Development of the Technical Framework for 2 GHz Spectrum Licences

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Table of Contents

1 INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the methodology and important assumptions used in obtaining the technical framework associated with spectrum licensing of the 2 GHz Third Generation Mobile (3G) band.

This document collects together the materials used by the Australian Communications Authority (ACA) in its considerations towards establishing the technical framework for the 2 GHz 3G band spectrum licences.

Readers of this document are assumed to possess a moderate level of technical knowledge and an understanding of spectrum licensing as practised in Australia.

1.2 Background

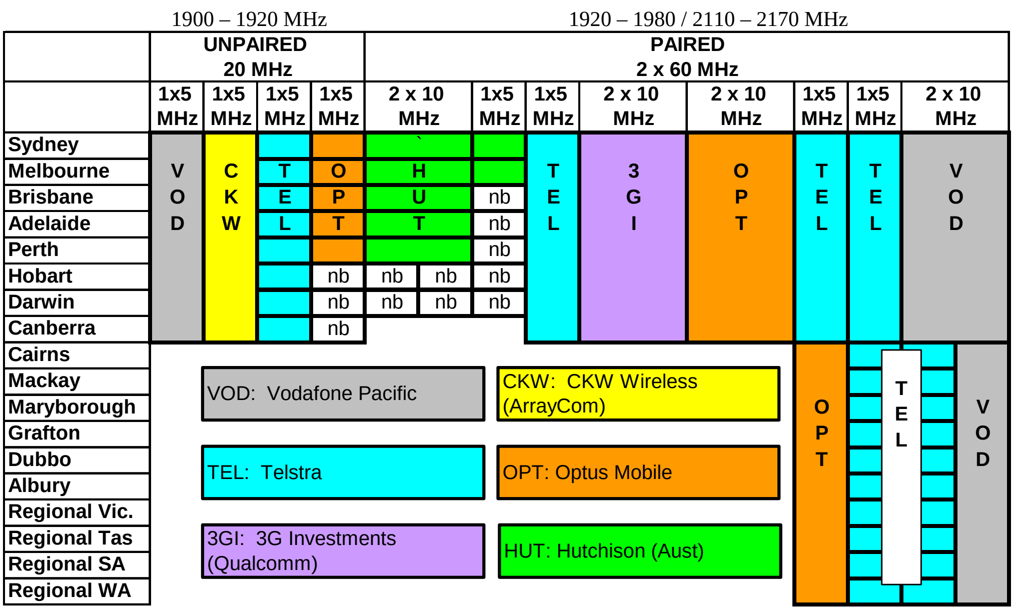
In 1992 the World Administrative Radio Conference (WARC-92) allocated the 1900 to 1980 MHz and 2110 to 2170 MHz frequency bands for mobile communications on a world wide basis. At the time, Future Land Mobile Personal Telecommunication Systems (FLMPTS), were expected to operate in these bands. FLMPTS are now known as International Mobile Telecommunications (IMT 2000). In International Telecommunications Union (ITU) fora, there were several reasons for promoting common worldwide spectrum allocations for IMT2000. These include:

- Promotion of economies of scale through ensuring maximum commonality of radiofrequency equipment that would drive down the cost of technology, especially consumer mobile handsets
- Facilitating common consumer equipment, and thereby encouraging seamless roaming between countries

The process of providing spectrum for the 3G services in Australia commenced in 1998, when the Australian government embargoed the spectrum from 1900 to 1980 MHz and 2110 to 2170 MHz. This embargo prevented further licensing in this band.

In 2000 RICHARD KENNETH ROBERT ALSTON, Minister for Communications, Information Technology and the Arts, signed the *Radiocommunications (Spectrum Re-allocation) Declaration No. 2 of 2000* [1] for the spectrum from1900 to 1980 MHz and 2110 to 2170 MHz. This declaration defined the frequency bands and the geographic areas to be allocated by means of a price based allocation (auction) and the time period by which pre-existing licensees had to cease operation. Spectrum auctions were held in March 2001 and licensees were determined. The spectrum licences come into effect in October 2002 and have a 15 year life span.

The result of the spectrum auction process for the 2 GHz 3G band is shown below:



nb = no bid

2 TECHNICAL FRAMEWORK OVERVIEW

At its simplest a spectrum licence conveys a property right that has a defined extent in terms of geographic area, frequency range and a defined time period. The definition of the frequency and geographic extent of the spectrum space is contained in the technical framework. Chapter 5 of the 2 GHz Applicant Information Package [2] provides a detailed explanation of the concepts of the technical framework and can be found in Appendix A.

Several sections of the Radiocommunications Act [3] are relevant to determining a technical framework for spectrum licences. The framework is essential for defining the spectrum licensee's rights and obligations, and providing an interference management framework. The relevant sections of the Act are:

- Section 66: Core conditions
  - Out-of-area emission limits
  - Out-of-band emission limits
- Section 145: Area boundary management (using Device Boundaries)
- Section 262: Radiocommunications Advisory Guidelines, further managing interference to and from other services

The technical conditions of the technical framework for the spectrum licences in the 2 GHz 3G band were developed by the Technical Liaison Group (TLG), which was composed of ACA and industry representatives. Details of TLG membership can be found in Chapter 4.

The different aspects of the technical framework are contained within the following documents:

- The Marketing Plan [4]
- The Section 145 (s.145) Determination [5]
- Advisory Guidelines for Apparatus Licence Transmitter to Spectrum Licence Receiver [6]
- Advisory Guidelines for Spectrum Licence Transmitter to Apparatus Licence Receiver [7]
- Advisory Guideline for Registration of Devices without an Interference Impact Certificate [8]

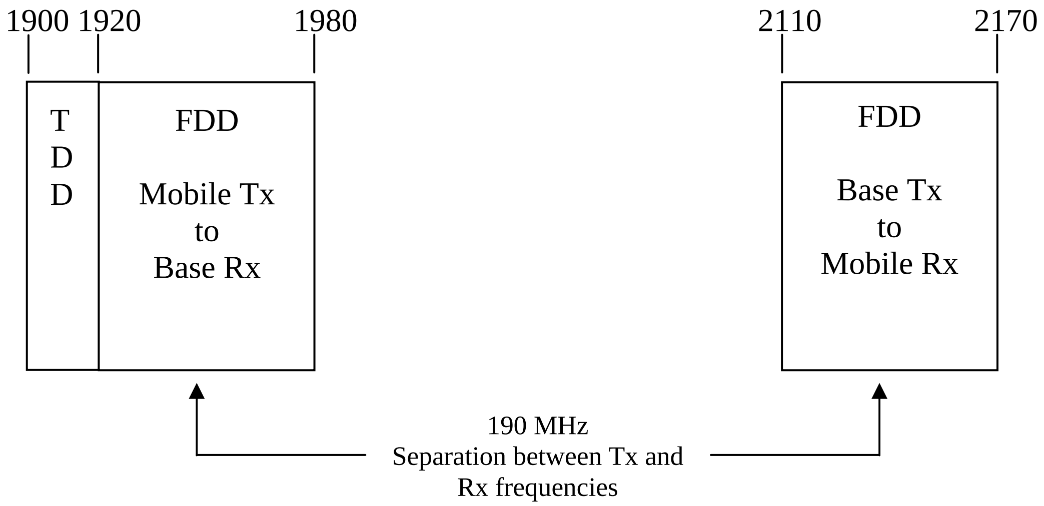
3 ENGINEERING NOTES

This document is intended to be read in conjunction with the technical framework documents mentioned in section 2. The following engineering notes are a supplement to, not a substitute for, the technical framework documents. Therefore this section does not reproduce the parameter values of the technical framework, rather it provides explanatory information on how the parameter values were derived.

3.1 Overview

In keeping with the "technology neutral" philosophy of spectrum licensing the technical framework for the 2 GHz 3G licences does not prescribe use by any specific service or technology. Nevertheless, while a spectrum licensee could operate any technology in this band, it was expected that 3G technologies would be the predominant technology. As such the technical framework for spectrum licences in this band was optimised for the 3G services expected to operate in this band.

The 3G technologies have been designed to operate in unpaired TDD and paired FDD arrangements. A diagram showing the notional spectrum arrangements for the 2 GHz IMT 2000 band is shown below.



Initial system parameter values for the technical framework were obtained from various ITU documents and other published standards for potential IMT 2000 systems. These initial values were then debated within the TLG and the final values agreed upon. An overview of these discussions and results are in Appendix B – Appendix F.

Note, EIRP levels are used in most cases, instead of specific equipment values, to allow the licensees different methods in satisfying the technical framework.

3.2 Core Conditions: Out-of-Area Emissions

The Out-of-Area Core Conditions limits place an overall cap on the EIRP at the boundary of a licence and limit the EIRP that can be used throughout the area. In deriving the limits, maximum possible transmitter power and antenna gain values were used as a guide. These values lead to EIRP values that are greater than currently achievable maximum values. This was deliberately done to allow for future improvements in equipment performance. These values were derived from industry consultation.

The FDD EIRP limit was based on:

Maximum Base Station Tx Power:	43 dBm / 200 kHz (20 W)	(a)
Antenna Gain:	20 dBi (including feeder losses)	(b)
Conversion from 200 kHz to 30 kHz:	8 dB	(c)

Horizontal Radiated Power (EIRP to the horizon): 55 dBm/30 kHz. (a+b-c)

The TDD EIRP limit was based on:

Maximum Base Station Tx Power:	33 dBm / 200 kHz (2 W)	(a)
Antenna Gain:	20 dBi (including feeder losses)	(b)
Conversion from 200 kHz to 30 kHz:	8 dB	(c)

Horizontal Radiated Power (EIRP to the horizon): 45 dBm/30 kHz. (a+b-c)

Different EIRP limits apply for the different FDD and TDD technologies. The lower level for TDD provides some necessary protection against adjacent band blocking (ie TDD base to TDD mobile).

3.3 Core Conditions: Out-of-Band Emissions

Emissions outside the frequency boundary of a Spectrum Licence are limited by the out-of-band emission limits. The out-of-band emission limits also provide spectrum licences expected levels of in-band interference that will be received from adjacent channel spectrum licences. Out-of-band emission limits are classified as:

- Non-spurious emissions limits:
- Spurious emissions
- Transient emissions

Non-spurious unwanted emissions are emissions outside the frequency boundary that are modulation or intermodulation products caused by transmitted information, or broadband/phase noise.

Spurious emission is any other type of emission outside the frequency boundary of a spectrum licence, including intermodulation products <u>not</u> caused by transmitted information, frequency conversion products, harmonics, products from instabilities introduced by the modulation process and parasitic products.

Transient emissions are typically due to switching transients.

The approach taken by the TLG was to create emission limits based on the expected 3G technology standards to be used in Australia. In determining the out-of-band emission limits, all 3G technologies were considered to ensure that the specification would allow any IMT 2000 system to operate effectively.

3.3.1 Non-spurious emissions limits

A (worst case for current technologies, including feeder loss) 19 dBi base station antenna gain was used to develop the EIRP limit for non spurious emissions. The emission limits for non-spurious unwanted emissions are illustrated in graphs in Appendix C, including comparison with other emission masks.

At the **unpaired/PHS spectrum boundary (1900 MHz)**, a very strict out-of-band requirement was developed, in order to minimise the chance of TDD mobiles and base stations causing excessive out-of-band interference to uncoordinated PHS base stations.

To assist in developing the above limits, *ITU-R Rec M.[IMT.UNWANT]* [9] was considered. Unfortunately, this Recommendation only describes mobile units, not base stations, so more detailed individual standards and manufacturer's data were considered. The TLG used a variety of sources (standards, technical studies, manufacturer's reports) to determine base station transmitter emission masks for the IMT-2000 technologies.

3.3.2 Spurious emissions

Limits for unwanted spurious emissions are specified in terms of radiated power in the spectrum licensing framework. Therefore, the maximum gain of the base station antenna (less minimum combiner and feeder loss) was added to the transmitter power limits specified at the antenna connector for emissions at frequencies that are within the base station antenna's 0 dBi bandwidth[1]. The 0 dBi bandwidth for base station antennas designed for operation at 2 GHz is from 1 GHz to 3.7 GHz. The initial spurious emission values were taken from IMT 2000 specifications and the 0 dBi bandwidth was derived from industry consultation.

3.3.3 Transient emissions

Switching transients are managed (kept within a licensee's spectrum space) by specifying a peak power emission limit at a frequency outside, but close to the band edge, of the spectrum licence. The transient emission values were derived from IMT 2000 specifications.

Note, peak power means the average power during one radio frequency cycle at the crest of the signal envelope.

[1] The 0 dBi bandwidth is the bandwidth over which the antenna's gain exceeds 0 dBi

3.4 Notional Receiver

The notional receiver is intended to provide a basis for managing interference to receivers operating 2 GHz spectrum licensed bands caused by transmitters operating under apparatus licences. This requirement does not apply to transmitters operating under class licences.

The compatibility requirement has been included in the Advisory Guidelines and forms the basis for both the development of coordination procedures and settlement of interference situations for devices operating under frequency-adjacent licences.

The minimum performance level for a receiver relates to:

- selectivity;
- intermodulation immunity; and
- blocking.

3.4.1 Adjacent Channel Selectivity

Adjacent Channel Selectivity means a measure of the ability of a receiver to receive a wanted signal in the presence of an unwanted adjacent channel signal at a given frequency offset. This degradation is usually caused by emissions from the unwanted signal falling within the IF bandwidth of the receiver. For the 2 GHz notional receiver, receiver selectivity is specified by an 'adjacent channel selectivity', as in IMT-2000 equipment standards. The minimum receiver performance was based on the WCDMA standard, because that technology had the widest bandwidth carrier of the key IMT-2000 technologies.

3.4.2 Intermodulation Response Immunity

Intermodulation Response Rejection means a measure of the capability of a receiver to receive a wanted signal in the presence of two or more unwanted interfering signals that have a specific frequency relationship to the wanted signal.

Models for this type of degradation are based on the RF selectivity of a receiver and a conversion ratio. The interference power may either be calculated from knowledge of these parameters and compared with the compatibility requirement, or by a specified 'intermodulation rejection level'. Two-signal third order, two-signal fifth order and three-signal third order intermodulation interference scenarios are normally checked in a coordination study. For the 2 GHz notional receiver, Intermodulation Response Rejection is specified by an 'intermodulation rejection level', as in IMT-2000 equipment standards. Again, the minimum receiver performance was based on the WCDMA standard, because that technology had the widest bandwidth carrier of the key IMT-2000 technologies.

3.4.3 Blocking

Receiver blocking means a measure of the ability of a receiver to receive a wanted signal in the presence of a high level unwanted interferer on frequencies other than those of the adjacent channels.

This type of degradation differs from the degradation caused by limited receiver selectivity, although both effects can sometimes occur simultaneously. Blocking is usually caused by reciprocal mixing of the off-tune signal with the receiver's local oscillator and/or changing the operating point of the RF-amplifier or mixer stages. The interference power is not easily modelled and a minimum blocking performance is specified. Again, the minimum receiver performance was based on the WCDMA standard, because that technology had the widest bandwidth carrier of the key IMT-2000 technologies.

3.5 Device Boundary Criteria

Device boundary criteria are used to maintain equitable access to spectrum across geographic area boundaries. Deployment constraints may be required in lieu of, or to supplement, device boundary criteria as part of the overall interference management framework.

Emissions that fall outside the geographic area of a spectrum licence are limited by Core Conditions that specify a maximum horizontally radiated power. As well as these Core Conditions, additional layers of interference management are specified in schedules contained in the *s.145 Determination* (*Unacceptable levels of Interference),* the most important schedule is the Device Boundary Criteria. Before registering a device a licensee (or accredited person acting on behalf of a licensee) must, in addition to checking that the core conditions are maintained, calculate the device boundary of an outdoor fixed (non-mobile) transmitter[2].

The effect of these layers of management is to create 'emission buffer zones' along the geographic boundaries of the licences.

3.5.1 System Models

The system models that were considered are described in Appendix B: Discussion Paper #1. As area boundary management is a two-way process, typical rather than worst case values, for equipment parameters were considered. This avoids radio "dead-zones" at the area boundary, from over-conservative requirements.

[2] Some transmitters have considerably lower radiated power levels and antenna heights than those of fixed base stations. As a consequence, these transmitters have a relatively lower interference potential than fixed base station transmitters. Therefore, mobile transmitters, along with indoor fixed transmitters with EIRPs of less than 25 dBm/30 kHz, were exempted from the Device Boundary criteria.

The device boundary was not optimised for the TDD case, as TDD is more likely to be used for urban micro- and pico-cells, and will not be used in areas near spectrum licence boundaries (usually suburban or rural environments)[3].

3.5.2 Level of Protection

The level of protection is used to develop the Maximum Power (MP) criteria used in the calculating the device boundary. The MP is used to determine the maximum allowable EIRP of a transmitter at a given distance from the spectrum licence geographic boundary. It acts as a limit on deployment of high power transmitters near the edge of the geographic boundary of the spectrum licence.

Initially the proposed level of protection was obtained from typical values in the System Model that were derived from the IMT 2000 standards and industry consultation. After further consultation within the TLG, it was decided to decrease the Level of Protection (LOP) to -118 dBm/30 kHz to account for body loss and possible increases in the noise floor, due to multiple CDMA carriers.

