Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

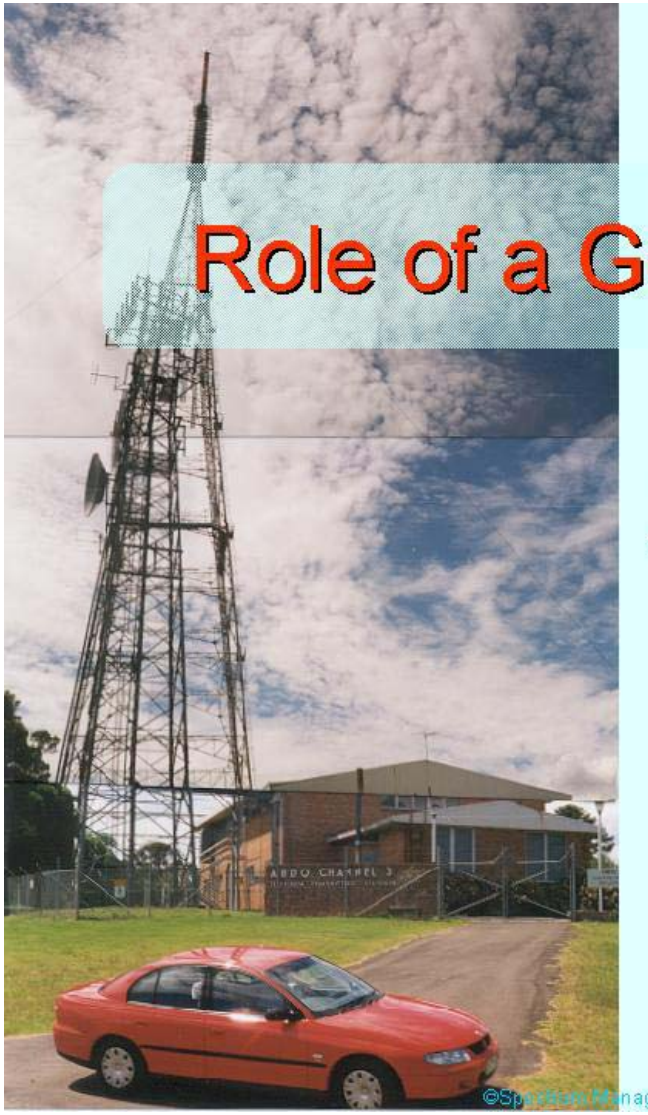
In the Matter of:

Commission Seeks Public Comment on Interference Immunity Performance Specifications for Radio Receivers	ET Docket No. 03-65

Comments of FuturePace Solutions

FuturePace Solutions
PO Box 451
Mitchell ACT 2911
Australia
+61 2 6242 0209
www.futurepace.com.au

March 14, 2003



Role of a Generic Receiver

— The Role of a Generic Receiver Specification in a General Method of Interference Management

by

Michael Whittaker

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Your Space

A blend of **LEGAL** and **TECHNICAL** conditions define access to, and the utility of, your spectrum space by telling you:

- how much space you require to operate a particular transmitter; and
- the **Receiver Protection** you can expect from transmitters operating in adjacent spaces.

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BackGround - Apparatus Licensing

FCC Manages Spectrum Space

Using:

- A Single Equipment Standard
- Defined Device(A)-to-Device(A) Coordination Procedures

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NewGround - Spectrum Licensing

Licensee Manages Own Spectrum Space

Using: proprietary Device(A)-to-Device(A/B) coordination procedures

FCC Manages Spectrum Boundaries

Using: FCC defined Space-to-Space coordination procedures*

*sometimes supplemented by Device-to-Device coordination across certain spectrum boundaries to protect pre-existing apparatus licensed services

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Why Space-to-Space Coordination?

