 Band Managers*

In its SFR consultation document Ofcom says it sees little evidence of band managers emerging. However, the recently released implementation plan has it as very much an option (See Section 5.26 of that document "*Award the spectrum to a band manager*"). However, it is highly unlikely that band managers will emerge in the UK until the last vestiges of central control have been fully divested and UK industry has developed the necessary skills. In 2000, the Australian Productivity Commission saw less regulation as desirable and private band managers as the logical next step in spectrum management in Australia. The ACA has just released (7 February 2005) a consultation document "*Private Management of Encumbered Spectrum Bands*" which aims to gauge the level of commercial interest in band management as well as canvas suitable bands and management frameworks.

The FCC has recently selected a private company as database manager for 71-76, 81-86, and 92-95 GHz. The role as a database manager will enable licensees to search for available spectrum in these bands and register their

links, ensuring interference-free operation with commercial and Federal Government users.

FuturePace is prepared for a similar technical role in Australia and elsewhere.

### ***3.2 The so-called “Burden” of providing Technical Information***

*“Several respondents” to Ofcom’s liberalisation consultation document “asked about responsibility for providing the technical information needed to assess the impact of proposed licence variations on the spectrum quality of neighbouring assignments and were concerned about the burden this might impose, especially if Ofcom was to require technical information to be provided by an ‘accredited person’ ”.*

In Australia, responsibility for providing technical information is with the licensee, not the accredited person. The accredited person then assesses the licensee provided information as Ofcom is currently proposing to do internally.

There is little practical distinction between an ‘accredited person’ and the ‘suitably qualified person’ mentioned by Ofcom except that the accredited person is responsible not only to the client but also to the NRA for the accurate performance of their work.

In 1996 when Australian industry was being required to develop technical tools for the management of spectrum licences, the present technical data used to manage interference under spectrum licensing was 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 addition, those devices that do not have a significant likelihood of causing interference were made exempt.

That agreed data list is now the basis for the national centralised online data base managed by the NRA as well as the data against which licensees and accredited persons have set up their software management systems.

In practice, there are no more than 9 distinct items to be collected for a transmitter (noting that registration of receivers is not mandatory):

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

The cost of including one or more data items in a file that can be automatically created by a licensee's network design software and subsequently automatically registered in the an on-line data base, is insignificant when compared with the cost of the spectrum that would be wasted by using the only other option, notional information. None of the data items can be removed from the above list without a significant degradation in spectrum utility. The so-called 'burden' is actually a benefit to licensees.

## **4.0 Australian Spectrum Licensing – Minimal Negotiation and Voluntary Equipment Standards**

Australian spectrum licensing offers a high level of flexibility as well as certainty for licensees to operate any type of equipment with minimal negotiation with either adjacent licensees or the NRA.

The primary technical objective for design of Australian licence conditions is the provision of all the necessary underpinning parameters, in the simplest manner possible, which provide a licensee with a clearly defined spectrum utility including the ability to derive coordination procedures between any type of device without the involvement of the NRA.

Rather than being based on “worst-case” the Australian interference management method allows a licensee to maximise spectrum utility by adjusting their operating parameters in relation to the likelihood of interference. ‘Harmful interference’ is defined indirectly by establishing simple rules for the level of transmitter power a spectrum licensee may radiate at a particular location within their geographic area. This and other licence conditions underpin coordination procedures, designed by spectrum licensees, to be specific to whatever equipment they are using, importantly, without the high cost and uncertainty of negotiation.

### **4.1 *The Generic Standard***

Australian spectrum licensing establishes a single generic equipment standard upon which licence conditions are based. The single generic standard includes all the usual parameters related to interference management. Parameter values are chosen with regard to theoretical

performance requirements, guided by the implementation limitations of any actual equipment standards existing at the time<sup>19</sup>.

#### ***4.2 Operating any Actual Standard***

Obviously, not all parameters from all actual standards can be included in a single generic standard. In addition, actual standards continue to evolve and are created over the life of the licence. Therefore, while certain equipment might conform to a European, USA or Asian standard it does not necessarily mean that it conforms wholly to the Australian generic standard. Nor is it meant to. This is never a practical problem because different actual standards can be provided with the more or less spectrum space depending on their operational requirements.