3.5.3 Propagation model

The propagation model was chosen to meet the following criteria:

- is suitable for cellular mobile applications at 2 GHz;
- is a 'generic' model, not requiring detailed terrain information; and
- is simple enough to be incorporated easily in specified Device Boundary calculations, resulting in minimal effort for the person registering the device.

The propagation models detailed in *ITU-R Recommendation M.1225* "*Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000*" (Annex 2, Section 1.2.1.2 and 1.2.1.3) were first suggested for use in developing the Device Boundary Criteria. However, these models were shown to be invalid for antenna heights over 60 m. This meant that they were not suitable for Device Boundary requirements, where the <u>effective</u> antenna height is a critical parameter. (**Effective antenna height** calculations take into account surrounding (average) ground height. This will often result in effective base station antenna heights that are above 60 m).

To provide a smooth transition between low and high effective antenna heights, and to model a realistic environment for a boundary area, a propagation model based on the **Hata/COST-231 Suburban** model [10] was chosen. This model is recommended for base antenna heights up to 200 m, and worked well for heights up to 800 m, but was considered inaccurate above 800 m. Taking this into account, the TLG decided to include another model that would work better at greater heights. The **Okumura** model was agreed to be used in situations where the base station height caused the Hata/Cost-231 Suburban model beyond 20 km to not work as effectively. The transition point between the two models was determined to be at an effective antenna height of 500 m.

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[3] It should be noted that the TDD band was allocated only in metro areas and Canberra, Hobart and Darwin. This means TDD lots do not share a geographic boundary with another spectrum licence using the same frequencies.

The path loss equations were simplified by standardising on a frequency of 2 GHz when establishing the equations. The slight variation between the actual frequency and the assumed frequency will be minimal. Also a scaling factor, S, has been placed in the equations to allow for future variations, if required. The scaling factor can be changed to effectively either increase or decrease the distance from a transmitter to a spectrum licence boundary.

3.5.4 Exemption from Performing Device Boundary Criteria

In spectrum licensing frameworks developed prior to the 2 GHz framework, all eligible transmitters in the licence area were required to have a device boundary calculated. However, it was recognised that for the 2 GHz spectrum licences in many areas, particularly for large regional licences, the device boundary requirements would obviously be met when base stations were located well away from the boundaries. It was agreed that a new condition to exempt such situations from the requirement to satisfy the device boundary criteria would be put in place.

To streamline the process of device registration, the ACA proposed an exemption from the requirement for calculating device boundaries for any transmitter located further than **40 km** from any spectrum licence boundary. The TLG debated the distance and the final decision was:

- Devices further than 70 km from all device boundaries would not need to calculate the device boundary criteria.

The reasoning for this was that using the propagation model, no transmitter that met the Core Condition Out-of-Area limit of 55 dBm EIRP per 30 kHz should have a device boundary larger than a circle with a 70 km radius. It was acknowledged that there might be situations where the 70 km radius may be surpassed (very open rural environments), but this compromise was chosen to maximise spectrum utility for the majority of cases and environments.

For this spectrum licence the step size (i.e. distance between calculation points) that is used when calculating the device boundary was decreased from 5 minutes to 1 minute. As a consequence, the maximum number of steps to ensure the 70 km end point along each radial could be achieved needed to be recalculated. The reduction in step size was done to provide a more accurate determination of the device boundary, thus allowing base stations to be deployed closer to the spectrum licence boundaries.

It should also be noted that the Device Boundary Criteria does not provide absolute protection, it simply aims to:

- provide equitable access to the spectrum at geographic boundaries;
- provide a level of certainty in planning near the boundary of other licensee's areas;
- minimise the need for negotiation between adjacent area licensees.

The device boundary calculation method takes account of terrain loss by adjusting its antenna height of a device according to its height above terrain, called its effective antenna height. There is an allowance of 48 m for ‘rolling terrain’ when calculating effective antenna heights. This has the effect of ‘smoothing’ the terrain around the site negating the terrain height unless the device is on a hill greater than 48 m above the surrounding terrain height. The basis for the use of this effective height is described in Chapter 5 of the 3.4 GHz Applicant Information Package [11].

3.5.5 Deployment Constraints

The technical framework has been developed based on “technology neutral” principles to the greatest extent possible. But, the technical framework has been optimized to allow for the operation of 3G services that are consistent with international standards.

In keeping with the ‘technology neutral’ concept, the technical framework does not prescribe the transmitter orientation, but places certain restrictions on transmitters operating within the band segments to ensure that 3G equipment operating under “normal” arrangements is not disadvantaged. Therefore, no extra conditions have been placed on the notional base transmit band of 2110 to 2170 MHz. However, in the notional mobile transmit band of 1920 to 1980 MHz, there are two main deployment constraints that ensure that the majority of transmitters will be mobile transmitters:

- A maximum EIRP limit of 25 dBm per 30 kHz for transmitters, which is not to be exceeded for more than 1 % of the time in any 1 hour period[4]
- A 20 m limit on the effective height for fixed transmitters.

These limits will not constrain conventional mobile transmitters, but will impose serious practical limits on the deployment of base station transmitters in the 1920 – 1980 MHz frequency segment.

3.5.6 Repeaters

Some members of the TLG indicated that repeaters are essential for the operation of their mobile service. Repeaters are used to re-transmit weak signals in areas of poor coverage within a cell and usually have low EIRP levels. As repeaters operate in both sections of the FDD band (ie, both Upper and Lower FDD), provisions needed to be made to allow for the use of repeaters within a spectrum licensee’s frequency band and geographic area.

Repeaters operating in the upper FDD band were subject to the same requirements as other devices transmitting in this band. In the lower FDD band the following provisions were required to minimise high site – high site interference:

For repeaters transmitting in the (lower) FDD Base Rx band, with an effective antenna height of <u>less than 20 m</u>:

[4] It was agreed by the TLG that mobiles could accept interference up 1 % of the time in any 1 hour period.

- device boundary criteria must be met (as for other fixed transmitters); and
- the EIRP must be confirmed as less than 25 dBm per 30 kHz for 99% of the time in any 1 hour period[5];

For repeaters transmitting in the (lower) FDD Base Rx band, with an effective antenna height of more than 20 m, or an EIRP of more than 25 dBm per 30 kHz:

- devices may still be registered if the 'guard area' requirements of Advisory Guideline "*Registration of Devices under Spectrum Licences without an Interference Impact Certificate*"(1998) can be met.

3.6 Other Services

In creating the technical framework, especially the Advisory Guidelines, it is essential to determine the compatibility requirements for all other services that operate in adjacent and co-channel bands. The services that were investigated were:

- DECT
- PHS
- Point-to-Point Fixed services
- MSS
- MDS
- Space services (deep space earth stations)
- HAPS

All these services, except HAPS, were able to be accommodated by the technical framework. Due to the nature of the HAPS system, the usual considerations of the technical framework did not provide a reasonable basis for interference management. As HAPS required further consideration, the process has been documented in the following subsection.

The compatibility requirements for services other than HAPS are documented in Appendix D. The compatibility requirements for HAPS are in Appendix C.

3.6.1 HAPS

The ITU Radio Regulations define a High Altitude Platform Stations (HAPS) as "a station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth."

A HAPS system consists of a HAPS, several ground stations, and numerous mobile and fixed subscriber stations. Each HAPS deploys a multi-beam antenna capable of projecting numerous spot beams within its coverage area. The HAPS system mobile and fixed subscriber stations for providing IMT-2000 services are planned to be identical to those used with traditional terrestrial IMT-2000 tower-based systems. Links between two HAPS and links between HAPS and HAPS system ground stations

[5] This provision is in accordance with the provision set out in the Deployment Constraints.

will not be in bands designated for IMT-2000 and will utilise non-IMT-2000 frequencies.

3.6.1.1 Core Condition: HAPS Emissions Outside the Area

Including a limit on horizontally radiated power will not be an effective method for limiting out-of-area emissions from a HAPS, due to the fact that HAPS antennas are likely to be pointing downward, with minimal gain in a horizontal direction. Instead an out-of-area power flux density limit was created, consistent with interference management techniques for satellites sharing with adjacent area fixed or mobile services.

The out-of-area limit for HAPS is:

- a co-channel power flux density (pfd) level of -121.5 dB(W/(m^2.1MHz)) on the Earth's surface anywhere outside the HAPS spectrum licensee's area boundary.

This level provides slightly better protection than the level of protection for the notional IMT-2000 base receiver. This pfd level was obtained from the level specified in *ITU-R Rec. M.1456,* 2000 [12] for protecting adjacent national boundaries.

The above mentioned pfd level is a 'provisional' level, subject to ITU studies for reconsideration at WRC-2003. The ACA has reserved the right to review the arrangements for HAPS post WRC-2003 and make any changes necessary in consultation with affected parties.

3.6.1.2 Core Condition: HAPS Emissions Outside the Band

HAPS out-of-band limits are identical to the limits for terrestrial IMT-2000 transmitters.

3.6.1.3 Device Boundary Criteria for HAPS

The Device Boundary concept is not appropriate for HAPS, and thus HAPS transmitters are exempt from the Device Boundary Criteria. The Out-of-Area Core Condition is seen as providing enough protection for adjacent area services. HAPS services would be likely to create an effective emission buffer zone (within their licence area), in order to meet the out-of-area pfd limit.

3.6.1.4 Other Arrangements for HAPS

HAPS transmitters are also required to follow ITU-R Rec. M.1456 (2000) and also pay regard to relevant Advisory Guidelines for 2 GHz Band services. The advisory guidelines may place additional constraints on emission levels above those required by the Core Conditions, due to other adjacent and co-channel services.

4 TECHNICAL LIAISON GROUP OVERVIEW

The Technical Liaison Group was formed to provide technical information to satisfy the requirements for the spectrum licence. The group members were a combination of ACA representatives (Spectrum Marketing Team and Spectrum Planning Team), relevant carrier representatives, product manufacturers and accredited assigners.

The members for this TLG were:

Name	Organisation
Owen Tang	Cable & Wireless Optus
Stephen Howell	Telstra
Stewart Wallace	Telstra
Dominic Arena	Vodafone
Gareth Meir	Vodafone
Robert Owen	Ericsson
Colin Rudolph	Alcatel
Alexander Kulshkin	Lucent
Paul Mundinger	Lucent
Jim Alabasinis	Marconi Australia
Bernie O'Shannassy	Motorola
Michael Hill	Motorola
Suradej Panchavinin	Nokia Networks Australasia
Graeme King	Nortel
John Tsaganas	Nortel
Nick Piscioneri	Nortel
Greg Rose	Qualcomm
Heiko Greiber	Siemens
Mike Whittaker	FuturePace
Joe T	NSW Govt
Geoff Hutchins	ACA - Spectrum Planning Team
Jim Cleaves	ACA - Spectrum Planning Team
Andrew Bull	ACA - Spectrum Planning Team
Gabriel Phillips	ACA - Spectrum Planning Team
Eleanor Kay	ACA - Spectrum Marketing Team

The Spectrum Planning Team prepared and distributed several discussion papers that outlined the technical information that needed to be addressed. These papers were discussed and final values were agreed. The final versions of the discussion papers are attached in Appendix B – Appendix F.

5 REFERENCES

[1] *Radiocommunications (Spectrum Re-allocation) Declaration No. 2 of 2000,* October 2000, http://www.aca.gov.au/legal/spectrum/2ghz/index.htm

[2] Chapter 5 of the Applicant Information Package, *Technical framework, http://auction.aca.gov.au/auction_results/2ghz_results_page/pdf/2ghz_applic.zip*

[3] Radiocommunications Act 1992, *Radiocommunications Act 1992*;

[4] Marketing Plan, *Radiocommunications Spectrum Marketing Plan (2 GHz Band) 2000*, Australian Communications Authority, http://www.aca.gov.au/legal/spectrum/2ghz/index.htm

[5] Section 145, *Radiocommunications (Unacceptable Levels of Interference —2 GHz Band) Determination 2001*, Australian Communications Authority, http://www.aca.gov.au/legal/spectrum/2ghz/index.htm

[6] Radiocommunications Advisory Guideline, *Radiocommunications Advisory Guidelines (Managing Interference from Apparatus-licensed and Class-licensed Transmitters — 2 GHz Band) 2001*, Australian Communications Authority, http://www.aca.gov.au/legal/spectrum/2ghz/index.htm

[7] Radiocommunications Advisory Guideline, *Radiocommunications Advisory Guidelines (Protection of Apparatus-licensed and Class-licensed Receivers — 2 GHz Band) 2001*, Australian Communications Authority, http://www.aca.gov.au/legal/spectrum/2ghz/index.htm

[8] Radiocommunications Advisory Guideline, *Radiocommunications Advisory Guidelines (Registration of Devices under Spectrum Licences without an Interference Impact Certificate) 1998*, Australian Communications Authority, http://www.aca.gov.au/legal/spectrum/2ghz/index.htm

[9] ITU-R Rec M.[IMT.UNWANT], *"Generic Unwanted Emission Characteristics Associated with the Terrestrial Radio Interfaces of IMT-2000"*, Working Party 8F, Report Of The First Meeting Of Working Party 8F, contained in Attachment 9 of Document 8F/2-E, 30 June 2000

[10] Hata/COST-231 Suburban model, ERC Report 68, **"***Monte Carlo Simulation Methodology for the Use in Sharing and Compatibility Studies Between Different Rradio Services or Systems" APPENDIX 1 TO ANNEX 2*, February 2000

[11] Chapter 5 of the 3.4 GHz Applicant Information Package, *Technical framework, http://auction.aca.gov.au/auction_results/3.4ghz_results_page/aip_34.htm*

[12] ITU-R Rec. M.1456, *"Minimum performance characteristics (HAPS) and operational conditions for High Altitude Platform Stations providing IMT-2000 in the bands 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz in Regions 1 and 3 and 1 885-1 980 MHz and 2 110-2 160 MHz in Region 2"*, 2000

APPENDIX A: CHAPTER 5 OF THE 2 GHz APPLICANT INFORMATION PACKAGE

5. TECHNICAL FRAMEWORK

In this Chapter...

- **an explanation of the technical framework underpinning licensing in the 2 GHz band**
- **an explanation of the purpose and operation of the section 145 Determination of Unacceptable Interference**
- **an explanation of the Advisory Guidelines that manage in-band and out-of-band interference with other services**
- **other important information about the technical framework**

Overview

The technical framework for the 2 GHz band has been established by the ACA to primarily support third generation mobile telecommunications services utilising any of the range of ITU designated IMT-2000 systems. It has evolved from the technical frameworks of previous spectrum licence allocations, in particular those for the 800 MHz and 1.8 GHz bands.

The framework seeks to minimise negotiation necessary between adjacent licensees for the management of in-band and out-of-band interference in most circumstances. Nonetheless, spectrum licensees may negotiate among themselves and, where relevant, with apparatus licensees, for alternative management arrangements about emission levels. Spectrum licensees should note, however, that alternative arrangements are not possible unless all affected and potentially affected licensees agree.

Included in these flexibility provisions is a prescribed *Form of Agreement* (included in the *Radiocommunications Spectrum Marketing Plan (2 GHz Band) 2000* at Attachment 3). The *Form of Agreement* provides a template for any agreements that relate to spectrum licensees agreeing to accept emissions that would, in the absence of those agreements, exceed the core conditions of their spectrum licence(s). For example, spectrum licensees might agree alternative arrangements with other licensees for higher levels of emission outside the frequency band of the spectrum licence, or for higher levels of radiated power across a geographic area boundary, than would have otherwise been allowed. Flexibility within the core conditions of licence gives effect to such arrangements between licensees. Applicants are advised to review carefully the arrangements set out for agreements between spectrum licensees, and between spectrum licensees and others, contained in the *Radiocommunications Spectrum Marketing Plan (2 GH Band) 2000***.**

The inherent flexibility of a spectrum licence acquired in this allocation is left for the licensee to determine. This should, however, be based on a careful technical and commercial assessment before the auction, in order to confirm that the desired spectrum space is sufficient to sustain the performance of the network and equipment the bidder desires to operate. The spectrum lots and subsequently issued licences are not pre-designed to accommodate any particular network design. They may accommodate the operation of a particular technology, as well as non-standard equipment, at a particular location and frequency, depending on the size and shape of the licence that a bidder has acquired.

The technical framework is crafted using three regulatory elements:

- licence core conditions, which are mandatory requirements made under the section 66 of the Act;
- a Determination of Unacceptable Interference for the purpose of device registration, made under section 145 of the Act; and
- Radiocommunications Advisory Guidelines made under section 262 of the Act.

The licence core conditions and the determination of unacceptable interference are used to keep significant levels of emission within the spectrum space of the licence. The advisory guidelines provide a framework for the management of interference with specific devices as required, usually associated with apparatus-licensed and class-licensed services operating within the limits of the 2 GHz band and surrounding spectrum.

The technical framework is predicated on the assumption that:

- spectrum and apparatus licensees will employ good engineering practice in establishing and maintaining their services;
- receivers employed by spectrum licensees will, as a minimum, meet the minimum receiver performance levels set out in Schedule 1 of the *Radiocommunications Advisory Guidelines (Managing Interference from Apparatus-licensed and Class-Licensed Transmitters — 2 GHz Band) 2000* (see Attachment 10); and
- spectrum licensees will be responsible for managing interference that they, or authorised third parties, cause to their own services.