Current FCC framework (traditional Device(A)-to-Device(B)) does NOT protect spectrum space asset:

- "*use of traditional coordination leads to non-reciprocal spectrum access for dissimilar equipment standards*" **(TIA/EIA TSB-84A)**
- "*lack of clear property rights reduces business activity*" **(Company A)**
- "*unnecessary level of negotiation with no set benchmarks*" **(Company B)**

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But Traditional Apparatus Licensing Methods are Sooo... Simple

- Sure! superficially simple
- A single equipment standard has **complex inherent** spectrum management functions
- Multiple Standards do not protect each other from interference

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NewGround Technical Objectives

The conditions seek to:

Maximise Technical Flexibility

- any type of service
- any band configuration

Retain Certainty

- fully defined responsibilities and rights
- minimise negotiation, including FCC involvement

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Managing Multiple Standards

Flexibility leads to **Complexity** (must transfer concealed interference management functions of standards to the direct visible action of licence conditions)

Certainty leads to **Explicit Interference Levels**

How is it done?

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Remove Focus on Individual Devices

NewGround is about:

- Spectrum **SPACE** management **NOT DEVICE** management
- After all, we do have **SPECTRUM AUCTIONS** **NOT** device authorisation auctions

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Defining the 'Size' of the Licensed Space

True 'size' is determined by what may be operated within it

'size' depends on all licence conditions including area, frequency band, emission limits and bias*

*see next few slides

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The Core Concept

Use a Generic Equipment Standard to define basic licence conditions that directly quantify its spectrum space requirements

This creates a benchmark for the assessment of the 'size' of spectrum space required for an actual standard

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Equipment Standards including channel plans

Theoretical Equipment Design

Generic Equipment Standard
(no channel plans)

Permanent single reference point for full flexibility

Design **Basic Licence Conditions** that define the 'Size' of the space in terms of the Generic Standard.

"One 'Size' Does Not Fit All"
Establish initial level of **bias** of fundamental license conditions toward a particular service category to increase spectrum efficiency for that category.

Regulator Management

Self Management

Licensees determine equipment characteristics, channelling and location etc. in accordance with the 'Size' of the space, supplemented when necessary, by internal or external (private spectrum sharing arrangements) guard space.

Allow adjacent licensees to negotiate with each other over time to modify the level of bias in the license conditions to increase spectrum efficiency for a different service category.

Creating a Sound Technical Foundation

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Designing Bias Licence Conditions

The basic licence conditions create a benchmark spectrum space 'size' for the Generic Equipment Standard

Deployment constraints then bias the basic conditions to increase spectrum efficiency for a particular service category

⇒ decrease in the spectrum efficiency of other categories

⇒ additional spectrum space then necessary to operate other categories (eg TDD when FDD bias)

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Example of Bias Conditions

- max Tx antenna height in specific bands sometimes coupled with antenna beamwidth limits
- max mobile Tx radiated power
- max fixed Tx duty cycle

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Designing Basic Licence Conditions