The operational certainty results from the upfront full definition benchmark of the generic standard on which the licence conditions for radiated power are derived.

Where necessary, these licence conditions then define the necessary additional spectrum space requirements to be obtained through spectrum sharing agreements. This is the solution to fitting actual devices to the licence conditions in all cases.

Importantly, the framework for spectrum sharing agreements is incorporated in the initial licence conditions, which serves to minimise negotiation costs.

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<sup>19</sup> For example see Table 4 of Williams C. et al “Personal Area Technologies for Internetworked Services” IEEE Radio Communications Dec 2004.

The authorisation process is fully defined and all liability is shouldered by industry, not the NRA. This is consistent with industry being able to take its own management decisions and risk assessments.

It is axiomatic that, in the highly innovative and creative environment of communications equipment development that standards will evolve and equipment and innovation will change over the lifetime of a spectrum licence. But it is not necessary for each instance of equipment usage or innovation to involve the NRA. Nor should the time delay of regulatory redefinition be a brake on industry innovation.

#### *4.3 The Australian Device Registration Process*

Under the device registration process, a suitably qualified person certifies compliance of each device with the licence conditions. Each device will have a different antenna system and operate at different separations from the geographic and frequency boundary of the spectrum licence. This information is provided by the licensee to the suitably qualified person. Registration effectively “type approves” the performance of each device against the generic equipment standard in relation to the size of the space of the spectrum licence. If the equipment complies, its operation is authorised by using a straight-forward certification process. If, on occasion, the equipment does not comply it is authorised under another certification process based on provision of internal or external guard space (guard area and guard band).

**“Registration effectively ‘type approves’ the performance of each device against the generic equipment standard in relation to the size of the space of the spectrum licence.”**

Many licensees have already utilised this flexibility after the spectrum auction (the first spectrum trade) to operate for example, point to point and land mobile services within the same spectrum licence. After certification, the device characteristics are directly recorded in the national centralised online database. While the NRA requires devices to be registered, it does not approve any of the registrations.

Change of use is not conditional on NRA approval. The person certifying the device shoulders the liability based on the coordination procedures they develop and which are underpinned by the full definition of fundamental interference parameters defined in the licence conditions.

The certification function could also be undertaken within the NRA, except for the liability issues and the conflict between assumption by the NRA of the dual role of NRA and industry participant. All political systems have their own character and communities have different expectations of Government. What can be transferred is the science, while the implementation methodology may be for national differentiation.

#### ***4.4 Managing the Three Types of Interference***

Table 1 provides an overview of how the two types of certification manage the three main types of interference to allow the authorisation of any type of equipment without involvement of the NRA (unless the NRA is one of the entities involved in a spectrum sharing agreement).

**Table 1. Authorising any Type of Equipment - Overview**

Type of Interference	Licence Conditions that manage this Type of Interference	When necessary, manner in which these Licence Conditions may be worked around
<b>A.</b> In-band Interference (Same Band – Adjacent Area)	Generic Device Boundary Criterion	Provision of Internal Guard Area or External Guard Area (Spectrum Sharing Agreement) or modify hardware eg increase antenna downtilt
<b>B.</b> In-band Interference (Same Area – Adjacent Band)	Generic emission mask	Provision of Internal Guard Band or External Guard Band (Spectrum Sharing Agreement) or utilise additional hardware eg transmitter filter
<b>C.</b> Out-of-band Interference	Deployment Constraints for Tx's and Rx's	Provision of Internal Guard Space (Guard Area and/or Guard Band) or External Guard Space (Spectrum Sharing Agreement)

#### 4.5 Defining 'Harmful Interference' for a Spectrum Licence

In the case of in-band interference, 'Harmful Interference' is defined indirectly by specifying the maximum radiated power allowed for a device operated under an area-adjacent and frequency-adjacent spectrum licence. A spectrum licensee takes these definitions into account when designing their network. A spectrum licensee must design a receiver to cope with emission levels up to these maximum levels which could be radiated at any time and from anywhere within the area-adjacent or frequency-adjacent spectrum space. **There is no need for the NRA to specify what level might be received.**

In the case of out-of-band interference, because radiated power limits would be overly restrictive, the most efficient and equitable solution is to coordinate services on a site by site basis. In this case 'Harmful Interference' is directly defined in the performance of a Generic Receiver. The spectrum licensee must coordinate its transmitters and receivers with any other devices operating at that particular point in time. Actual receiver performance is allowed to be better or worse than the generic definition but it only receives

protection up to the level defined by the interference susceptibility of the generic receiver.