The following general principles are pertinent to this technical framework:

- The ACA has attempted to provide maximum flexibility to spectrum licensees to establish services.
- Emission limits have been specified as absolute power levels (in EIRP) rather than power levels relative to transmitter power, allowing licensees to strike a balance between the maximum radiated power of a device and its out-of-band performance.

- The core conditions indirectly specify frequency stability by requiring the emission limits outside the band to be maintained under all conditions. A licensee is able to balance device emission bandwidth against frequency stability, by providing internal 'guard bands' as necessary.
- Spectrum licensees have the responsibility to manage interference that arises within 200 metres of devices registered under their licences.

The interference mechanisms that the technical framework seeks to manage are those caused by:

- unwanted in-band emissions;
- emissions falling outside the frequency band of the licence; and
- intermodulation effects.

These mechanisms are dealt with by a combination of the core conditions relating to out-of-area and out-of-band emissions and those parts of the registration process which give effect to those conditions at the point of registration of devices prior to their operation.

It should be noted that agreements between licensees can only continue to apply while the size and the shape of the spectrum space owned by licensees remain unchanged. Where trading of licences takes place and new boundaries are formed, these agreements will need to be re-negotiated. This re-negotiation can occur at any time, that is, before or after the trade, so that there is no loss of flexibility to licensees.

When trading occurs by means of the division of spectrum space, and agreements are not in place, a check will be required to ensure that devices meet the requirements of the licence within the changed spectrum space.

The comments made within this chapter indicating how the interference management regime might affect proposed services and spectrum utility are not intended to be exhaustive. Potential spectrum licensees are reminded to take such expert technical and other advice necessary to inform themselves of possible effects on their proposed services.

Licence Core Conditions

This part of the chapter explains what the core conditions of the licence are intended to achieve (a sample licence can be found in Schedule 5 of the *Radiocommunications Spectrum Marketing Plan (2 GHz Band) 2000)*, and how the emissions subject to those conditions are further managed under the technical framework.

For each licence, the core conditions set out:

- the geographic area;
- the frequency band;
- the out-of-area emission limits; and

- the out-of-band emission limits.

Geographic area

The geographic area or aggregate of areas within which the operation of radiocommunications devices is authorised by the licence is described in Part 3 of Licence Schedule 1.

Frequency Band

The frequency band of the licence within which the operation of radiocommunications devices is authorised by the licence consists of the contiguous range of frequencies between the upper and lower frequency limit set out in Part 2 of Licence Schedule 1.

Out-of-area emissions

Out-of-area emission limits, through the Determination of Unacceptable Interference, protect geographically adjacent licensees. A fixed transmitter operated under a 2 GHz spectrum licence may be located anywhere in the geographic area of the licence. However, emissions from the transmitter must not cause the radiated powers outside the geographic bounds of the licence to exceed the limit imposed by core conditions 3 to 7 of the licence; as mentioned previously these limits can be extended by agreement with adjacent licensees.

The out-of-area power limit for a terrestrial transmitter in the 2 GHz Lower Band is a radiated power of 45 dBm/30 kHz. The out-of-area power limit for a terrestrial transmitter in the 2 GHz Upper Bands A and B is a radiated power of 55 dBm/30 kHz. In the case of a high altitude platform (HAPS)[7] transmitter, the out-of-area limit is specified as a power flux density (pfd) limit of -136 dB(W /(m^2·30 kHz)) at any point on the earth's surface outside the licence area.

Note that the definition of the out-of-area limit for terrestrial transmitters effectively places a cap on the radiated power of transmitters anywhere in the area of the licence.

An additional layer of out-of-area management is imposed at the point of registration of devices; this is discussed in detail in the later section "Determination of Unacceptable Interference".

Out-of-band emissions

[7] HAPS is a platform located at an altitude of between 20 and 50 km. It is a station recognised by the ITU as permitted within the 2 GHz bands.

Out-of-band emission limits, through the Determination of Unacceptable Interference, protect licensees in adjacent spectrum. Out-of-band emission limits are imposed by core conditions 8 to 15 of the licence. A licensee or accredited person must work out the radiated power of the device within specified bandwidths outside the frequency band of the licence using good engineering practice to establish whether the operation of a device will breach these emission limits, causing 'unacceptable interference'.

Out-of-band emission limits have been expressed in the form of absolute levels, rather than levels relative to the transmitter output power, to allow licensees to operate transmitters with an optimised balance between transmit power and out-of-band emission suppression. These levels may be varied through negotiated agreement with affected adjacent licensees.

If the power calculated is greater than a figure specified in the relevant licence condition, two things follow:

- if the device is not yet registered — the ACA will generally refuse to register it, because the interference that it would cause will be 'unacceptable interference' within the meaning of section 145 of the Act, (unless, for example, all relevant licensees agree alternative arrangements);
- if the device is already registered — there will be a breach of the core licence condition, unless all relevant licensees have agreed to the alternative arrangements.

The limits for out-of-band emissions have been chosen to enable adjacent STU operation for systems located more than 200 metre apart (within this distance additional interference management measures may need to be taken by licensees- see next section).

Other licence conditions

Whilst core conditions go some way to limit interference to adjacent services their primary purpose is to define the spectrum space (geographic and frequency) of the spectrum licence. Some additional protection from interference may be required beyond that provided indirectly through the core conditions. One method of implementing this protection is by including other conditions in the licence.

Interference management at sites

The licence includes a condition requiring the licensee to manage interference within 200 metres of a device operated under this licence. This condition has been included due to the difficulty in specifying emission limits to prevent interference between a large range of services that may operate in close proximity at prime radiocommunications sites.

To manage out-of-band interference, spectrum licensees may for example have to utilise guard bands between licensees, install filters at the edges of their spectrum, and/or negotiate with adjacent licensees either to employ transmitter filtering or avoid placing transmitters near the frequency boundary at certain locations.

Determination of Unacceptable Interference

Before a transmitter can be operated under a spectrum licence its details must be recorded in the register. The ACA may refuse to register a device if the licensee or accredited person cannot show that the requirements deemed to prevent unacceptable interference are met. These requirements are detailed in the relevant determination made by the ACA under section 145 of the Act - the *Radiocommunications (Unacceptable Levels of Interference – 2 GHz Band) Determination 2000* (Attachment 6).

The Determination sets out basic requirements to manage unacceptable levels of interference:

- that the core conditions of the licence are met;
- that specified device boundary criteria are met; and
- that specified device deployment constraints are met; and
- that full details of the transmitter are provided for the register.

Device Boundary Criteria

Before registering a device a licensee or accredited person must, in addition to checking that the core conditions are maintained, calculate the device boundary of the transmitter in accordance with the relevant determination made by the ACA under the *Radiocommunications (Unacceptable Levels of Interference – 2 GHz Band) Determination 2000.* This involves establishing the distance, along radials from the transmitter, that is required for the emission level to drop below a level that is likely to cause interference to receivers in adjacent geographic areas. The distance along each radial is based on a mathematical propagation model. The device boundary method takes account of the terrain loss by adjusting the antenna height of a device according to its height above average terrain, called its effective antenna height. Effective antenna heights are calculated every 5 minutes in distance along each radial. The ACA publishes software tools (RadDEM CD) for calculating tables of effective antenna heights for any location in Australia.

The effect of the device boundary procedure is to create 'buffer zones' of reduced emissions along the geographic boundaries of a licence. It is an important element of the framework because it specifies an exact and direct procedure to determine the allowed maximum radiated power of a transmitter (based on the effective antenna height and distance from the boundary) that cannot be challenged by an adjacent licensee. The direct nature of the limit means that licensees can work closer to the geographic boundary of the licence than otherwise because no reliability margins are required to ensure specified field strengths occurs at a boundary. In addition, licensees can accurately plan for transmitters operated by adjacent spectrum licensees across the area boundary at any time in the future. Also, the device boundary may or may not be based on actual propagation models depending on the outcome required. Additionally, it provides a simple facility for establishing agreements between licensees for sharing spectrum space across area boundaries by employing a single parameter ('S', the 'device boundary scaling parameter', mentioned in the Device Boundary Criteria) which may be varied to expand or contract the device boundary to provide more or less in-band protection respectively.

If the device boundary falls outside the geographic area of the relevant spectrum licence the ACA will, generally speaking, refuse to register the device because the levels of emission outside the licence that it would cause will be ‘unacceptable interference’ within the meaning of section 145 of the Act. An exception to this general rule can be made where there is an agreement in the form prescribed in the *Radiocommunications Spectrum Marketing Plan (2 GHz Bands) 2000.* In these circumstances, the agreement provides that a device boundary may exceed the licence boundary of a licensee because the adjacent licensee has specifically agreed to that and accepts any interference caused to its use of the spectrum.

Under the determination, a device boundary does not need to be established for:

- mobile or indoor fixed transmitters where the radiated power is less than 25 dBm per 30 kHz;
- any fixed transmitter located more than 70 km from any spectrum licence boundary; or
- a HAPS transmitter.

Deployment Constraints

Whilst the two core conditions aimed at emission levels provide some measure of protection from intermodulation effects and other out-of-band interference, the ACA considers it necessary to provide further means of protection to avoid close-range high site-to-high site (base station) interference paths. To this end the licensing framework imposes some constraints on the deployment of transmitters.

It is, however, important to note that the technical framework does not provide any protection from these effects where transmitters are sited within 200 metres of each other. Consequently spectrum licences include a special condition requiring spectrum licensees to come to an arrangement with neighbours in relation to interference in such cases.

The deployment constraints vary from band to band. The constraints are generally expressed in terms of effective antenna height (calculated using the average ground height within approximately 10 kilometres of each device) or through limits on power levels. For a more detailed explanation of effective antenna height, please see the relevant section 145 determination.

For the 2 GHz band, deployment constraints are imposed in the Upper Band A to optimise the deployment opportunities for base receiver stations in this band, and also in the 2 GHz Lower Band to manage potential interference with class-licensed services in the spectrum below 1900 MHz.

Registration of Devices

The ACA will, generally speaking, refuse to register a device whenever it would give rise to levels of emission outside the licence that would be ‘unacceptable interference’ within the meaning of section 145 of the Act.

The ACA has provided for exceptions to this general rule (under the *Radiocommunications Advisory Guidelines (Registration of Devices under Spectrum Licences without an Interference Impact Certificate) 1998*). The exception can be made where it is shown that there is sufficient internal spectrum guard space or where there is an agreement, in the form prescribed in the *Radiocommunications Spectrum Marketing Plan (2 GHz Band) 2000*. In these circumstances, the agreement provides that emissions of a device may exceed the core conditions of a licence because the adjacent licensee has specifically agreed to that, and accepts any interference caused to its use of the spectrum space. Spectrum licensees should take such expert technical and other advice they consider necessary to inform themselves of this aspect of the technical framework.

The corollary of this aspect of interference management is that spectrum licensees must expect that certain levels of emission will legitimately cross their geographic (and spectrum) boundaries from points within other spectrum licensed areas. Accordingly, when considering what services they might establish within their own geographic areas, spectrum licensees should take into account the fact that transmitters may be located at certain points within other spectrum licensed areas. Furthermore, those transmitters may radiate power into the spectrum licensee’s area at any level up to that allowed under the relevant section 145 determination of unacceptable interference, or levels otherwise negotiated with the relevant spectrum licensees.

The ACA recommends that radiocommunications devices are registered at the system design stage. This will enable other licensees, if they wish, to re-check the coordination and if an obvious error is detected, negotiate directly with the spectrum licensee before further costs are incurred when transmitters cannot be operated due to interference. The registration of devices never intended for operation is not recommended because this has the potential to inhibit unnecessarily the operation of adjacent licensees’ devices.

Registering Groups of Transmitters and Receivers

The Determination also sets out the definition of a group of transmitters and a group of receivers for the purpose of simplifying registration of those devices. The Determination specifies how the registration details for a group of transmitters and receivers must be calculated.

Unless exempted, transmitters must always be registered as either an individual transmitter or as part of a group of transmitters. If two or more transmitters are operated for the purpose of communicating with the same receiver or same group of receivers and they have identical emission characteristics, then those transmitters may be treated as a group in order to simplify the registration process. A transmitter may belong to more than one group. Groups are defined to help minimise the work associated with the registration process of similar transmitters. A group of devices may have location details consisting of a centre and an associated effective radius that can take into account the distribution of subscriber transmitters. Mobile and indoor transmitters are exempted from device registration requirements. Licensees may decide whether to register receivers based on a risk assessment of the benefits achieved through coordination to manage out-of-band interference.

Radiocommunications Advisory Guidelines

There are two Radiocommunications Advisory Guidelines made under section 262 of the Act issued by the ACA associated with spectrum licensing of the 2 GHz band. They are:

- *Radiocommunications Advisory Guidelines (Managing Interference from Apparatus and Class-licensed Transmitters—2 GHz band) 2000* (**Attachment 10**); and
- *Radiocommunications Advisory Guidelines (Protection of Apparatus-licensed and Class-licensed Receivers—2 GHz band) 2000* (**Attachment 11**).

These guidelines do not bind licensees or the ACA. This approach has been adopted in order to provide the maximum flexibility for both spectrum and apparatus licensees in how they arrange their affairs so as to avoid interference between services. The ACA is prepared to consider alternative interference management arrangements agreed between spectrum licensees and, where relevant, apparatus licensees. Spectrum licensees should note, however, that the ACA would not give effect to alternative arrangements unless all affected and potentially affected licensees have agreed (subsequent trading of spectrum will affect any agreements made previously).

Licensees who are unable to resolve interference issues between themselves may expect the ACA to have regard to the guidelines in dealing with such disputes.

Managing Interference from Apparatus-licensed and Class-licensed Transmitters

The *Radiocommunications Advisory Guidelines (Managing Interference from Apparatus and Class-licensed Transmitters—2 GHz band) 2000* contains information for spectrum licensees on managing interference from non-spectrum-licensed services.

Only registered receivers will receive protection in the planning of services by the ACA. For the management of interference from out-of-band services, the ACA in this guideline has set out a minimum performance level for receivers in the 2 GHz band and a compatibility requirement for transmitters of apparatus-licensed services. These criteria provide a basis upon which spectrum and apparatus licensees are able to develop procedures for the management of interference between services, using good engineering practice.

Receiver performance. As mentioned previously, licensees will need to take account of the emission limits permitted under the technical framework when deciding the level of performance they require for their receivers. Receivers will cope with emission levels with differing degrees of success, depending on their interference susceptibility. A receiver with poor performance would normally deny large amounts of spectrum space for transmitters in order to protect it from interference. The ACA does not intend to enforce receiver standards. It is for licensees to balance the cost of receiver performance against the cost of spectrum space denied to their transmitters.

Poor receiver performance is only an issue when a licensee attempts to use spectrum space belonging to an adjacent licensee as part of the receiver protection requirement. The framework provides for the operation of receivers that have interference susceptibility commensurate with that achieved by current technology and intends for this level of performance to guide the interference settlement process. Receivers with poor interference susceptibility performance can be used, but in those cases licensees may have to use more of their own spectrum space as guard space. For example, interference that results from a receiver having a RF or IF bandwidth that is larger than the frequency band of the licence will be the licensee's responsibility. It is the licensee's responsibility to use receivers in a manner that is both consistent with good engineering practice and effectively copes with the levels of emissions permitted under the technical framework.

Protecting Apparatus-licensed and Class-licensed Receivers

The *Radiocommunications Advisory Guidelines (Protection of Apparatus-licensed and Class-licensed Receivers—2 GHz band) 2000* contains information for spectrum licensees regarding protection they should provide to non-spectrum-licensed receivers.

These guidelines relate to the protection of receivers of a number of services operating in or near the 2 GHz band, including:

- microwave fixed point-to-point services;
- the mobile satellite service;
- cordless telecommunications services;
- multipoint distribution services; and
- space services.

Interference that the technical framework does not prevent

No matter how rigorous the engineering analysis of a device, there is always a possibility of actual interference when devices are deployed in the field. This is because the technical framework is designed according to certain levels of acceptable interference probability. Under the framework described in this Chapter, it is anticipated that interference between spectrum licensed devices will occur at about the same rate as between apparatus licensed devices, that is, interference will arise in fewer than one percent of cases. Such interference may be caused by emissions at frequencies either inside or outside licensees' spectrum space.

Licensees are strongly advised before making an interference complaint to attempt to locate the source of any interference by checking the Register of Radiocommunications Licences (http://www.aca.gov.au/database/radcomm/index.htm*)*. This investigation may indicate the likely cause of the interference and it may be possible to settle the problem without the ACA's intervention. If the ACA becomes involved, licensees may be charged for any work undertaken.

International co-ordination

The ITU Radio Regulations have international treaty status and are binding on Australia. Transmitters operated under a spectrum licence, other than in accordance with ITU Radio Regulations, must not cause interference to any services of any other country (for example, Papua New Guinea or Indonesia) which are operating in accordance with ITU Radio Regulations. If operation of a transmitter does cause harmful interference to overseas services operating in accordance with ITU Radio Regulations, the transmission must cease. Spectrum licensees must also accept interference from any overseas service operating in accordance with ITU regulations. Spectrum licensees should note that the ACA will impose such additional licence conditions on spectrum licences as may be necessary from time to time to meet Australia's international obligations.