Must manage two types of interference

1. In-Band Interference
2. Out-of-Band Interference

Note: Out-of-Band Interference is NOT synonymous with Out-of-Band Emission

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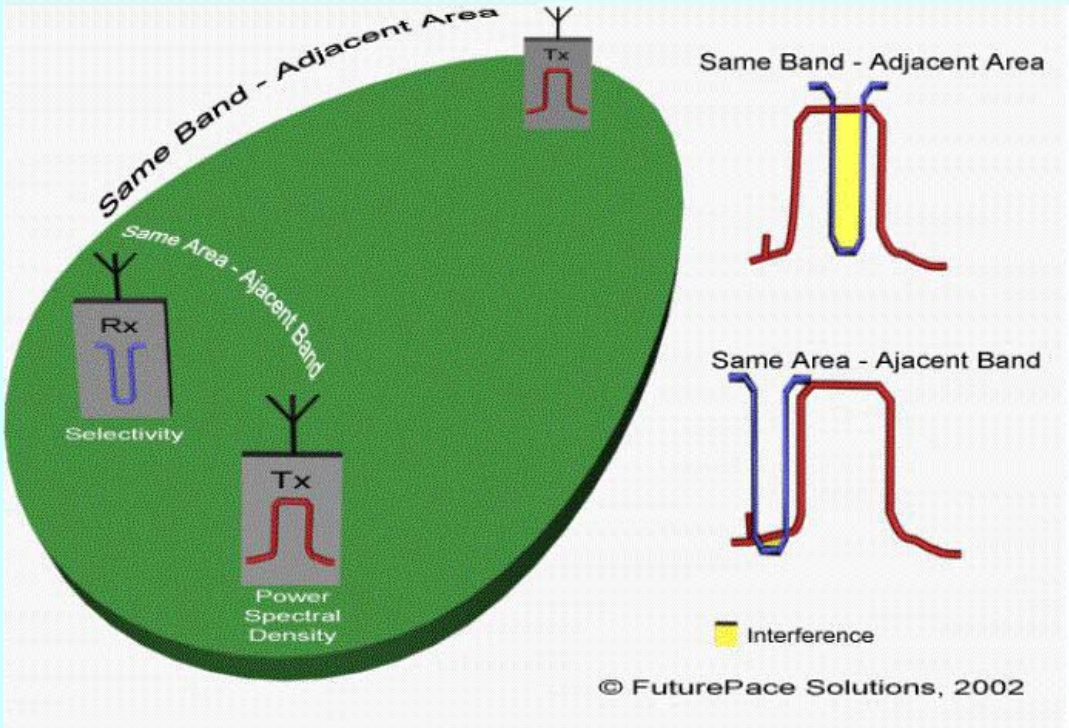
Sources of In-band Interference



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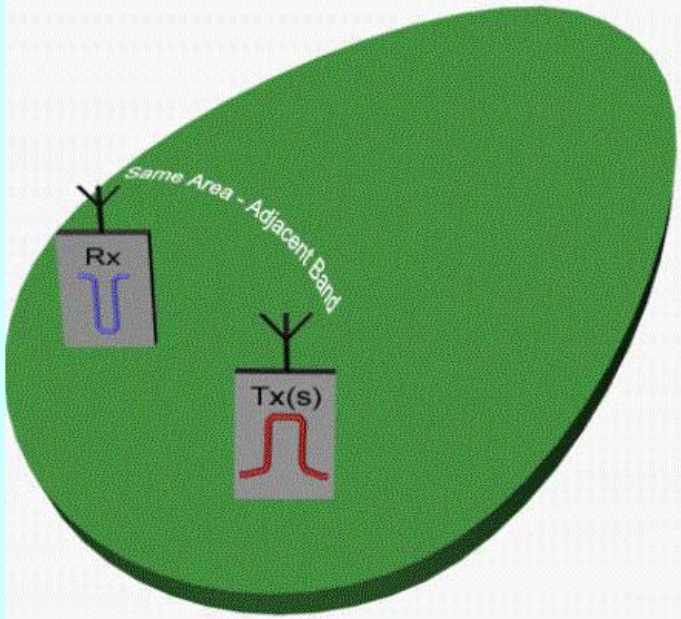
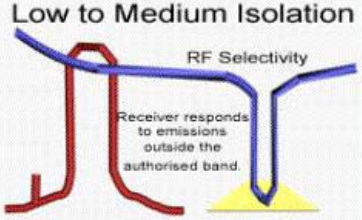
Sources of Out-of-Band Interference



Caused by design imperfections in the receiver - interference level depends on receiver quality



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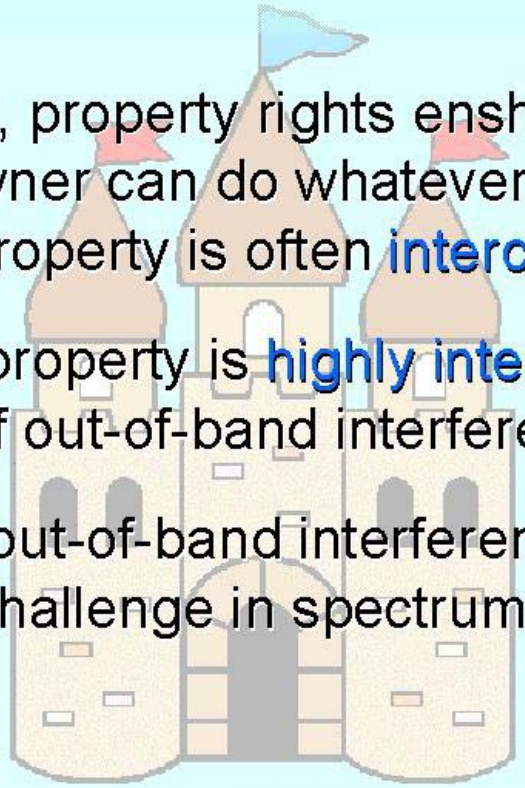
Property Rights?