See Table 2 for an overview of how harmful interference is defined and managed under a spectrum licence.

**Table 2. Defining and Managing Harmful Interference for a Spectrum Licence**

Type of Interference	Definition of Harmful Interference	Time Restrictions	Operator Responsible for Managing Interference	Action
<b>A.</b> In-band Interference (Same Band – Adjacent Area)	Define maximum in-band <b>radiated</b> power spectral density usually as a function of effective antenna height and distance to the area boundary	No	<b>Area-adjacent</b> operator of a receiver	Must take definition into account in planning
<b>B.</b> In-band Interference (Same Area – Adjacent Band)	Define maximum steady-state and transient out-of-band <b>radiated</b> power spectral density	No	<b>Frequency-adjacent</b> operator of a receiver	
<b>C.</b> Out-of-band Interference	Define a generic receiver performance	Yes	<b>Frequency-adjacent</b> operator of a receiver and transmitter	Must coordinate with any other devices operating at that point in time

The above definitions and process manage interference between devices operated under adjacent spectrum licences.

In the case of devices that are not within spectrum licences and have been authorised to operate before nearby spectrum licences are allocated, interference is managed on a device-specific basis. Any new devices outside spectrum licences are coordinated with the spectrum licence boundaries as if the new device is also operating under a spectrum licence.

#### *4.6 No Fixed Guardband Width*

The Australian solution does not utilise specific fixed guardband widths to manage interference. Again, it is the responsibility of the licensee/accredited person to determine the necessary guardband width, as part of the coordination procedure they devise, underpinned by the fundamental parameters set by the NRA. Obviously, the necessary guardband width varies according to the type of equipment being operated. If the NRA sets a fixed guardband width it usually reduces spectrum productivity, being a worst case assessment. Spectrum is an expensive commodity and efficient use has to be a factor in any administrative system. Cost and efficiency are certainly issues for industry.

#### *4.7 Outsourcing Liability*

The Australian technical solution is a completely new method of interference management. Previously, different industry groups would lobby the ITU (the Regulator's Regulator) to allocate spectrum for a mandatory standard. Under spectrum licensing, all standard, or even non-standard equipment may be authorised to operate, not through the NRA, but by a suitably qualified person using the two types of certification. The NRA's former task of granting equipment spectrum access is now outsourced to industry.

#### *4.8 Software Design*

The Australia solution has also been specifically designed to simplify automated management by the NRA.

One example is the Australian **Spectrum Map Grid** which is designed to:

- simplify the NRA's programming when checking automatically that no geographic area becomes "lost in the cracks" during a process of spectrum trading, aggregation or division<sup>20</sup>;
- simplify the definition of the geographic area for a licence – aggregation of a few squares each simply defined by two corners;
- provide an area resolution appropriate to a particular population density;
- assist in defining the area used by a particular device and make it consistent with the licence area – the device boundary; and
- take account of irregular international boundaries, eg border with Papua-New Guinea, Indonesia and other territorial limits in a special legal solution.

#### *4.9 A Traditional Need for Equipment Standards Removed*

One major function of equipment standards is to manage interference. In Australian spectrum licensing, the hidden interference management functions of equipment standards have been transferred to the direct visible action of licence conditions. There are no mandated equipment standards and equipment may be designed, with the generic equipment standard taken only as a benchmark, in whatever manner a licensee wishes. An equipment manufacturer no longer needs approval from the NRA to access spectrum. Approval now comes from the relevant spectrum licensee. And that licensee already has all the tools necessary to work out what has to be done to authorise operation of any equipment under the licence. Equipment manufacturers no longer check with the NRA for "approved" equipment. Australian spectrum licensing has ushered in a new era of equipment design flexibility and creativity.