Health and safety

Every spectrum licensee will need to take into account occupational health and safety requirements for radiofrequency devices. Occupational health and safety requirements that concern use of radiofrequency devices are currently the responsibility of State and Territory Governments.

In addition, licensees will be required to comply with any health exposure standards that may be made by the ACA for the health and safety of persons who operate, work on or use radiocommunications transmitters and receivers.

Environmental and other considerations

Antenna siting, height and construction may be regulated by State, Territory or local government legislation. Licensees should investigate the local rules pertaining to the erection of towers and antennas before planning for a device to operate in a certain location.

Obtaining a permit to operate non-standard devices

A licensee who wishes to operate standard devices under a spectrum licence (that is, equipment that conforms to mandatory ACA standards) does not need to apply to the ACA for permission to do so. However, a permit will be required to supply or operate any non-standard devices. These permits may be issued by the ACA under section 167 of the *Radiocommunications Act 1992*, and will only be issued during the term of the licence.

Permits to supply non-standard devices for operation under a spectrum licence may also be issued by the ACA under section 174 of the Act.

APPENDIX B: DISCUSSION PAPER NO. 1

Technical Liaison Group (2 GHz IMT-2000 Bands)

Design Requirements for the Technical Framework for 2 GHz IMT-2000 Bands

DOCUMENT RELEASE INFORMATION

Version	Date Released	Remarks
1	18 July 2000	Initial Release
2	30 August 2000	Updated System Models

1. Background

The Government has announced its intention to auction spectrum in the 2 GHz band suitable for third generation mobile (IMT 2000) services. A discussion paper containing draft Spectrum Re-allocation Declarations for the 2 GHz and 800 MHz bands is being prepared by the ACA. These draft instruments will identify the frequency bands, geographic areas and re-allocation periods proposed by the ACA to be recommended to the Minister.

The ACA has yet to finalise the discussion paper, but it is expected that it will be along the lines of a proposal to recommend to the Minister for Communications, Information Technology and the Arts that he make a spectrum re-allocation declaration that the following 2 GHz spectrum be re-allocated:

- 1900-1920 MHz in all State and Territory capitals;
- 1920-1980 paired with 2110-2170 MHz in Adelaide, Brisbane, Melbourne, Perth and Sydney;
- 1935-1980 paired with 2125-2170 MHz in Canberra, Darwin and Hobart; and
- 1960-1980 MHz paired with 2150-2170 MHz in regional areas, as defined in the draft declaration.

The proposed allocations and related band arrangements are depicted graphically at Attachment 1.

The planning of the technical framework for the 2 GHz band will be based on this draft declaration, along with assumptions on marketing and packaging arrangements that take into account industry submissions received recently in response to ACA discussion papers.

2. Marketing Principles

At this stage, the ACA is inclined to propose auctioning the 2 GHz bands in lots of 5 MHz, with a mixture of paired and unpaired frequency arrangements in accordance with the draft declaration. Conditions may be imposed relating to the minimum or maximum amounts of spectrum able to be obtained; this is however outside the scope of the technical framework planning.

Pairing arrangements, system parameters and interference management rules will be based on an anticipated use of the spectrum by IMT-2000 technologies. The technical framework planning will not consider other types of services, eg. fixed links. The obvious differences in system parameters (eg. duplex splits, bandwidths, out of band emissions) between these two service types make it impractical to have a viable *technical* framework that supports both. However, it will be still be possible for other service types to be accommodated in the 2 GHz spectrum, by way of regulatory provisions in the overall licensing arrangements, specifically by extending the flexibility arrangements in the core conditions[8].

3. STU Bandwidth for Spectrum Licensing

Under spectrum licensing, trading of spectrum is allowed only in multiples of Standard Trading Units (STUs). STUs are defined in terms of both geographic area and frequency bandwidth. In the case of geographic area, STUs are defined in the ACA's Spectrum Map Grid[9]. In the frequency domain, a STU is chosen for each band. STUs for bands currently spectrum licensed or proposed for spectrum licensing are as follows:

Band	**STU**
500 MHz	12.5 kHz
800 MHz	1 MHz
1.8 GHz	2.5 MHz
28/31 GHz	50 MHz
3.4 GHz	250 kHz (with a minimum aggregation of 2.5 MHz)
27 GHz	50 MHz

[8] The core conditions will provide for emissions limits to be waived, with the agreement of all affected parties. This approach recognises the difficulty in seeking to have fixed links (legally) meet the out of band emission limits imposed on spectrum licensees. Amendments along these lines have been made to the 1.8 GHz spectrum licences to facilitate this flexibility.

[9] ***Spectrum map grid*** means the map grid developed by the ACA for Australia, showing cells the sides of which measure 3 degrees of arc, I degree of arc or 5 minutes of arc, published by the ACA, copies of which are available from the ACA.

The STU bandwidth is chosen to reduce the occurrence of receiver intermodulation between adjacent spectrum licences. Licensees have the major responsibility for managing intermodulation interference within their own spectrum space. The STU bandwidth has been used to place a cap on the number of frequency boundaries that are permissible within the spectrum. Very small STU bandwidths, eg. 12.5 kHz at 500 MHz, require more complex deployment constraints to manage receiver intermodulation. Interference still needs to be managed across the frequency boundary and the recorded registered device details of all licensees enable this interference to be managed using coordination procedures.

The TLG has agreed to recommend an STU of 250 kHz for the 2 GHz band, but with a minimum aggregation size of 5 MHz, along similar lines to and for similar reasons as the 3.4 GHz arrangements.

4. *Elements of the Technical Framework*

The technical framework will need to manage:

- emissions across the frequency and geographic boundaries of spectrum licences;
- emissions across the frequency and geographic boundaries of spectrum managed under apparatus licensing and spectrum licensing.

Regarding the second dot point, interference management need to be developed for a number of apparatus licensed services, including:

- Point to point fixed services, including incumbents subject to re-allocation and out of area current and future licences.
- Mobile satellite services.
- Cordless telephone services (DECT/PHS).
- Space services, including deep space uplink bands.

The requirements for the framework will be detailed in appropriate ACA instruments, including in the Marketing Plan, the spectrum licence core conditions, and in unacceptable interference determinations and advisory guidelines made under the *Radiocommunications Act 1992*. Subsequent discussion papers will detail the requirements for and seek industry input on each of these instruments.

5. *Equipment Standards to be considered in establishing the Framework*

There are 4 technologies (in line with ITU-R Draft New Recommendation M.IMT[RSPC]) to be considered in the spectrum licence framework for IMT-2000 Terrestrial Radio :

IMT DS (Direct Spread), widely known as WCDMA	FDD - 2F
IMT MC (Multi Carrier), widely known as cdma2000 (1X and 3X)	FDD - 2F
IMT TC, called UTRA TDD or TD SCDMA	TDD - 1F

IMT SC, called UWC136, widely known as EDGE	FDD - 2F

The DECT technology is also listed in the ITU Recommendation, but is not likely to be used in the 2 GHz band subject to auction.

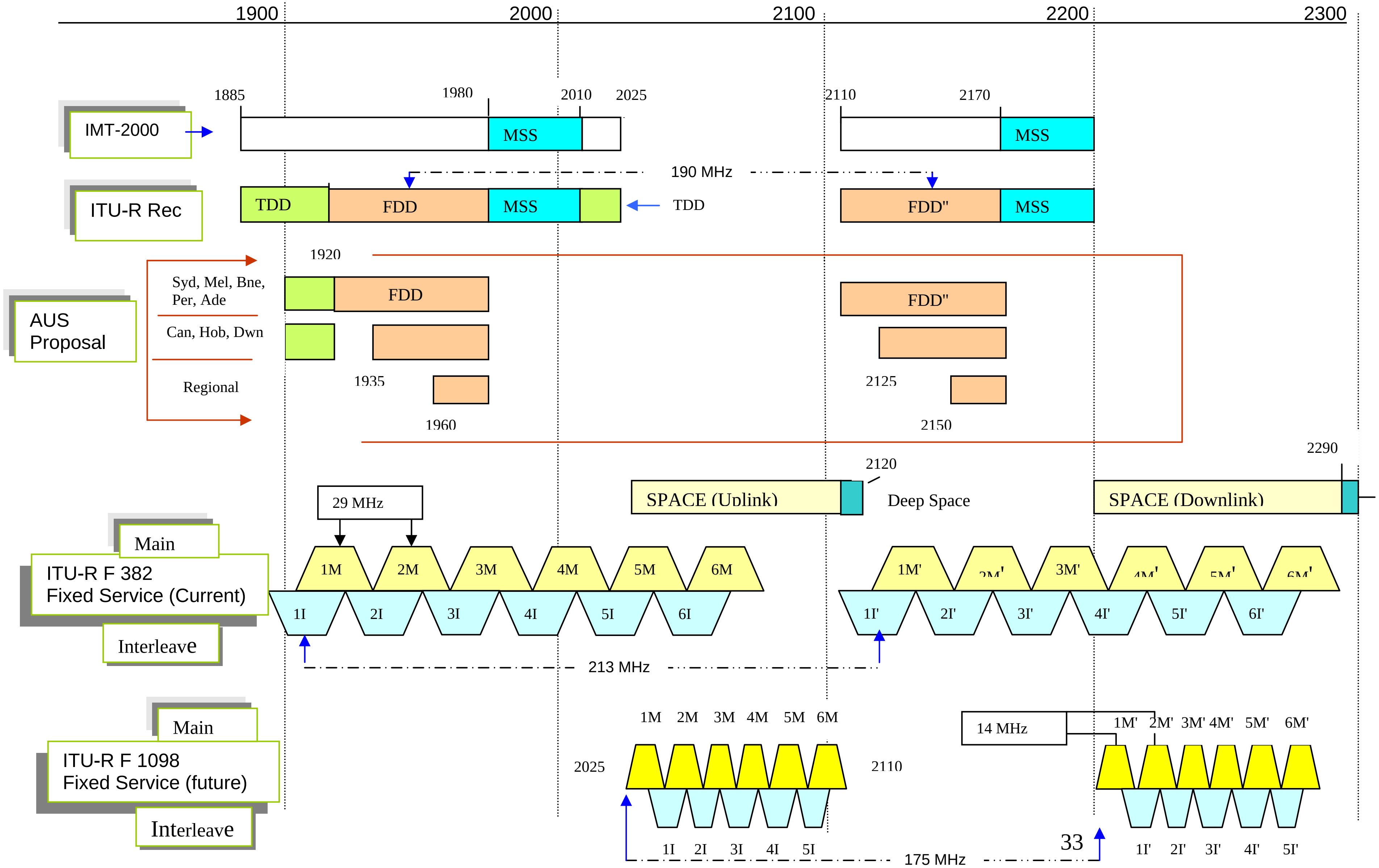
Standards for each of the four IMT-2000 technologies have been developed, and these currently include many key RF parameters. However, some RF parameters are not yet published and the TLG has used other sources for this information.

6. IMT-2000 System Models

Attachment 2 contains system models for each of the IMT-2000 technologies. These system models are an essential part of the Technical Framework, as they are used in developing almost all of the Spectrum Licence technical requirements (out-of-band limits, out-of-area limits, device boundary criteria, etc.).

The Technical Liaison Group has refined these system models, drawing on information from available Standards, manufacturers' data, technology evaluation reports and European studies.

Attachment 1: Proposed Australian 2 GHz IMT2000 Allocations and Related Band Arrangements



Attachment 2: System Models

There are 5 System Models listed below:

- WCDMA
- cdma2000 (1X)
- UWC-136 (EDGE)
- UTRA-TDD
- TD-SCDMA

SYSTEM MODEL -- WCDMA 30-Aug-00

Parameter	Comments	Units	*Base Station*	*Mobile*	Source
Carrier occupied bandwidth	**typical 3-dB bandwidth**	**MHz**	**3.84**	**3.84**	**[IMT.RSPC]**
Tx frequency range			2110-2170	1920-1980	TS 25.104 (3/2000)
Carrier centre freq.	(likely min. separation from 5 MHz edge	MHz	2.5	2.5	TLG
Tx Power	(max.)	dBm	46	33	TLG / 25.101
Tx. Out-of-band emission	as Adjacent Channel Leakage Ratio				
attenuation in ch @ 5 MHz	(ACLR)	dB	45	33	TS 25.104 / 25.101
attenuation in ch @ 10 MHz		dB	50	43	TS 25.104 / 25.101
Tx emission mask	see standards for specified Tx RF emissions mask				TS 25.104 / 25.101
Ant Gain (incl. Feeder loss)	max. gain sectoral antenna	dBi	19	0	TLG
Tx EIRP per 30 kHz	**(maximum / worst case)**	**dBm**	**44**	**12**	**calculated**
Noise Figure		dB	5	9	ERC Report 65
Interference Margin	(CDMA loading: 3dB-heavy, 0dB-light)	dB	0	0	assumed
Interference Threshold	(noise floor =kTBF)	dBm	-103	-99	calc. noise floor
Int. Threshold per 30 kHz	**(conversion only)**	**dBm**	**-124**	**-120**	**calculated**
Target Eb/No		dB	5.6	7.5	IEE journal
Processing gain	(high data rate - to - low data rate)	dB	3 to 24	3 to 24	UMTS Eval. report
Rx Sensitivity		dBm	-121	-117 dBm	TS 25.104 / 25.101
Rx Blocking Level	(at 10 MHz offset)	dBm	-40	-56	TS 25.104 / 25.101
Rx Blocking Level	(at 15 MHz offset)	dBm	-40	-44	TS 25.104 / 25.101
Adjacent Channel Selectivity					
@ channel + 1 (5MHz)		dB	45	33	[IMT.RSPC]
Cell radius	typical rural	km	19		TLG
	maximum rural	km	70		TLG

SYSTEM MODEL -- WCDMA 17-Jul-00

IMT-DS [WCDMA-FDD]	Units	*Base Station*	*Mobile*	Source
Typical carrier occ. Bandwidth	MHz	3.84	3.84	[RSPC]
Tx frequency		2110-2170	1920-1980	TS 25.104 (3/2000)
Tx Power	dBm	41 dBm [erc65]	30 dBm	UMTS Evaluation report
Adj. Channel Leakage (ACLR)				
attenuation in ch @ 5 MHz	dB	45	33	[RSPC]
attenuation in ch @ 10 MHz	dB	50	43	[RSPC]
Tx Power control		not considered	not considered	
Ant Gain (incl. Feeder loss)	dBi	14.5	0	ERC Report 65
Antenna diversity	not considered, as not always used			
C/I	dB	assume 0	assume 0	
Rx Sensitivity	dBm	-121	-118 dBm	TS 25.104 (3/2000)
Rx Noise Figure	dB	5		ERC Report 65
Interference Threshold	dBm	-103	-99	ERC Report 65
(maybe 20% of the time?)				
Min. Processing gain	dB	3	3	UMTS Evaluation report
Rx Blocking Level (@ 10MHz)	dBm	-40	-44	25.104/[RKEY]
Adjacent Channel Selectivity				
@ channel + 1 (5MHz)	dB	45	33	[RSPC]

SYSTEM MODEL -- cdma2000 (1X) FDD 30-Aug-00

Parameter	Comments	Units	*Base Station*	*Mobile*	Source
Carrier occupied bandwidth	**typical 3-dB bandwidth**	**MHz**	**1.25**	**1.25**	**[IMT.RSPC]**
Tx frequency range			2110-2170	1920-1980	
Carrier centre freq.	(likely min. separation from 5 MHz edge	MHz	1.25	1.25	TLG
Tx Power	(max.)	dBm	45	33	TLG / TIA-98-C
Tx. Out-of-band emission	Adjacent Channel Leakage Ratio				
attenuation @ 5 MHz	(ACLR)	dB	40-55	30-40 dBc	[IMT.RKEY]
attenuation @ 10 MHz		dB	50-65	40-50 dBc	[IMT.RKEY]
Tx emission mask			see TIA-97B & 97C	see [IMT.UNWANT]	
Ant Gain (incl. Feeder loss)	max. gain sectoral antenna	dBi	19	0	TLG
Tx EIRP per 30 kHz	**(maximum / worst case)**	**dBm**	**47.8**	**16.8**	**calculated**
Noise Figure		dB	4	8	IS-95
Interference Margin	(CDMA loading: 3dB-heavy, 0dB-light)	dB	0	0	IS-95
Interference Threshold	(noise floor =kTBF)	dBm	-108	-104	calc. noise floor
Int. Threshold per 30 kHz	**(conversion only)**	**dBm**	**-124**	**-120**	**calculated**
Required Ec/Io	(downlink Ec/Io)	dB	-3	-3	IS-95
Processing Gain	(high data rate - to - low data rate)	dB	1 to 20	1 to 20	assumed
Rx Sensitivity		dBm	-119	-113	TIA-97-C / IS-95
Rx Blocking Level	(up to 15 MHz)	dBm	not spec.	-44	[IMT.RKEY]
Adjacent Channel Selectivity					
@ channel + 1		dB	64	15.6	TIA-97-C / [IMT.RKEY]
Cell radius	typical rural	km	-	-	
	maximum rural	km	-	-	