Historically, property rights enshrine the view that the owner can do whatever they want, however property is often interconnected.

Spectrum property is highly interconnected because of out-of-band interference

Managing out-of-band interference is the main technical challenge in spectrum licensing.

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Receiver Protection Rights

Legal Rx protection rights usually flow from Tx emission limits and bias conditions

Emission and protection rights, respectively from, and to, a space may be summed up as the Yin-Yang* of spectrum management.

"What is allowed to go out, comes back in"

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Managing Adjacent Apparatus Licensed Spectrum

The same Yin-Yang balance (same conditions) may be used to manage new services in any adjacent spectrum that continues to be managed under apparatus licensing.

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Managing In-Band Interference Indirectly

Traditional method: Set maximum limits for in-band and out-of-band emissions

→ Indirectly establishes acceptable levels of in-band interference

Regulator does not have to define or audit very low signal levels

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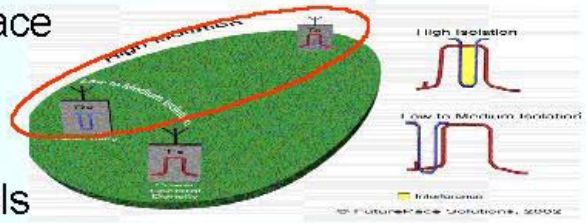
Practical In-Band Adjacent-Area Interference Management

Onus placed on adjacent-area Rx operator

- Specify allowed Tx **radiated** power spectral density with a single mathematical formula
- Operator of Rx designs their network taking account of in-band interference probability based on:
  - Likelihood of future Tx operation by **adjacent-area** licensee
  - the mathematical formula
  - any Tx Bias or required guard space
  - Distance of Rx from boundary
  - Rx antenna gain
  - high resolution propagation models



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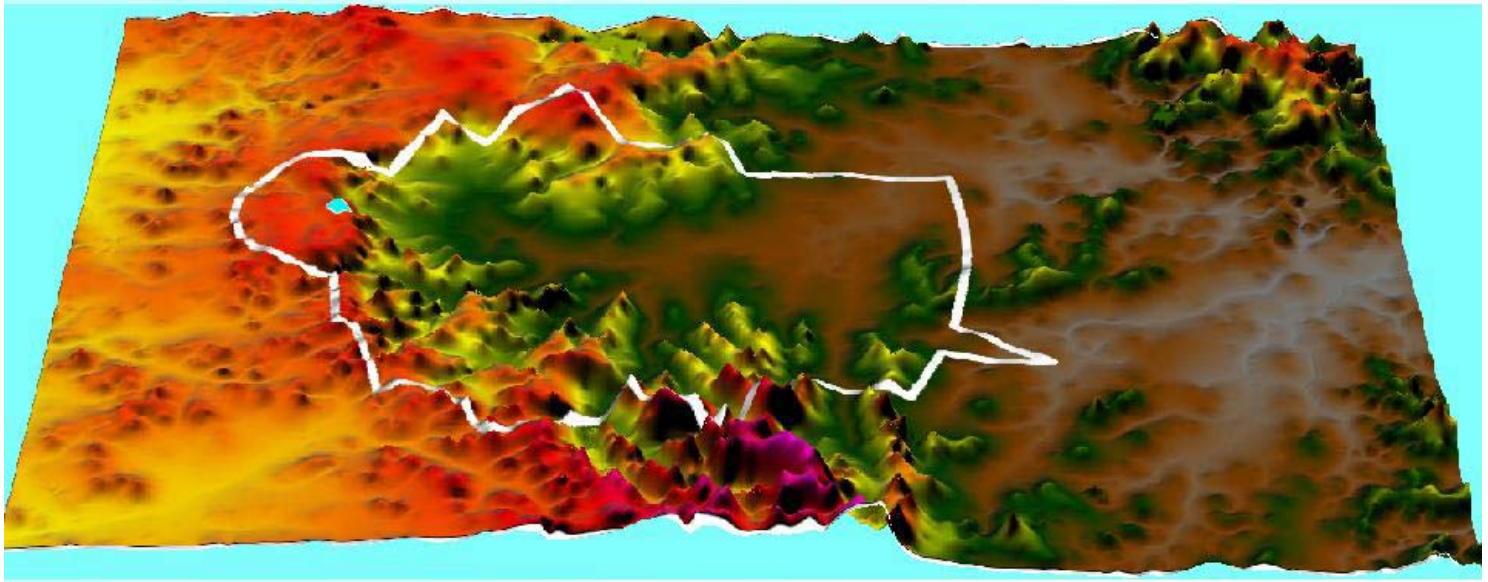
Australia's Single Mathematical Formula - "The Device Boundary*"