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<sup>20</sup> Australia prefers the term licence "division" rather than the ungainly "disaggregation" which originated in the USA.

**“...the hidden interference management functions of equipment standards have been transferred to the direct visible action of licence conditions.”**

Ofcom’s stated end point is the same as that already arrived at in Australia. Spectrum licensing technical rules have been applied for any application, whether fixed, mobile, broadcast and any convergence of these including software defined radios since 1997.

There are no technological constraints beyond those necessary to avoid interference.

## **5.0 Managing the Vested Interests of Equipment Manufacturers**

One reason Australia has been able to achieve this huge leap forward in spectrum management methodology is that the Australian NRA, in the absence of a significant local manufacturing sector has not needed to deal with established industry management structures which tend to prefer the established system of lobbying government for a spectrum allocation for their equipment. Ofcom’s proposed vetting procedure fits neatly within the current equipment manufacturer’s lobbying model. The Australian technical solution has quickly introduced industry self-management, a situation which apparently is the end game sought by Ofcom.

The Ofcom proposal means Ofcom itself is likely to slow the process and attract major costs in terms of resourcing the function. If UK industry is to eventually pay for these services it might need to look before leaping to accept an open ended commitment on user pays in an unnecessary and convoluted process. A commercial rate of payment for spectrum surely implies a commercially sensible and sustainable means of managing and using that spectrum in an unfettered manner. In Australia, industry self management has been balanced by significant reduction in staffing numbers at the NRA.

## **6.0 No Need to Re-invent the Wheel**

In addition to this paper an overview of many of the technical answers Ofcom is looking for is available, since 2003, at [www.futurepace.com.au](http://www.futurepace.com.au) see “Spectrum Trading”.

Under the self-managed Australian framework FuturePace has been able to develop web-based operational software for spectrum licensing over the past 8 years to a point where it provides significant cost-efficiencies with:

- online requests for device authorisation;
- automated compliance checks for both deemed (benchmark levels) and actual interference;
- online licensing with direct access to the NRA’s database; and
- integrated real time online EMR management for radiocommunications sites consistent with the requirements of ARPANSA and ICNIRP radiation safety Standards<sup>21</sup>.

These web based tools can be readily adapted to new markets

## **7.0 Options for Ofcom**

Accepting Ofcom has a responsibility to manage interference it still has two options:

- It can either provide a full definition of the interference environment upfront, providing industry with all the necessary tools to self-manage their task; or
- use a hands-on iterative approach based on traditional approval of equipment standards by the NRA and presented to industry as seeking a “better” definition of spectrum usage rights.

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<sup>21</sup> See FuturePace Solutions and EMC Technologies “Managing EMR in the Community”, EMC UK Conference Proceedings, Newbury, October 2004.

Good public policy objectives suggest the need to carefully re-examine the options on cost and certainty grounds and to do so in the context of a consistent approach for Europe.

If it is not possible for non-technical reasons, to generally provide a full definition of the interference environment upfront, then it would be better to do so in targeted areas/bands.

## **8.0 Liberalisation is Born from a Spectrum Space Focus**

Analogies to property, land or natural resources follow from traditional approaches to spectrum management using an **equipment standard focus**. Those analogies break down when the rate of technology change becomes high and management according to individual equipment standards is no longer practical. Australia realised this and that a better system of management was required in 1990. This led to the provision of spectrum licensing in the Radiocommunications Act 1992 and its practical implementation in 1997.

Flexible spectrum management (liberalisation) is born from a **spectrum space focus**<sup>22</sup>. This new approach operates with a fully defined interference environment and space-to-space coordination (internal or external guard space etc) to manage interference.

Ofcom's two options can be simply restated as:

- equipment focus; or
- spectrum space focus.

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<sup>22</sup> Pre-conference workshop 11<sup>th</sup> CEPT Implementing Spectrum Trading, "Australian Model and Experiences" FuturePace Solutions Australia 21<sup>st</sup> October 2003. <http://www.ero.dk/2233A4EE-C145-4F88-BB23-921F62A1EC2F?frames=no&Conference>

A spectrum space focus offers simplicity, maximum flexibility and market efficiency.