SYSTEM MODEL -- UWC-136 HS Outdoor (EDGE) 30-Aug-00

Parameter	Comments	Units	*Base Station*	*Mobile*	Source
Carrier occupied bandwidth	**typical 3-dB bandwidth**		**200 kHz**	**200 kHz**	**TIA-136-290 [1900]**
			[1.6 MHz for indoor]	[1.6 MHz for indoor]	[IMT.RSPC]
Tx frequency range			2110-2170	1920-1980	
Carrier centre freq.	(likely min. separation from 5 MHz edge	MHz	0.2	0.2	TIA-136-110 [2GHz)
Tx Power	(max.)	dBm	43	30	TIA-136-290 [1900]
Tx. Out-of-band emission	Adjacent Channel Leakage Ratio				
attenuation in ch @ 200 kHz	(ACLR)	dB	30	30	TIA-136-290 [1900]
attenuation in ch @ 400 kHz		dB	56	54	TIA-136-290 [1900]
Ant Gain (incl. Feeder loss)	max. gain sectoral antenna	dBi	19	0	TIA-136-290 [1900]
Tx EIRP per 30 kHz	**(maximum / worst case)**	**dBm**	**53.8**	**21.8**	**calculated**
Required C/I			**	**	TIA-136-290 [1900]
Rx Sensitivity		dBm	-102	-102	TIA-136-290 [1900]
Interference Threshold		dBm	-99.5	-99.5	TIA-136-290 [1900]
Int. Threshold per 30 kHz	**(conversion only)**	**dBm**	**-107.7**	**-107.7**	**calculated**
Rx Blocking Level	(@600kHz)	dBm	-43	-43	TIA-136-290 [1900]
Rx Blocking Level	(above 3MHz)	dBm	-33	-26	TIA-136-290 [1900]
Adjacent Channel Selectivity					
@ channel +1	(for 1.7 MHz carrier)	dB	not spec.	-23	[IMT.RKEY]
@ channel + 2		dB	not spec.	-44	[IMT.RKEY]

** C/I ratios were specified in 6.3 Table 1a, at a maximum of 24.5 dB for a -75 dBm wanted signal.
This results in an Interference level of -99.5 dBm

SYSTEM MODEL -- UTRA-TDD 30-Aug-00

Parameter	Comments	Units	*Base Station*	*Mobile*	Source
Carrier occupied bandwidth	**typical 3-dB bandwidth**	**MHz**	**3.84**	**3.84**	**TS 25.105 / 25.102**
Tx frequency range			1900-1920 & 2010-2025	1900-1920 & 2010-2025	
Carrier centre freq.	(likely min. separation from 5 MHz edge	MHz	2.5	2.5	TLG
Tx Power	(max.)	dBm	43	24	assumed / 25.102
Tx. Out-of-band emission	Adjacent Channel Leakage Ratio				
attenuation in ch @ 5 MHz	(ACLR)	dB	45 or 70*	33	TS 25.105 / 25.102
attenuation in ch @ 10 MHz		dB	55 or 70*	43	TS 25.105 / 25.102
Tx emission mask	(see p15 of standard)				TS 25.105 / 25.102
Ant Gain (incl. Feeder loss)	max. gain sectoral antenna	dBi	19	0	erc65
Tx EIRP per 30 kHz	**(maximum / worst case)**	**dBm**	**41**	**3**	
Interference Margin	(CDMA loading: 3dB-heavy, 0dB-light)	dB	0	0	assumed
Interference Threshold	(noise floor =kTBF)	dBm	-103	-99	calc. noise floor
Int. Threshold per 30 kHz	**(conversion only)**	**dBm**	**-124**	**-120**	**calculated**
Required C/N		dB	6	not spec.	assumed from 25.105
Processing gain	(high data rate - to - low data rate)	dB	3 to 25	3 to 25	UMTS Eval. report
Rx Sensitivity		dBm	-109	-105	TS 25.105 / 25.102
Rx Blocking Level	(at > 10 MHz)	dBm	-40	-56	TS 25.105 / 25.102
Adjacent Channel Selectivity					
@ channel + 1		dB	45	33	[IMT.RSPC] / 25.102
Cell radius		km	3.75		TLG

* 70 dB ACLR is for when TDD BS is operated in proximity to another TDD BS, or an FDD BS on an adjacent frequency.

SYSTEM MODEL -- TD-SCDMA (TDD) 30-Aug-00

Parameter	Comments	Units	*Base Station*	*Mobile*	Source
Typical carrier occ. Bandwidth	**typical 3-dB bandwidth**	**MHz**	**1.6**	**1.6**	**TS C402/401 (v3.0)**
Tx frequency range			Any IMT band	Any IMT band	
Carrier centre freq.	(likely min. separation from 5 MHz edge	MHz	1	1	TLG
Tx Power	(max.)	dBm	43	33	assumed / TS C401
Tx. Out-of-band emission	Adjacent Channel Leakage Ratio				
attenuation in ch @ 1.6 MHz	(ACLR)	dB	40	33	TS C402/401 (v3.0)
attenuation in ch @ 3.2 MHz		dB	50	43	TS C402/401 (v3.0)
Tx emission mask					TLG
'Out-of-block' attenuation	up to 1.6 MHz offset from carrier	dB	59		TS C402/401 (v3.0)
Ant Gain (incl. Feeder loss)		dBi	19	0	erc65
Tx EIRP per 30 kHz	**(maximum / worst case)**	**dBm**	**44.7**	**15.7**	**calculated**
Interference Margin	(accounts for CDMA loading)	dB	not used	not used	(worst case)
Interference Threshold	(noise floor =kTBF)	dBm	-107	-103	calc. noise floor
Int. Threshold per 30 kHz	**(conversion only)**	**dBm**	**-124**	**-120**	**calculated**
Required C/I	(from Eb/Io for 384 kpbs)		9	10	TS C402/401 (v3.0)
Processing gain		dB			
Rx Sensitivity		dBm	-110	-105	TS C402/401 (v3.0)
Rx Blocking Level	(@ > 3.2 MHz)	dBm	-40	-56	TS C402/401 (v3.0)
Rx Blocking Level	(@ > 5 MHz)		-40	-44	TS C402/401 (v3.0)
Adjacent Channel Selectivity					
@ channel + 1		dB	45	33	[IMT.RSPC] / TS C401
Cell radius	maximum	km	11.25		TLG

APPENDIX C: DISCUSSION PAPER NO. 2

Technical Liaison Group (2 GHz IMT-2000 Bands)

- **Core Condition (Emission Limit Outside the Area)**
- **Core Condition (Emission Limits Outside the Band)**
- **Propagation Models**
- **Core Conditions for HAPS**

DOCUMENT RELEASE INFORMATION

Version	Date Released	Remarks
1	19 July 2000	Initial Release
2	5 September 2000	Updated emission limits -- both Out-of-Area and Out-of-Band. Material on accommodation of HAPS also included.

1. Introduction

A complete interference management framework for spectrum licensing needs to manage:

1. in-band (co-channel) interference across the geographic boundaries of spectrum licences; and

2. out-of-band interference across the frequency boundaries of licences.

Interference is managed by creating emission buffer zones along the geographic and frequency boundaries of the licence using a number of tools and conditions provided in the Radiocommunications Act. These are:

- the core conditions (s.66)

    - emission limit (outside the area)

    - emission limit (outside the band)

- the s.145 Determination of unacceptable interference.

This paper discusses the core conditions, including both out-of-area and out-of-band emission limits.

2. Emissions Outside the Area

Emissions that fall outside the geographic area of a spectrum licence - due to a fixed transmitter operating under the licence - are limited by **Core Conditions** that specify a maximum horizontally radiated power. These conditions place an overall cap on power at the boundary of a licence and effectively limit in practice the power able to be used within the area.

As well as these Core Conditions, additional layers of management are specified in the s.145 Determination (*Unacceptable levels of Interference)*, the most important being the **Device Boundary Criteria**. Before registering a device a licensee or accredited person must, in addition to checking that the core conditions are maintained, calculate the device boundary of the transmitter. The Device Boundary Criteria effectively sets up an emission buffer zone at the geographic border of a spectrum licence. The Device Boundary criteria (and boundary calculation method) for the 2 GHz Band will be proposed later in a further Discussion Paper.

Mobile handsets are exempt from the Device Boundary criteria, as they do not have a fixed geographic location. However, another part of the s.145 determination limits the emissions from a mobile transmitter to a level considerably lower than out-of-area limits for fixed base stations.

The effect of these two layers of management is to create ‘emission buffer zones’ along the geographic boundaries of the licences.

The corollary of this aspect of interference management is that spectrum licensees must expect that certain levels of emission will legitimately cross their geographic boundaries from points within other spectrum licensed areas. Accordingly, when considering what services they might establish within their own geographic areas, spectrum licensees will have to take into account the fact that transmitters may be located at certain points within other spectrum licensed areas. Additionally, those transmitters may radiate power into the spectrum licensee’s area at any level up to that allowed under the relevant s.145 determination of unacceptable interference.

2.1 Proposed Emission Limits Outside the Area

The proposed FDD limit (for paired spectrum) aims to accommodate all IMT-2000 technologies and is a horizontally radiated power of **55.0[10] dBm EIRP per 30 kHz.** The highest power (worst-case) technology accommodated is UWC-136HS Outdoor (EDGE), with a maximum base station transmit power of 43 dBm per 200 kHz, with a 19 dBi antenna gain (including feeder loss). This limit allows for possible high power transmitters in the future, for example a 120 W cdma2000/1X base station with a high gain 20 dBi sectoral antenna. This type of allowance is important for regional areas in Australia.

[10] Editors note: The original document was in error and stated this number as 550. The correct number has been used.

This cap is an absolute maximum and in practice, the emission levels may be further reduced by either the device boundary criteria or device specific coordination requirements that protect frequency-adjacent or area-adjacent apparatus licensed devices. It should also be noted that for some technologies, transmitters close to this EIRP limit may find it difficult to meet the Out-of-Band limits (see next section) without additional filtering.

The proposed TDD limit (for unpaired spectrum) aims to accommodate all IMT-2000 TDD technologies and is a horizontally radiated power of **45 dBm EIRP per 30 kHz.** This lower TDD limit accommodates the two IMT-2000 TDD technologies and also provides some necessary protection against adjacent band blocking (TDD base to TDD mobile).

The arrangements for High Altitude Platform Stations (HAPS), including a proposed emission limit outside the area are detailed in Section 5 of this paper.

3. Emissions Outside the Band

These limit emissions outside the frequency boundary of a Spectrum Licence. The limits create an emission buffer zone along the frequency boundaries of spectrum licences and maintain equitable spectrum access between licences.

The emission limits outside the band allow potential licensees to assess the value of spectrum with regard to:

- the levels of in-band interference that will be received from devices operated under frequency-adjacent spectrum licences; and
- the requirement for either guard bands or transmitter filters for the operation of specific devices.

When there is also interference to be managed between specific apparatus licensed devices (eg. fixed services in adjacent bands) and devices operated under spectrum licences, compatibility requirements based on target grades of service will be published by the ACA as **advisory guidelines** under s.262. These guidelines are being developed and will be presented to the Technical Liaison Group in later Discussion Papers. The advisory guidelines may place additional constraints on emission levels above those required by the emission limits outside the band.

3.1 Classes of Unwanted Emissions (outside the band)

For spectrum licensing, unwanted emissions outside the frequency band of a spectrum licence are classified as:

- non-spurious emissions;
- spurious emissions; or
- transient emissions.

Non-spurious unwanted emissions means emissions that are modulation or intermodulation products caused by transmitted information, or broadband/phase noise.

Spurious emission is any other type of emission outside the frequency boundary of a spectrum licence, including intermodulation products not caused by transmitted information, frequency conversion products, harmonics, products from instabilities introduced by the modulation process and parasitic products.

Transient emissions are typically due to switching transients.

3.2 Method for Managing Unwanted Emissions (outside the band)

Unwanted emissions are managed by establishing a number of different limits that each manages a particular type of unwanted emission. These limits take account of the IMT-2000 technologies likely to be used in Australia. In taking account of each of the IMT-2000 services, it is important not to penalise one service at the expense of another by requiring a large frequency separation from the upper or lower limit of a spectrum licence (or transmitter filtering), which could be unreasonable when compared with their relative in-band spectrum efficiency.

Limits in core conditions of Spectrum Licences are expressed in terms of radiated power. This requirement makes sense because it both sets emission limits for devices with respect to their interference potential and maximises flexibility for spectrum use.

The following arrangements for managing out-of-band interference also apply to High Altitude Platform Stations (HAPS), as mentioned later in Section 5 of this paper.

3.3 Managing Non-spurious Unwanted Emissions

The management of non-spurious unwanted emissions requires limits to manage:

- unwanted modulation products (similar to the adjacent channel power limit specified in equipment standards); and
- transmitter sideband noise (if not dominated by unwanted modulation products) and broadband/phase noise.

The limits are established by paying regard to:

- the applicable standards for, and the actual emission spectra of known equipment;
- antenna gain vs. frequency response; and
- the total radiated power.

Measurement Unit Definitions

A 30 kHz rectangular (or noise) bandwidth is used for specifying broadband unwanted emission limits because it is narrow enough to resolve the roll-off rate of those emissions and because it is a clear definition for legal purposes. The limit within this measurement bandwidth is specified in maximum true mean power.

The definition of **maximum true mean power** was introduced in the development of spectrum licensing to cover all types of modulation processes. Maximum true mean power means the maximum of any *true mean power* measured in a rectangular bandwidth that is located within a specified frequency band. The power within a specified rectangular bandwidth is normally established by taking measurements using either a measuring receiver or a spectrum analyser. The accuracy of measuring equipment, measurement procedure and any corrections to measurements necessary to take account of practical filter shape factors and spectrum analyser response would normally be made in accordance with good engineering practice.

True mean power means:

(a) for an unmodulated carrier - the *mean power* measured while the unmodulated carrier is present; and

(b) for a modulated carrier - the *mean power* measured while transmitted information is present.

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

Establishing the Limits

Because the unwanted emission characteristics of TDMA and wideband CDMA are different, a compromise is made in setting emission limits outside the band to accommodate all technologies. The limits are specified for frequency offsets measured with respect to the frequency band limits of a particular spectrum licence and do not vary with respect to the occupied bandwidth of a transmitter's emission. There is only one set of limits.

For **non-spurious unwanted emissions** using a measurement bandwidth (rectangular) of 30 kHz, the proposed limits for frequencies outside the frequency band of a spectrum licence and measured from the frequency boundary (band edge) of a particular spectrum licence are:

1. *for transmitters in paired (FDD) spectrum:*

- a maximum true mean power of **12.0 dBm[11] EIRP** for frequency offsets of 0 kHz to 750 kHz; and

- a maximum true mean power of **2.0 dBm[1] EIRP** for frequency offsets of 750 kHz to 1 MHz; and

[11] The FDD out-of-band limits between 0 and 1 MHz have been raised significantly from version 1 of this Paper, in order to accommodate cdma2000/1X base station emissions.

- a maximum true mean power of **-9.0 dBm EIRP** for frequency offsets of 1 MHz to 5 MHz; and

- a maximum true mean power of **-16.0 dBm EIRP** for frequency offsets greater than 5 MHz.

2. *for transmitters in unpaired (TDD) spectrum and in spectrum at the paired/unpaired (FDD/TDD) boundary:*

- a maximum true mean power of **4.0 dBm EIRP** for frequency offsets of 0 kHz to 400 kHz; and

- a maximum true mean power of **-16.0 dBm EIRP** for frequency offsets of 400 kHz to 5 MHz; and

- a maximum true mean power of **-25.0 dBm EIRP** for frequency offsets greater than 5 MHz.

3. *for transmitters in spectrum at the unpaired/PHS (TDD/PHS) boundary:*

- a maximum true mean power of **-16.0[12] dBm EIRP** for frequency offsets of 0 kHz to 400 kHz; and

- a maximum true mean power of **-20.0[2] dBm EIRP** for frequency offsets of 400 kHz to 1 MHz; and

- a maximum true mean power of **-30.0[2] dBm EIRP** for frequency offsets greater than 1 MHz.

A (worst case, including feeder loss) 19 dBi base station antenna gain is used to develop all the above EIRP limits. These emission limits for non-spurious unwanted emissions are illustrated in graphs in Attachment B, including comparison with other emission masks.

At the **unpaired/PHS spectrum boundary**, a very strict out-of-band requirement is proposed, in order to minimise the chance of TDD mobiles and base stations causing excessive out-of-band interference to uncoordinated PHS base stations. Systems in unpaired (TDD) spectrum adjacent to the PHS boundary (at 1900 MHz) will need to take care to ensure that mobiles also meet the strict out-of-band limits for this particular spectrum lot.

An in-band limit for mobiles is also imposed at the unpaired/PHS boundary, for 500 kHz adjacent to the boundary (see Attachment B). This limit is seen as necessary to minimise blocking of PHS base station channels closer (in frequency) to the 1900 MHz boundary, whenever a TDD mobile is in close proximity. The in-band limit will be specified in the s.145 Determination (Unacceptable Levels of Interference), not in the Core Conditions which manage out-of-band and out-of-area emissions.

[12] Limits at the TDD/PHS boundary have been reduced to a very strict level, as explained in the text. Higher power class TDD mobiles may find it difficult to meet out-of-band requirements in this spectrum lot.

To assist in developing the above limits, ITU-R Rec M.[IMT.UNWANT] "Generic Unwanted Emission Characteristics Associated with the Terrestrial Radio Interfaces of IMT-2000" has been considered. Unfortunately, this Recommendation only describes mobile units, not base stations, so more detailed individual standards and manufacturers data needed to be considered. The TLG used a variety of sources (standards, technical studies, manufacturers reports) to determine base station transmitter emission masks for the IMT-2000 technologies.