*Purposely designed to be low resolution to provide a workable solution in most cases

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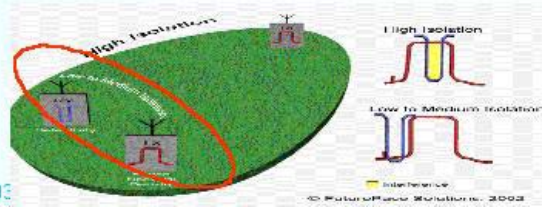
Practical In-Band Adjacent-Frequency Interference Management

- Specify **steady-state** and **transient**, **radiated** out-of-band emission limits*

Onus placed on adjacent-frequency Rx operator

- Operator of Rx designs their network taking account of in-band interference probability based on:
  - Likelihood of Tx operation by **adjacent-frequency** licensee
  - the out-of-band limits
  - any Tx Bias or required guard space
  - Likely distance of Rx from Tx's in same area (near-far effect)
  - Rx antenna gain
  - high resolution propagation models

*important, must not be worst case



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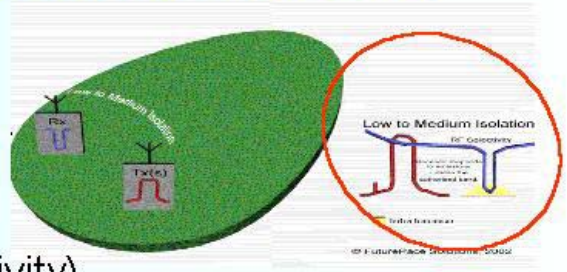
Managing Out-of-Band Interference Directly

Onus placed on last-in-time frequency-adjacent Tx/Rx operator

- Out-of-band interference is non-linear ⇒ direct coordination on a site by site basis is the best first line of defence (Tx emission limits would be too restrictive)
- Interference susceptibility is dependent on receiver design ⇒ must specify a **Generic Receiver***:
  - RF and IF selectivity
  - blocking
  - intermodulation immunity
  - spurious response immunity
  - compatibility requirement (sensitivity)



*actual Rx is allowed to be better or worse

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Time-Related Transmit Rights

Follow from Indirect and Direct Interference Management

A **transmitter** may be operated inside a spectrum licence in accordance with:

- In-Band (area-adjacent), Device Boundary **Anywhere, Any Time***
- In-Band (freq-adjacent), OOB Emission Limits **Anywhere, Any Time***

But must **first coordinate** with Tx's and Rx's registered at that point in time on a Device-by-Device basis to manage out-of-band Interference

*subject to protecting any pre-existing apparatus licensed **Rx's** just outside the licensed space

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Time-Related Receiver Protection

Follows from Indirect and Direct Interference Management

A **receiver** must be designed to cope with emission levels radiating from **Anywhere** in adjacent spectrum or apparatus licensed spectrum defined by:

- In-Band (area-adjacent), Device Boundary at **Any Time***
- In-Band (freq-adjacent), OOB Emission Limits at **Any Time***