## **9.0 International Praise for New Interference Management Method**

Praise for Australia's reform of traditional interference management methods includes:

- April, 2001, Motorola Labs, Paris, France - *"Spectrum licensing in Australia is an important case study of modern spectrum management where a higher degree of flexibility is available for more spectrum efficient uses"*
- March 2002, UK Cave Review : *"The (Australian) framework is an innovative variation on conventional interference management techniques" and "A number of other national authorities... have begun to introduce a more generic approach to licensing access to radio spectrum... Of these, the Australian approach is the most fundamental reform of traditional spectrum management methods."*
- May, 2003, ACA - *"We acknowledge the valuable contribution that FuturePace (Spectrum Management International) has made in making sure that spectrum licensing works."*
- February, 2004, Fabio Leite, ITU, Spectrum Management for a Converging World: Case Study on Australia, *"Australia (is) a unique benchmark of modern spectrum management."*

## **10.0 About FuturePace Solutions**

Spectrum Management International Pty Limited, trading as FuturePace Solutions (see [www.futurepace.com.au](http://www.futurepace.com.au)), is a private company operating since 1997 and headquartered in Canberra, Australia.

FuturePace is, consistent with the stated Australian government objectives for industry self-management of spectrum, developing innovative web based on-line business practices including the on-line integration of licensing with EMR human exposure risk management at radiocommunications sites in a

commercial alliance (Site Management Alliance) with EMC Technologies, Australia and Bailey Dixon Lawyers and Consultants (see [www.sitemanager.net.au](http://www.sitemanager.net.au)).

FuturePace has a long-term commitment to professional research and the development of cost effective spectrum solutions for wireless networks and regulatory and public interest matters. We have provided advice to all Australian government consultations as well as many International consultations dealing with spectrum licensing. FuturePace has no contractual obligations towards any particular type of equipment, does not endorse products and does not own spectrum.

### *10.1 About the Co-Directors*

Michael Whittaker was principally responsible for designing the Australian 500 MHz, 800 MHz, 1.8 GHz, 3.4 GHz and 28/31 GHz spectrum licensing technical frameworks.

Barbara Phi has extensive experience in government, having spent 10 years with the Australian Department of the Prime Minister and Cabinet. Ms Phi was also involved in the development of policy for spectrum licensing in Australia.

## **Annex A - Why Ofcom might think Change of Use is Difficult in Australia**

### **A.1 Introduction**

Ofcom have clearly formed the opinion that change of use is difficult in Australia. We are uncertain where this opinion has originated and in an effort to cover all possibilities we will recount two occasions when amendments have been sought to Australian technical frameworks **after** the relevant spectrum auction. FuturePace remains willing to discuss practical examples of change of use with Ofcom.

#### *A.1.1 Technically Unnecessary and Technically Limiting Changes at 3.4 GHz*

At 3.4 GHz, the particular accredited person working for a small new-start telco was unwilling to use the full flexibility of the spectrum licence conditions and was sufficiently eloquent about competition issues to persuade the NRA to turn former guidelines into determinations. The 3.4 GHz compromises, while perhaps providing comfort for the commercially timid, also had the effect of reducing flexibility for all spectrum licensees in the band – an unfortunate, and completely unnecessary outcome, especially as reduced flexibility, and hence utility, means reduction in value of the spectrum asset.

#### *A.1.2 Partially Defined 2 GHz Spectrum Licence Conditions*

A situation has arisen recently in the 2GHz band where in 2000 the NRA developed a technical framework with, because of time constraints, the omission of a few technical parameters essential for TDD operation. While the current staff of the NRA have been efficient in finding solutions and compromises, a partial solution for one client will have taken around 6 months out of the use of a 15 year licence, and this is for some relatively simple parameters. It is difficult to quantify the potential delay in network rollout and the potential loss of access to purchased spectrum rights which might flow

from the initial system of negotiation proposed by Ofcom. Of course Ofcom may have it in mind to resource the function to a level where there is no delay. However, that solution is not only both costly and difficult, especially given the paucity of available skills, but is also inconsistent with any long term intention to remove Ofcom from the process.