The set of limits proposed endeavours to provide equitable access to spectrum for the range of IMT-2000 technologies. In some less typical carrier configurations, additional transmit filtering may be required for both compliance with the emission limits outside the band and extraction of maximum utility from a spectrum licence. This may also be the case for some high powered transmitters with a maximum power close to the 55 dBm/30 kHz EIRP (out-of-area) limit.

3.4 Managing Spurious Unwanted Emissions

Spurious unwanted emission limits need to be specified in radiated power in the spectrum licensing framework. Therefore, the maximum gain of the antenna (less minimum combiner and feeder loss) needs to be added to the limits specified at the antenna connector for emissions at frequencies that are within the antenna's 0 dBi bandwidth. The bandwidth for 0 dBi gain of antennas at 2 GHz is from 1 GHz to 3.7 GHz. For spurious unwanted emissions using a measurement bandwidth (rectangular) of 100 kHz (unless otherwise noted), the proposed limits for frequencies outside the frequency band of a spectrum licence are:

- for transmitters:
    - measured at frequencies from 9 kHz to 150 kHz, a mean power of **-36 dBm EIRP** using a measurement bandwidth of 1 kHz; and
    - measured at frequencies from 150 kHz to 30 MHz, a mean power of **-36 dBm EIRP** using a measurement bandwidth of 10 kHz; and
    - measured at frequencies from 30 MHz to 1 GHz, a mean power of **-36 dBm EIRP;** and
    - measured at frequencies from 1 GHz to 3.7 GHz, a mean power of **-11 dBm EIRP;** and
    - measured at frequencies from 3.7 GHz to 12.75 GHz, a mean power of **-30 dBm EIRP.**
- for receivers (as receivers radiate low-level emissions):
    - measured at frequencies from 9 kHz to 1 GHz, a mean power of **-57 dBm EIRP;** and
    - measured at frequencies from 1 GHz to 3.7 GHz, a mean power of **-23 dBm EIRP;** and
    - measured at frequencies from 3.7 GHz to 12.75 GHz, a mean power of **-47 dBm EIRP.**

Higher limits do not appear to be necessary for subscriber units based on information available at this time.

3.5 Managing Transient Emissions

Switching transients are managed (or kept within a licensees spectrum space) by specifying a peak power emission limit close outside the band edge of the spectrum licence.

For transient unwanted emissions using a measurement bandwidth (rectangular) of 300 kHz, the proposed limits for all transmitters for frequencies outside the frequency band of a spectrum licence are:

- a peak power of **[25] dBm EIRP** for frequency offsets of 200 kHz to 500 kHz.

Peak power means the average power during one radio frequency cycle at the crest of the signal envelope.

Equipment manufacturers [*TDMA especially*] should ensure that this limit is consistent with the guard bandwidth required to satisfy the steady-state mean power requirement above and advise the TLG of any significant inconsistency.

4. Propagation Models

In developing the Device Boundary Criteria (to be presented in a later Discussion Paper), and other sharing issues, a propagation model needs to be selected which meets the following criteria:

- is suitable for cellular mobile applications at 2 GHz;
- is a 'generic' model, not requiring detailed terrain information; and
- is simple enough to incorporate easily in specified Device Boundary calculations, resulting in minimal effort for the person registering the device.

Propagation models were presented in an earlier version of this paper, but now the discussion and models are contained in Discussion Paper #3 (version 2). The revised Discussion Paper #3 recommends including an extended Hata Suburban model in the Device Boundary Criteria.

A comparison of popular models for a typical 2 GHz mobile case is shown in Attachment A.

5. Arrangement for HAPS

High Altitude Platform stations are defined in the ITU Radio Regulations as "a station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth."

A HAPS system consists of a HAPS, several ground stations, and numerous mobile and fixed subscriber stations. Each HAPS deploys a multibeam antenna capable of projecting numerous spot beams within its coverage area. The HAPS system mobile and fixed subscriber stations for providing IMT-2000 services are planned to be identical to those used with traditional terrestrial IMT-2000 tower-based systems. Links between two HAPS and links between HAPS and HAPS system ground stations will not be in bands designated for IMT-2000 and will utilise non-IMT-2000 frequencies. HAPS may offer a new means of providing IMT-2000 with minimal ground network infrastructure.

5.1 Core Condition: HAPS Emissions Outside the Area

The horizontally radiated power limit to reduce out-of-area emissions is not relevant to HAPS, due to the fact that HAPS antennas are likely to be pointing downward, with minimal gain in a horizontal direction. Instead a power flux density limit is proposed, consistent with interference management techniques for satellites sharing with adjacent area fixed or mobile services.

The proposed out-of-area limit for HAPS is:

- a co-channel power flux density (pfd) level of -121.5 dB(W/(m^2.1MHz)) on the Earth's surface anywhere outside the HAPS spectrum licensee's area boundary.

This level provides slightly better protection than the level of protection for the notional IMT-2000 base receiver (specified in Discussion Paper #5). This pfd level is specified in ITU-R Rec. M.1456[13] for protecting adjacent national boundaries. The level is a 'provisional' level, subject to ITU studies for reconsideration at WRC-2003. The ACA will reserve the right to review the arrangements for HAPS post WRC-2003 and make any changes necessary in consultation with affected parties.

5.2 Core Condition: HAPS Emissions Outside the Band

HAPS out-of-band limits are proposed as being identical to the limits for terrestrial IMT-2000 transmitters. (see section 3 of this paper)

5.3 Device Boundary Criteria for HAPS

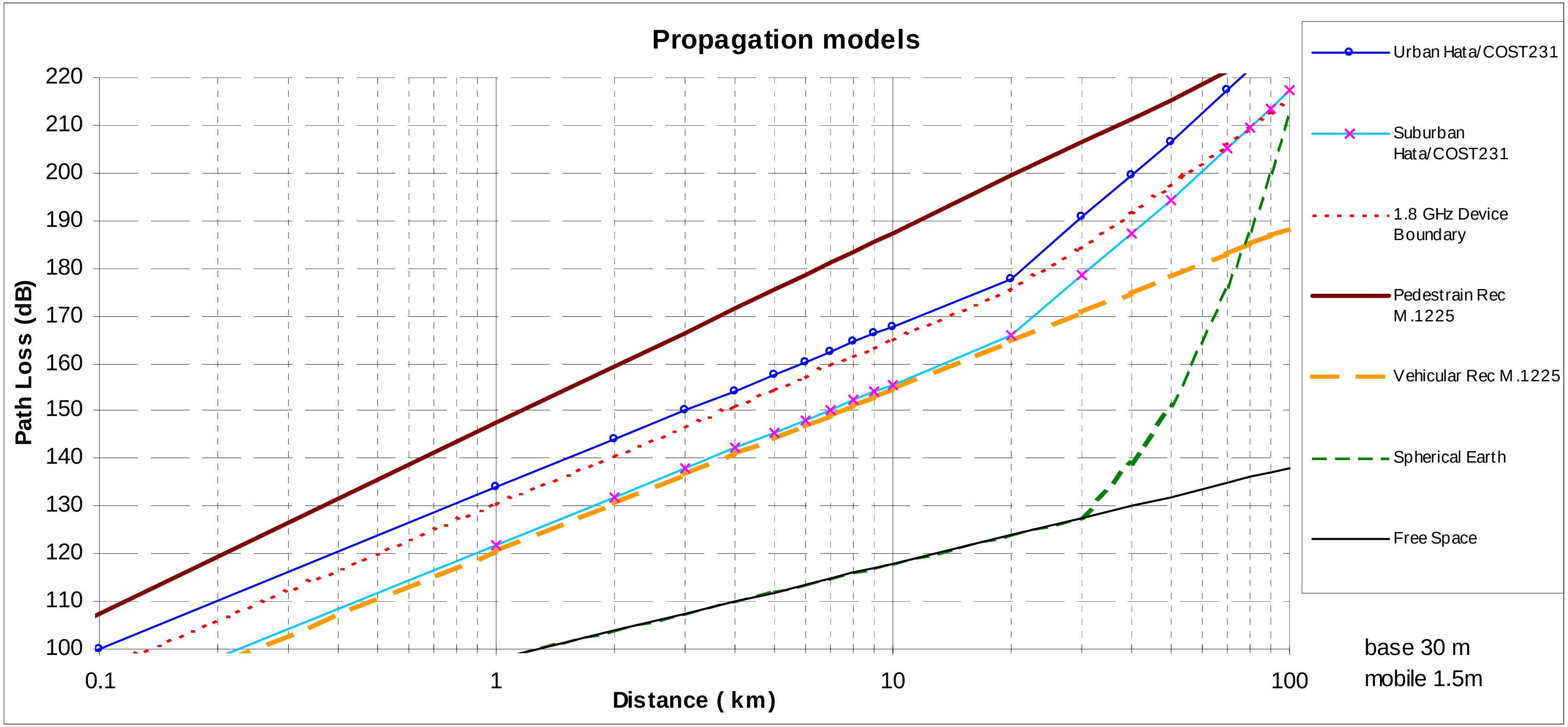
The Device Boundary concept is not appropriate for HAPS, and thus HAPS transmitters are exempt from the Device Boundary Criteria. The Out-of-Area Core Condition is seen as enough protection for adjacent area services. HAPS services would be likely to create an effective emission buffer zone (within their licence area), in order to meet the out-of-area pfd limit.

5.4 Other Arrangements for HAPS

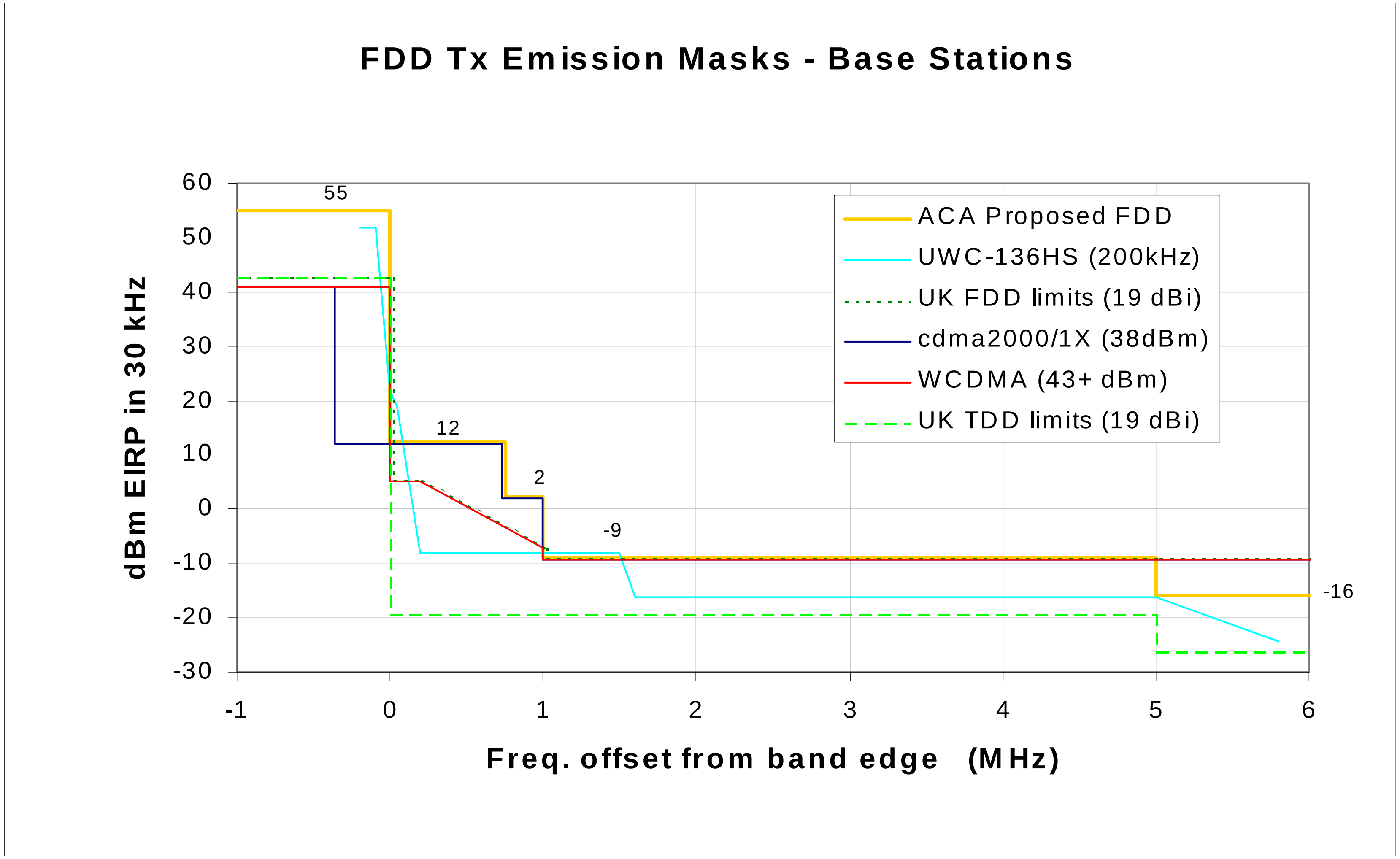
HAPS transmitters will also be required to follow ITU-R Rec. M.1456 and also pay regard to relevant Advisory Guidelines for 2 GHz Band services. The advisory guidelines may place additional constraints on emission levels above those required by the Core Conditions, and are detailed in Discussion Paper #4.

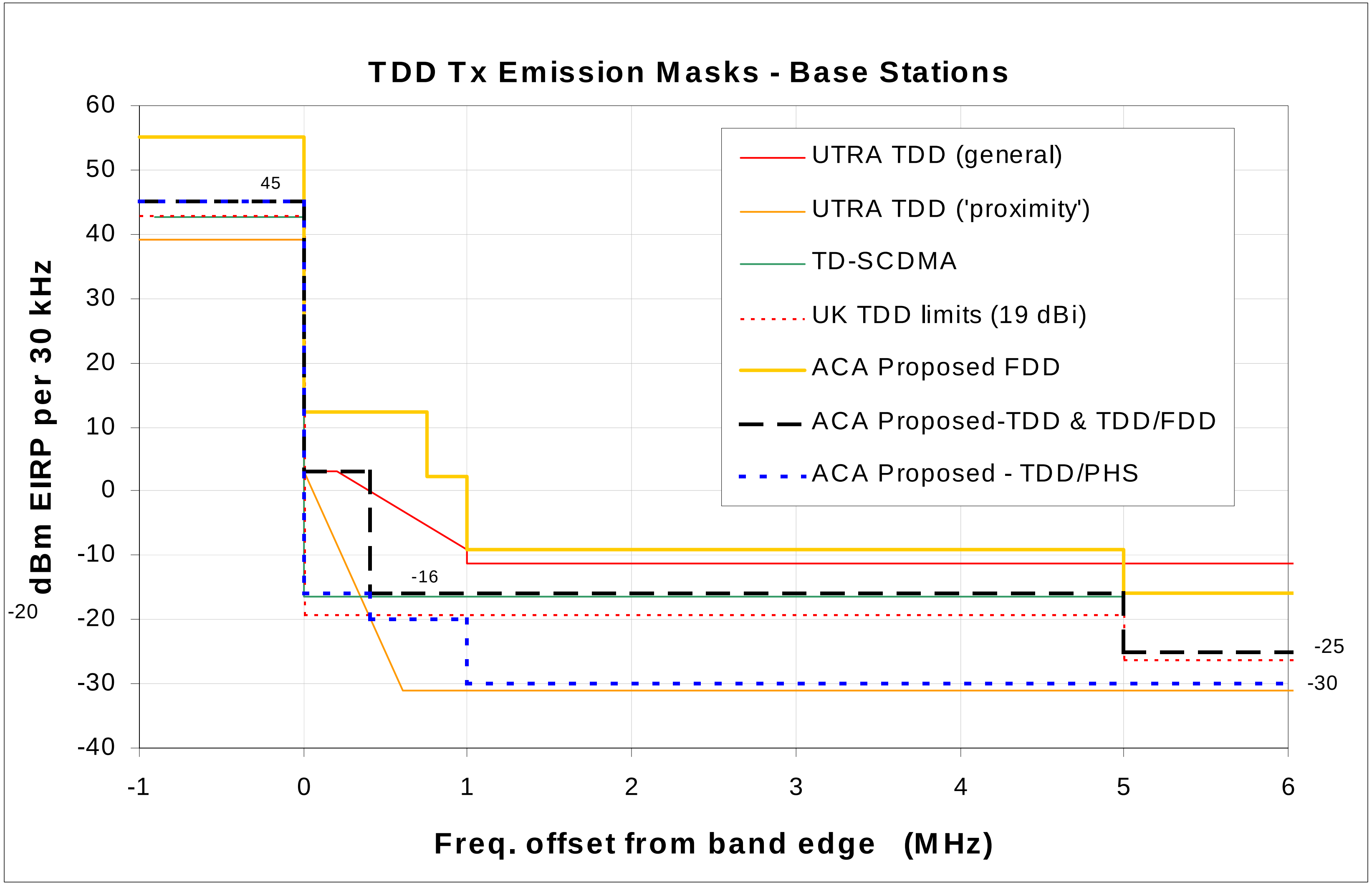
[13] "Minimum performance characteristics (HAPS) and operational conditions for High Altitude Platform Stations providing IMT-2000 in the bands 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz in Regions 1 and 3 and 1 885-1 980 MHz and 2 110-2 160 MHz in Region 2"

Attachment A: Comparison of Popular Propagation Models for 2 GHz Case



Attachment B: Masks for non-spurious unwanted emissions




TDD Tx Emission Masks - Base Stations
dBm EIRP per 30 kHz
60
50
40
30
20
10
0
-10
-20
-30
-40
-1
0
1
2
3
4
5
6
Freq. offset from band edge (MHz)
45
-16
-20
-25
-30
UTRA TDD (general)
UTRA TDD ('proximity')
TD-SCDMA
UK TDD limits (19 dBi)
ACA Proposed FDD
ACA Proposed-TDD & TDD/FDD
ACA Proposed - TDD/PHS

APPENDIX D: DISCUSSION PAPER NO. 3

Technical Liaison Group (2 GHz IMT-2000 Bands)

- **Device Boundary Criteria**
- **Deployment Constraints**

DOCUMENT RELEASE INFORMATION

Version	Date Released	Remarks
1	14 August 2000	Initial Release
2	30 August 2000	Updated Device Boundary Propagation model and Deployment Constraints.