And must **first coordinate** with Tx's registered at that point in time on a Device-by-Device basis to manage out-of-band interference

*must also cope with emissions from any pre-existing apparatus licensed **Tx's** just outside the licensed space

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Registering Devices

Certified registration in a public data base creates both a technical basis and a clear chain of legal liability for management of out-of-band interference at the two frequency boundaries that exist everywhere throughout a licence area

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Exemptions From Registration

Transmitters with low interference likelihood do not have to be registered:

- mobile or fixed Tx with $\leq$ 25 dBm EIRP per 30 kHz
- higher powered mobiles operating outside towns
- fixed Tx with $\leq$ 5% duty cycle operating outside towns
- a Rx that radiates narrowband emission

Exempted devices can cause interference and are a important part of the spectrum space product definition

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Group Registration

Simplifies certification of multiple fixed Tx's with high radiated power distributed over a wide area:

- a single registration for up to thousands of subscriber Tx's;
- Individual locations not recorded;
- Devices must **EITHER** mimic mobile behaviour (≤ 5% duty cycle) to manage out-of-band interference **OR** provide necessary guard space

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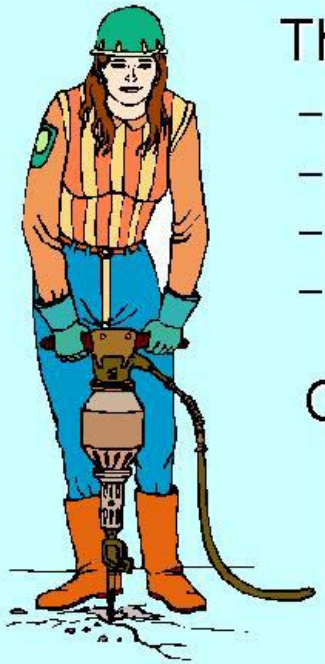
RF Noise Floor



The combination of:

- registration exemption;
- group registration;
- any adjacent impulsive transmissions (eg UWB); and
- any pre-existing class licensed devices;

Creates an indirectly defined RF Noise Floor for the licensee to take into account

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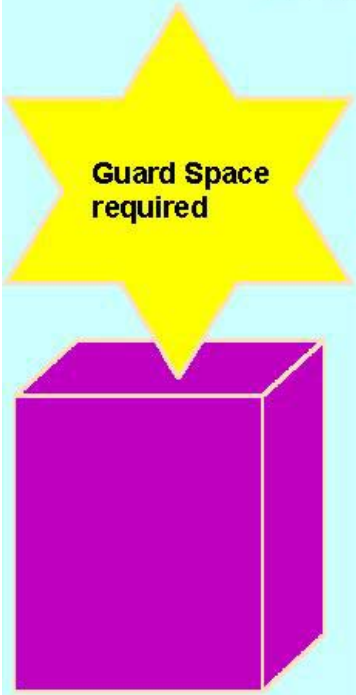
But Our Device Doesn't Fit



The FCC can provide two ways to certify and authorise operation of devices:

1. **follow step by step instructions of the Basic and Bias conditions; or**
2. **Assess necessary internal or external (spectrum sharing) guard space**

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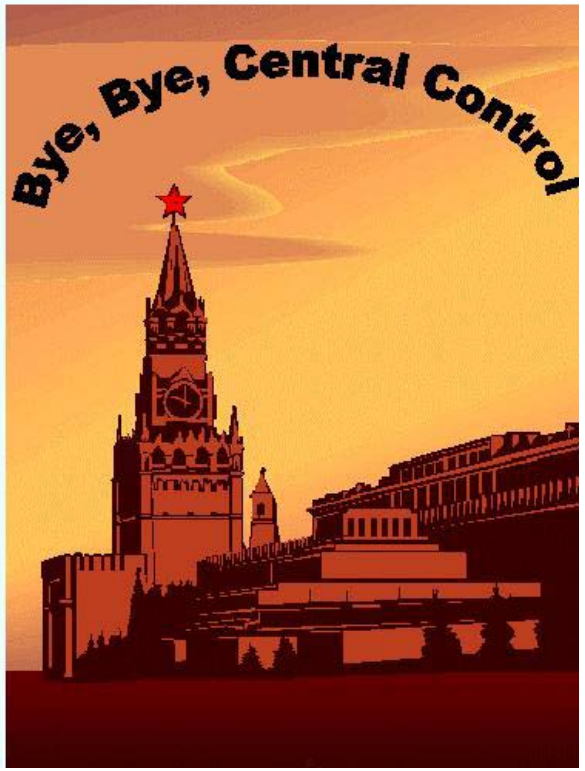
Licensees Doing It For Themselves

The two means of certification provide **ALL** the flexibility to operate **ANY** type of equipment **WITHOUT** recourse* to the FCC

Technology Neutral?
(well, as good as it gets)

* except when shared spectrum remains managed by the FCC/NTIA.



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What's This Thing Called Guard Space?

Internal or external (spectrum sharing) guard space must provide protection to area-adjacent (guard area) and frequency-adjacent (guard band) spectrum to the **Same Extent as the Protection Inherent in the Bias Conditions**.

Provide sufficient:

- **Guard Area** to manage additional in-band interference when operating outside the bias conditions
- **Guard Band** to manage additional out-of-band interference (based on **Generic Receiver** specification) when operating outside the bias conditions

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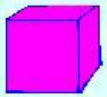
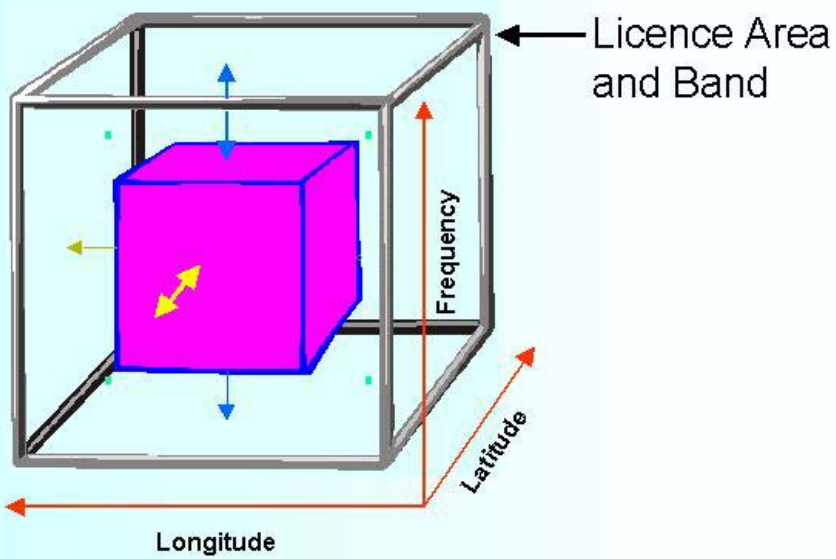
Internal Guard Space



Space Available to Tx's operating outside of Bias Conditions



Internal Guard Area

Internal Guard Band

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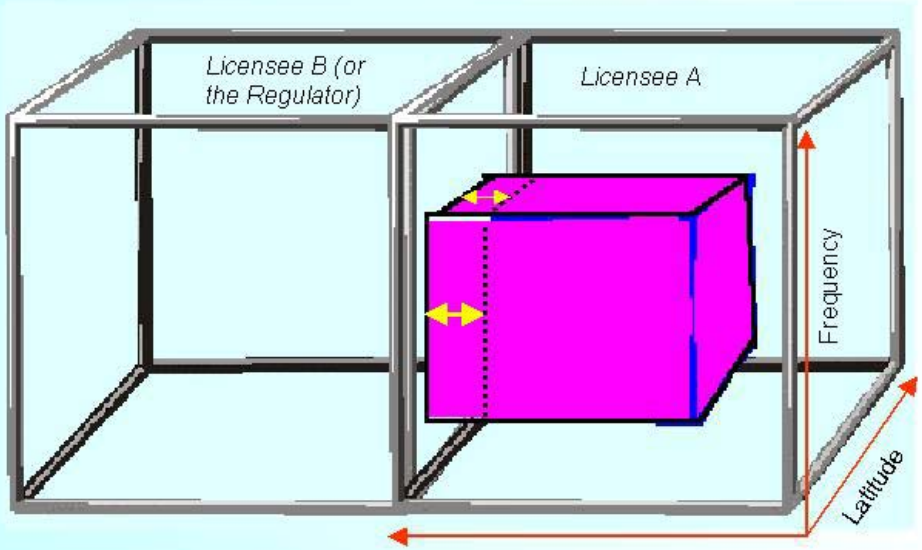
External Guard Space - Spectrum Sharing Agreement