1. Introduction

This paper proposes device boundary criteria and deployment constraints for transmitters operating under 2 GHz spectrum licences. Device boundary criteria are used to maintain equitable access to spectrum across geographic area boundaries. Deployment constraints may be required in lieu of or to supplement device boundary criteria as part of the overall interference management framework.

Emissions that fall outside the geographic area of a spectrum are limited by **Core Conditions** that specify a maximum horizontally radiated power. These conditions place an overall cap on power at the boundary of a licence and effectively limit in practice the power able to be used within the area.

As well as these Core Conditions, additional layers of interference management are specified in the *s.145 Determination* (*Unacceptable levels of Interference),* the most important being the **Device Boundary Criteria**. Before registering a device a licensee or accredited person must, in addition to checking that the core conditions are maintained, calculate the device boundary of a fixed transmitter.

Mobile transmitters are exempt from the Device Boundary criteria, as they do not have a fixed geographic location. However, the s.145 determination limits the emissions from a mobile transmitter to a level considerably lower than out-of-area limits for fixed base stations.

The effect of these layers of management is to create ‘emission buffer zones’ along the geographic boundaries of the licences.

2. Device Boundary System Model

The device boundary criteria consist of a family of curves relating maximum emission levels, antenna height and distance to the boundary. This family of curves is referenced to the operating characteristics of a system model.

The proposed device boundary criteria is designed to accommodate all technologies for the current 2 GHz IMT-2000 spectrum arrangements, optimised for the Device Boundary System Model. The system model represents technologies likely to operate in the 2 GHz band in an area near a spectrum licence area boundary, being primarily WCDMA and cdma2000, both FDD technologies.

The device boundary is not optimised for the more demanding TDD case, as TDD is more likely to be used for urban micro- and pico-cells, and less likely to be used in areas near spectrum licence boundaries (usually suburban or rural environments)[14]

Table 1 lists the relevant characteristics used for the (FDD) system model.

[14] It should also be noted that the TDD band is proposed for allocation only in metro areas and Canberra, Hobart and Darwin. This means under the current arrangements, TDD lots will not share a geographic boundary with another spectrum licence using the same frequencies.

SYSTEM MODEL -- Typical large macrocell near boundary (FDD WCDMA or cdma2000 assumed)

	Parameter	Comments	
	Base Station transmitter		
	Tx frequency range		2110-2170 MHz
A	Tx Power	Typical large macrocell (eg. 50 W WCDMA or 16 W cdma2000 1X)	26 dBm / 30 kHz
B	Ant Gain (incl. Feeder loss)	typical 3-sector	19 dBi
	Effective Antenna Height	typical	60 m
C	**Tx EIRP per 30 kHz**	**A+B**	**45 dBm / 30 kHz**
	Mobile Handset Rx		
	Rx frequency range		2110-2170 MHz
	Rx Antenna Gain	(including losses)	0 dBi
D	Body Loss	(due to human body / obstruction)	8 dB
	Noise Figure		9 dB
E	**Interference Threshold**	**(noise floor =kTBF)**	**-120 dBm / 30 kHz**
F	Target Eb/No		7.5 dB
G	Rx Sensitivity	(condition, G < I-D)	-139 dBm / 30 kHz
H	Max. Processing Gain	(at low data rate)	25 dB
I	**Minimum Wanted Signal**	(E+F-H+D) (incl. Body loss)	**-129.5 dBm / 30 kHz**
	Fade Margin (lognormal σ=9dB)	3 % of time (97% availability)	17 dB
J	**Proposed Level of Protection**	**(E+D, based on noise floor)**	**-112 dBm / 30 kHz**

SYSTEM MODEL -- Typical large macrocell near boundary (FDD WCDMA or cdma2000 assumed)

	Parameter	Comments	
	Base Station transmitter		
	Tx frequency range		2110-2170 MHz
A	Tx Power	Typical large macrocell (eg. 16 W WCDMA or 5 W cdma2000 1X)	21 dBm / 30 kHz
B	Ant Gain (incl. Feeder loss)	typical 3-sector	14 dBi
	Effective Antenna Height	typical	60 m
C	**Tx EIRP per 30 kHz**	**A+B**	**35 dBm / 30 kHz**
	Mobile Handset Rx		
	Rx frequency range		2110-2170 MHz
	Rx Antenna Gain	(including losses)	0 dBi
D	Body Loss	(due to human body / obstruction)	8 dB
	Noise Figure		9 dB
E	**Interference Threshold**	**(noise floor =kTBF)**	**-120 dBm / 30 kHz**
F	Target Eb/No		7.5 dB
G	Rx Sensitivity	(condition, G < I-D)	-139 dBm / 30 kHz
H	Max. Processing Gain	(at low data rate)	25 dB
I	**Minimum Wanted Signal**	(E+F-H+D) (incl. Body loss)	**-129.5 dBm / 30 kHz**
	Fade Margin (lognormal σ=10dB)	3 % of time (97% availability)	19 dB
J	**Proposed Level of Protection**	**(E+D, based on noise floor)**	**-112 dBm / 30 kHz**

Tab

le 1. Technical Parameters used in the 2 GHz System Model

The typical RF link budget of 174.5 dB (45 dBm to -129.5 dBm) results in a cell radius of about 27 km using the propagation model (discussed in Part 4). In rural areas, with a higher power base station and higher site elevation, the cell radius may exceed 70 km for low data rates and favourable terrain.

3 Level of Protection

The maximum or benchmark level of protection for a receiver is usually based on the receiver sensitivity, a fade margin and allowances for receive antenna gain and body loss. In this case, as the noise floor is high in comparison to the receive sensitivity (typical for CDMA systems), an Interference Threshold level is used, based on the noise floor in handset receivers. An additional 8 dB for loss due to proximity to the human body is also accounted for. It is assumed that it is not necessary to protect a CDMA system to a level below this Interference Threshold.

Therefore, the level of protection is, from Table 1:

LOP = -112 dBm per 30 kHz.

To achieve this level of protection from the system model base station, a separation of 11.5 km is needed between base and victim mobile in the adjacent area. Unlike the arrangements at 1.8 GHz, mobiles in the adjacent area are assumed to be able to roam right up to the spectrum licence boundary, which is consistent with a 1:1 frequency reuse capability for IMT-2000 CDMA systems. The device boundary criteria is based on the system model base station being located at a distance of 11.5 km from the licence area boundary, as shown in Figure 1 below.

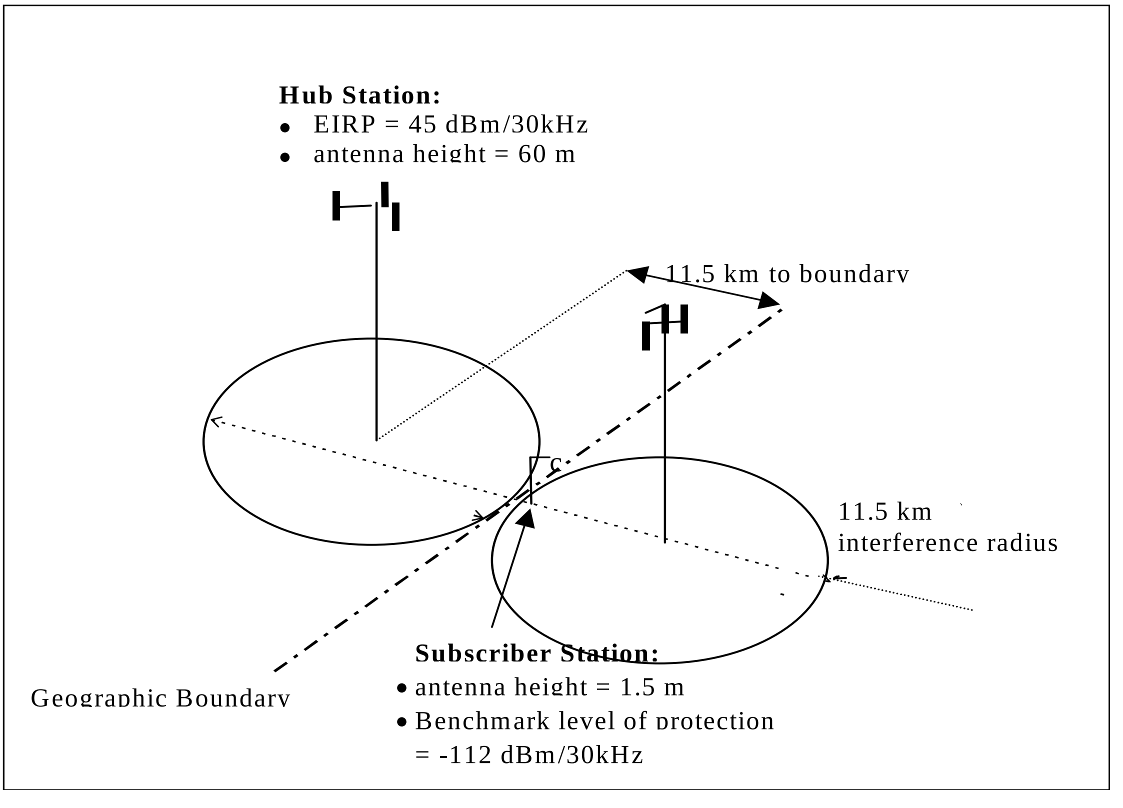


Figure 1. System Model

4. Propagation Model

As discussed in Discussion Paper #2, in developing the Device Boundary Criteria, a propagation model needs to be selected which meets the following criteria:

- is suitable for cellular mobile applications at 2 GHz;
- is a 'generic' model, not requiring detailed terrain information; and
- is simple enough to incorporate easily in specified Device Boundary calculations, resulting in minimal effort for the person registering the device.

In version 1 of this Discussion Paper, the propagation models detailed in ITU-R Recommendation M.1225 "*Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000*" (Annex 2, Section 1.2.1.2 and 1.2.1.3) were suggested for use in developing the Device Boundary Criteria. However, these models have been seen to be not valid for antenna heights over 60m, which means they are not suitable for Device Boundary requirements, where the effective antenna height is a critical parameter. The **effective antenna height** takes into account surrounding (average) ground height, resulting in an 'effective' base antenna height often much higher than the actual antenna height above local ground. (See the 1.8 GHz s.145 Determination for a detailed description of Effective Antenna Height)

To provide a smooth transition between low and high effective antenna heights, and to model a realistic environment for a boundary area, a propagation model based on the **Hata/COST-231 Suburban** model has been chosen. The model is recommended for base antenna heights up to 200m, but works quite well for the expected range of heights (typically up to 800m, maximum of 1600m). In some cases, the boundary area will be closer to an open (line-of-sight) environment, but if the open environment propagation model were chosen, the emission buffer zone would become too conservative and unnecessarily large. The model is detailed in Appendix A.

5. Establishing the Device Boundary Criteria

The system model characteristics and the propagation model are used in the device boundary expression to create criteria for each transmitter. The expression is:

HRP – Lb = LOP

Where:

HRP = Horizontally radiated power

Lb = path loss

LOP = Benchmark level of protection

This expression may be solved to find a distance required for a given horizontally radiated power and effective antenna height. That distance then defines the location of the device boundary along radials taken every 2.5 degrees about a transmitter. The effective antenna height is calculated every 5 minute segment in distance along each radial to determine if the criterion is satisfied for that segment.

5.1 Proposed exemption.

As noted above, present spectrum licensing frameworks require all eligible transmitters in the licence area to have a device boundary calculated. However it is recognised that in many areas, particularly for large regional licences, the device boundary requirements would obviously be readily met in many locations away from the boundaries. To assist in streamlining the process of registration of devices, the ACA is proposing an exemption from the requirement for calculating device boundaries for:

- any transmitter that is further than **40 km** from any spectrum licence boundary.

Under the current propagation model, no transmitter which meets the Core Condition Out-of-Area limit of 55 dBm EIRP per 30 kHz should have a device boundary larger than a circle with a 40km radius. It is acknowledged that there may be situations where this is not realistic (very open rural environments), but this compromise was chosen to maximise spectrum utility for the majority of cases and environments.

It should also be noted that the Device Boundary Criteria does not provide absolute protection, it simply aims to:

- provide equitable access to the spectrum at geographic boundaries;
- provide a level of certainty in planning near the boundary of other licensee's areas;
- minimise the need for negotiation between adjacent area licensees.

6. Examples of Device Boundary Criteria

The following examples illustrate the current device boundary criteria:

A. A high power 30 W cdma2000 (1X) base station at an effective antenna height of 100m, with a 19 dBi sectoral antenna (22 dBi -3 dB loss) pointing directly at the boundary does not need to consider reducing in-band emissions until within 19.5 km of a boundary.

B. The 'system model' base station transmitter (50 W WCDMA or 16 W cdma2000) at an effective antenna height of 60m, with a high-gain 19 dBi sectoral antenna with a sector pointed directly at the boundary does not need to consider reducing in-band emissions until within 12 km of a spectrum licence boundary.

C. A 15 W WCDMA base station at an effective antenna height of 20m, with a 10 dBi omni-directional antenna does not need to consider reducing in-band emissions until within 2.4 km of a boundary.

D. A 20 W EDGE base station at an effective antenna height of 100m, with a 19 dBi sectoral antenna pointing directly at the boundary does not need to consider reducing in-band emissions until within 24 km of a boundary.

E. A 16 W cdma2000 base station at an effective antenna height of 300m, with a 19 dBi sectoral antenna pointing directly at the boundary does not need to consider reducing in-band emissions until within 25 km of a boundary.

If the device boundary criteria is exceeded (if the device boundary extends outside the area of the spectrum licence), the operator will need to consider measures to reduce emissions over the spectrum licence boundary, such as:

- pointing of sectoral antennas;

- relocation of base stations further from boundary, or lower on hill;
- reducing antenna height; or
- reducing transmit power;

in order to meet the device boundary criteria and register the device.

7. Deployment Constraints

As with the technical framework for 1.8 GHz spectrum licences, a fundamental component is that the device boundary criteria are based on a high site - low site propagation model. This type of model is necessary to ensure that an excessively wide emission buffer zone is not created that would unreasonably inhibit use of the spectrum.

The unusual case of high site-to-high site paths (eg. from Base transmitters to Base receivers) would occur when adjacent area, co-frequency licensees are using the same band for base transmit and base receive. This is not expected to be the case for the 2 GHz paired band, as the (anticipated use of) IMT-2000 FDD equipment standards follow the ITU-R harmonised arrangements that designate the upper FDD band (2110-2170 MHz) for base transmit and the lower (1920-1980 MHz) for base receive. The exception to this is for repeater stations, where the base station re-transmits signals from mobiles (usually at a low level) in the mobile transmit (lower FDD) band.

To facilitate consistency with the harmonised arrangement, the 2 GHz technical framework imposes certain deployment constraints in the paired bands. Use of repeaters is discussed in the next section.

As with the device boundary criteria, the deployment constraints are also part of the s.145 Determination. The constraints proposed are:

- A maximum EIRP limit of **25 dBm per 30 kHz** for transmitters in the lower FDD band (1920-1980 MHz), equal to the radiated power limit for mobiles; and
- A **20m** limit on the effective antenna height for fixed transmitters in the lower FDD band (1920-1980 MHz).

The deployment constraints proposed above would not be appropriate for TDD services, and are not considered necessary at this time in the unpaired TDD band (1900-1920 MHz).

8. Use of Repeaters

As mentioned earlier, provision needs to be made to allow the use of repeaters (or any other high site-to-high site requirement) within a spectrum licensee's frequency band and geographic area. If a repeater cannot meet the Core Conditions then the licensee has the option to negotiate a formal agreement with the adjacent (area or band) licensee. For most cases, repeaters should be able to operate without the need for negotiation under one of the following options:

a. For repeaters transmitting in the (lower) FDD Base Rx band, with an effective antenna height of less than 20 m:

- device boundary criteria must be met (as for other fixed transmitters); and
- the EIRP must be confirmed as less than 25 dBm per 30 kHz for 99% of the time in any 1 hour period;

b. For repeaters transmitting in the (lower) FDD Base Rx band, with an effective antenna height of more than 20 m, or an EIRP of more than 25 dBm per 30 kHz:

- devices may still be registered if the 'guard area' requirements of Advisory Guideline "*Registration of Devices under Spectrum Licences without an Interference Impact Certificate*"(1998) can be met.