External Guard Area

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Other Uses of Guard Space

In addition to working around Tx bias conditions, guard space may also used to operate Tx's when:

- they do not comply with the out-of-band emission limits; or
- they require a Tx power greater than that allowed by the single mathematical formula that manages in-band interference (includes errors caused by its low resolution design - in practice about 1% of cases).

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Protecting Pre-Existing Services in or near an Overlayed Licence

If necessary, Spectrum Space management conditions may be supplemented by a requirement for **Device-to-Device** coordination across certain spectrum boundaries to protect pre-existing apparatus licensed services, either for a short defined period or for the full term of the spectrum licence.

The length of the period effectively provides the apparatus licensee with **compensation** that may be either traded with the incoming spectrum licensee to pay for relocation or used to continue operation.

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Changing the Basic and Bias Conditions after Sale

DIFFICULT! would require agreement of all licensees

WHY? they represent the quantified useable space (effective core condition)

AND, they represent inherent interference protection

ANYWAY, certification under Guard Space already provides a work-around

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However……

Bias Conditions cause a shift in spectrum efficiency from one service category to another.

FuturePace believes model legal / technical instruments could be designed to assist **licensees** in shifting bias to other service categories during a licence term.

No need to ever amend Basic Conditions if first correctly designed

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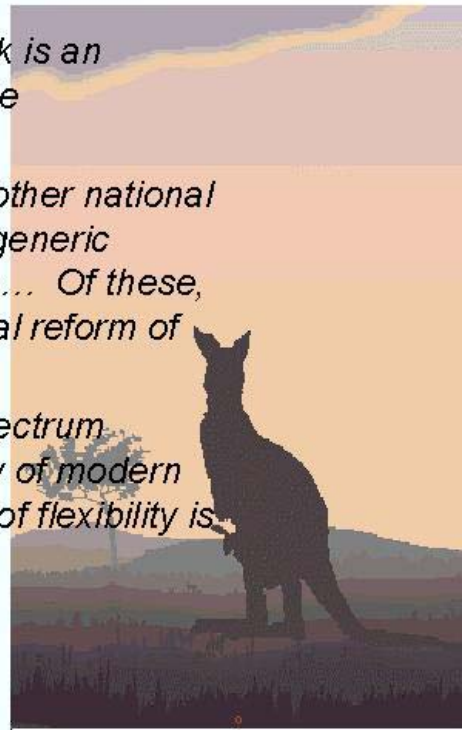
International

Praise for reform of traditional spectrum management methods:

- March 2002, UK Cave Review : "*The framework is an innovative variation on conventional interference management techniques*"
- March, 2002, UK Cave Review : "*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.*"
- 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*"



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End

Biography Michael Whittaker, B Sc. (Physics), Grad. Dip. Electronics, (futurepace@ozemail.com.au) has worked for the Australian government in spectrum management since 1984, pioneering automated frequency assignment systems and publishing widely in that field. He had previously worked for 10 years as manager of a Nuclear Magnetic Resonance (the basis of MRI) research group in the Australian National University and has also published in that field. He led the introduction of spectrum licensing techniques in Australia as chairman of the Technical Liaison Group, a government sponsored industry consultative forum, which established the licence conditions for 800 MHz and 1.8 GHz spectrum licences. He is now a director of FuturePace Solutions working part time on a contractual basis with the Australian Communications Authority as a special adviser for the government's continuing roll out of spectrum through price based re-allocation processes.

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