This option (b) may involve using a high site-to-high site (eg. terrain dependant diffraction, spherical diffraction) propagation model to show emissions outside the licence area do not exceed the compatibility requirement [-126 dBm per 30 kHz] for base stations in the adjacent area.

9. Groups of Transmitters

Provisions for registering groups of transmitters have been made for the 1.8 GHz band and in some other bands to enable:

- groups of high power mobiles to be registered (not required for IMT-2000); and
- groups of fixed transmitters to be registered as one in specific cases.

The TLG agreed that these 'group' provisions might be useful in some cases for easier registration of several similar transmitters at the same site, so they will be retained for the 2 GHz framework.

Attachment A: Detail of Propagation Model

This model is based on an extended Hata/COST-231 Suburban model, as detailed in ERC Report 68 (Feb 2000), Annex B.a.1. This model has been used by ITU-R Study Groups 1 and 3, as an outdoor high site-to-low site propagation model covering a wide range of VHF and UHF frequencies.

Proposed Model
This model is applicable for suburban areas outside the high rise core where buildings are of nearly uniform height and the mobile is likely to be in a lightly cluttered environment. This model assumes a mobile height of 1.5m, and a frequency of 2140 MHz (centre of FDD Base Tx band).

The path loss equation is,

for d <= 20 km:

$$L = 158.5 - 13.82 \log(\max[30;h_e]) - \min([\ 0;20\log(h_e/30)\ ]) - 12.27 + \{44.9 - 6.55 \log(\max[30;h_e])\}.\log(d) \quad \text{dB}$$

for d > 20 km:

$$L = 158.5 - 13.82 \log(\max[30;h_e]) - \min([\ 0;20\log(h_e/30)\ ]) - 12.27 + \{1 + (0.54 + 0.00107.he).(\log[d/20])^{0.8}\}.\{44.9 - 6.55 \log(\max[30;h_e])\}.\log(d) \quad \text{dB}$$

where:

d : base station – mobile station separation (km)

h_e: Effective Antenna Height (m), must be between 5 and 1600 m.

NOTE 1 – L shall in no circumstances be less than free space loss. Lognormal shadow fading with 9 dB standard deviation is assumed.

APPENDIX E: DISCUSSION PAPER NO. 4

Technical Liaison Group (2 GHz IMT-2000 Bands)

Compatibility Requirements for Apparatus and Class Licensed receivers operating in or near the 2 GHz Spectrum Licensed Bands

DOCUMENT RELEASE INFORMATION

Version	Date Released	Remarks
1	11 August 2000	Initial Release
2	7 September 2000	More information on compatibility requirements for PHS cordless service and inclusion of the Space Services.

1. INTRODUCTION

Parts of the 2 GHz band are proposed to be re-allocated for spectrum licensing purposes. Receivers of apparatus licensed and class licensed services currently operate in those frequency bands and in adjacent frequency bands. The bands and areas proposed and the relationship with these other receivers can be seen in the spectrum chart included in TLG Discussion Paper 1[15]. These receivers may suffer interference from unwanted emissions and blocking, caused by a spectrum licensed transmitter. Advisory Guidelines[16] are required for the management of interference to apparatus and class licensed receivers operating in the following circumstances:

- Point to point fixed services operating in and adjacent to the 2 GHz spectrum licensed bands;
- Mobile Satellite Services (MSS) operating in the bands above 1980 MHz and 2170 MHz, adjacent to the 2 GHz spectrum licensed bands;
- Multipoint Distribution Services (MDS) operating in the band below 2110 MHz; and
- Cordless Telecommunications Services (CTS) authorised by apparatus licences or class licences and operating in the band 1880-1900 MHz.

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15 Design requirements for the technical framework for the 2 GHz IMT-2000 bands. July 2000
16 Under s 262 of the *Radiocommunications Act*

- Space Services in the bands 2025-210 MHz and 2200-2300 MHz.

The ACA will take into account such advisory guidelines in determining whether a spectrum licensed transmitter is causing interference to an apparatus licensed or class-licensed receiver operating in the circumstances set out in the guidelines. Guidelines do not prevent a licensee negotiating other protection requirements with another licensee.

2. COMPATIBILTY REQUIREMENTS for Point to Point Fixed Service Receivers

2.1. The fixed services channelling arrangements in the 2 GHz bands that need to be considered in the compatibility requirements are:

- The "2.1 GHz" plan, which supports use by medium capacity fixed point to point links in line with ITU Recommendation F382. The band operates from just below 1900 MHz to about 2300 MHz and contains six main and six interleaved 29 MHz channels with a 213 MHz paired spacing. A number of channels in this band are affected by the 2 GHz spectrum-licensing proposals.
- The "1.8 GHz" plan, which supports use by low to medium capacity fixed point to point links in line with ITU-R F283. The band operates from 1700 MHz to about 1907.5 MHz, contains six main and six interleaved 14 MHz channels with a 119 MHz paired spacing. Channel 5'I, 6' and 6I' are affected by the 2 GHz licensing. The *1.9 GHz Band Plan (1996)* prohibits the issue of new licences in the 1880-1900 MHz band.
- The ITU-R F1098 channel plan proposed by the ACA to be introduced in the near future to assist in the relocation of the 2.1 GHz channels. Channels adjacent to the 2110 MHz spectrum licence boundary need to be considered in the interference management framework.

2.2. Fixed services in the 1.8 GHz band are licensed in accordance with the frequency assignment criteria detailed in RALI FX-3, which provides details about channel plans for individual microwave bands and guidance on interference criteria and frequency coordination between microwave links to achieve certain performance objectives. Assignment criteria are provided for each frequency band, including specified protection ratios. In bands that are shared with other services, e.g. fixed satellite and cordless systems, RALI FX-3 directs the reader to other relevant RALIs or guidelines for additional coordination criteria and advice. The criteria are typically based on internationally accepted ITU recommendations.

2.3. The receivers of fixed services operating in the above bands can be categorised as follows:

- *Category 1* - incumbent receivers, ie. subject to clearance from the band within the designated re-allocation period; such receivers are to be provided with out-of-band and in-band protection during the re-allocation period; or
- *Category 2* - receivers that are not incumbents, with apparatus licences issued before the date of issue of the *Radiocommunications Spectrum Marketing Plan* for

the 2 GHz band; such receivers are to be provided with continuing out-of-band and in-band protection; or

- *Category 3* - receivers that are not incumbents, with apparatus licences issued after the date of issue of the *Radiocommunications Spectrum Marketing Plan* for the 2 GHz band -*)*. Such receivers are:
  - to be provided with out-of-band protection from interference caused by frequency adjacent transmitters that were registered after the issue date of the apparatus licence under which the receiver operates (ie. adjacent channel protection ratios as per FX-3); and
  - required to accept levels of in-band emissions from a device operated under a spectrum licence, if the device is operated in accordance with the core conditions of the licence and the relevant s.145 Determination of unacceptable levels of interference.

Protection requirements

2.4 The protection requirements for fixed services operating in the 1.8 GHz and 2.1 GHz bands are specified in RALI FX-3. In planning for the operation of transmitters under a spectrum licence, spectrum licensees are to provide an equivalent level of out-of-band and in-band protection from those transmitters as would be provided from apparatus licensed fixed service transmitters whose frequencies are assigned in accordance with RALI FX-3.

3. COMPATIBILTY REQUIREMENTS for Multipoint Distribution Systems

3.1. A multipoint distribution system is a fixed service comprising at least one multipoint distribution station (a transmitting station), four multipoint distribution station receivers and any number of multipoint distribution repeater stations. MDS operates in two segments of the 2 GHz band. The frequency band relevant to this paper is the MDS "A" band at 2076-2111 MHz, adjacent to and partially overlapping the IMT-2000 band above 2110 MHz.

3.2. The MDS allocation in this band is prescribed in the *MDS Band Plan 2000*. This plan provides that the MDS allocation will terminate on 25 July 2002, well before the earliest re-allocation date possible for the 2 GHz spectrum licensed bands. MDS services will require protection from spectrum licensed services up to that cessation date.

3.3. Under the technical framework for MDS, hub transmitters servicing an area are required to be co-sited and to transmit at the same power level. This approach combined with appropriate subscriber receiver performance, enables adjacent MDS channels to be used at any particular location. This framework was used to pre-plan the 1994 price based allocation of MDS apparatus licences in the 13 *city MDS* areas, and was incorporated in the 1995 Coordination Guidelines (a legal instrument) for *regional MDS* that can be found in the MDS Regional Co-ordination Handbook. The MDS areas themselves are defined explicitly in various legal Determinations. In general, city MDS areas are of either 50 km or 20 km radius around 13 key population centres (eg, the capital cities) and regional MDS areas, 17 in total, are typically much larger irregular shapes that encompass much of a State (eg, the Northern NSW Area). The protection level for MDS receivers currently established in various MDS legal instruments is 32 dBμV/m.

Protection requirements

3.4 In planning for the operation of transmitters under a spectrum licence, spectrum licensees will be required to provide a level of protection of 32 dBμV/m to licensed MDS services until 25 July 2002.

4. COMPATIBILTY REQUIREMENTS for Mobile Satellite Service Receivers

4.1. MSS is allocated in the bands 1980-2010 MHz (Earth to space) and 2170-2200 MHz (space to Earth). At this stage there are no licensed MSS services in these bands in Australia but the ACA is in active consultation with a prospective MSS operator concerning an anticipated requirement to access this spectrum. Provision of this access will involve the clearance of some of the point to point links in the bands. The initial clearance requirement will not involve the spectrum immediately adjacent the 1980 and 2170 MHz boundaries, of relevance to this paper.

4.2. It is anticipated that the operation of the MSS systems in these bands will be authorised by the apparatus licensing of the space stations and the class licensing of the mobile earth stations (MES), in line with similar arrangements for other MSS and some fixed satellite services.

4.3 The interference management issues relevant to this paper in this case are:

- IMT-2000 mobile terminal transmit compatibility with space station receivers in the adjacent band 1980-2010 MHz, at the 1980 MHz boundary.
- IMT-2000 base station transmit compatibility with MES receivers in the adjacent band 2170-2200 MHz, at the 2170 MHz boundary.

4.4 The ACA understands that the technical specifications for the proposed MSS system are currently under review by the developer, as a result of recent commercial restructuring of companies involved in these ventures. As such, there is no clear indication of the precise protection requirements likely for the current MSS proposal. However, some earlier studies and spectrum allocation options adopted in the UK give some indication of the likely compatibility requirements.

4.5 The UK has included guard bands of 300 kHz at these spectrum boundaries in the packaging of its IMT-2000 spectrum. Presumably this took into account studies done by the ERC as reported in ERC Report 65[17] indicating the probable need for some form of isolation between the two systems. However, as stressed in ERC 65, these studies used the expected MSS parameters at that time and noted the need for review if such parameters changed. Further, the report noted that there is as yet no agreed ITU-R Recommendation relevant to this issue and that the studies relied on

[17] "Adjacent band compatibility between UMTS and other services in the 2 GHz band"; May 1999

general planning principles. The ERC report assumed a MSS channel width of 25 kHz with channels immediately abutting the allocated band edges - a worst case situation. It is understood that the MSS proponent is now considering a wider bandwidth system. As such, the protection requirements may be less onerous, depending on the separation between closest carriers of the two systems. (As noted above, the initial MSS requirement is for spectrum not adjacent to the IMT boundaries).

4.5 For the 1980 MHz IMT MES transmit to MSS space receive segment case, consideration needs to be given to the adequacy of the out of band emission limits proposed for the core conditions to allow for reasonable compatibility with MSS space receivers. From previous discussions with MSS proponents, the ACA is of the preliminary view that there is no requirement for more stringent limits. The TLG is invited to contribute information to assist the ACA in this matter. (ACA will also liase with MSS proponents in this matter).

4.6 For the 2170 MHz IMT base station transmit to MSS terminal receive segment case, a number of factors needs to be considered:

- the anticipated low density of MSS subscribers, compared with likely IMT-2000 users;
- the expectation that most MSS use would be in regional / remote areas as it is likely that many MSS applications would utilise dual mode MSS / IMT-other cellular system. In areas where terrestrial systems were deployed, it is likely that the terminal would default to the terrestrial system.

As such the probability of interference to MES receivers from IMT bases is seen to be low, and that in any event, dynamic assignment techniques should be able to mitigate against such interference. The ACA is thus inclined not to impose any additional limits on the IMT 2000 bands in this regard, but invites industry input to assist in confirming this approach.

Proposed Protection Requirements

[4.7 Provided that a spectrum licensee complies with all relevant conditions of the spectrum licence, then unacceptable interference is taken not to be caused to the MSS. Note: It would be expected that reciprocal compatibility would apply, ie. that spectrum licensees be required to accept interference from MSS terminals in adjacent bands within limits yet to be determined during MSS licensing.**]**

5. COMPATIBILTY REQUIREMENTS for Cordless Telecommunications Services

5.1 CTS operate in the frequency band 1880-1900 MHz in accordance with the *1.9 GHz Band Plan 1996*. This band is adjacent to the 2 GHz IMT-2000 spectrum, in parts designated for TDD applications. Technologies which may operate in the band[18] are those complying with the Digital Enhanced Cordless Telecommunications

[18] As at September 1999.

(DECT) and the Japanese Personal Handyphone Service (PHS) standards[19]. Typical CTS applications, referred to as "private CTS" and for which radiocommunications licensing arrangements are established, include domestic and business telephones, wireless PABX and wireless local area networks. These CTS technologies may also be used for wireless local loop (WLL) applications (also called fixed wireless access FWA), however at this time there are no WLL systems in operation and suitable licensing arrangements for these "public CTS" applications would need to be developed should demand for this service arise.

5.2 The following licensing arrangements apply to the operation of private CTS in the 1.9 GHz band:

Until 30 June 2001. All CTS base station operations must be authorised by apparatus licences. The issue of a licence is subject to successful frequency coordination with fixed service point-to-point link receivers operating in the same band. CTS handset and other terminal operation connected with an apparatus licensed base station is authorised by the *Radiocommunications Class Licence (Cordless Telecommunications Devices) 1999*. As at August 2000, there were about 1700 private CTS licences recorded on RADCOM, with about 300 of these being for PHS.

From 1 July 2001. Following extensive consultation in 1999 with relevant industry stakeholders, the ACA has adopted a policy whereby apparatus licensing of private CTS base stations will not be required from this date. Fixed service receivers will no longer be protected from CTS. Ongoing operation of all private CTS devices in this band will be authorised by a class licence. The class licence will require compliance with the DECT or PHS standards. There will be no requirement (or capability) for individual CTS frequency coordination with fixed services or with spectrum licensed services. Due to likely IMT-2000 TDD services at 1900-1905 MHz, there is likely to be an advisory note in the CTS Class Licence for PHS concerning the possibility of interaction with PHS in close proximity (co-sited) situations. Typically, for these indoor services, 'co-site' would refer to operation on the same floor (or open space) inside the same building.

5.3 The system parameters for DECT and PHS as described in ACA RALI MS-25 are:

DECT Channel	Carrier Frequency (MHz)	DECT Channel	Carrier Frequency (MHz)
1	1881.792	6	1890.432
2	1883.520	7	1892.160
3	1885.248	8	1893.888
4	1886.976	9	1895.616
5	1888.704	10	1897.344

Table 1: DECT Channel Arrangement

[19] ACA Standards TS-028 and TS -034. The DECT standard supports operation over the entire 1880-1900 MHz band, whilst the PHS standard restricts operation to 1895-1900 MHz.

PHS Channel	Carrier Frequency (MHz)	PHS Channel	Carrier Frequency (MHz)
1	1895.15	9	1897.55
2	1895.45	10	1897.85
3	1895.75	11	1898.15
4	1896.05	12 *	1898.45
5	1896.35	13	1898.75
6	1896.65	14	1899.05
7	1896.95	15	1899.35
8	1897.25	16 *	1899.65

Table 2: PHS Channel Arrangement

Note: * PHS channels 12 and 16 are control channels

Parameter	DECT	PHS
ACA Technical Standard	TS 028	TS 034
Frequency	1880-1900 MHz	1895-1899.8 MHz
Number of carriers	10	16
Carrier spacing	1.728 MHz	300 kHz
Multiplexing	TDMA	TDMA
Duplexing	TDD	TDD
Modulation	GFSK/GMSK	π/4 QPSK (roll-off = 0.5)
Channel bit rate	1152 kbit/s	384 kbit/s
Voice coding	32 kbit/s ADPCM	32 kbit/s ADPCM
Base station transmit power	10 mW (average[20]), 250 mW (peak)	Indoor: 10 mW (average) 80 mW (peak) Outdoor: 20 mW (average) 160 mW (peak)
Maximum base station antenna gain	12 dBi	2.14 dBi; or 10 dBi for Public system
Handset transmit power (EIRP)	10 mW (average), 250 mW (peak)	10 mW (average) 80 mW (peak)
Frame duration	10 ms	5 ms
Number of time slots per carrier	24 (ie. 12 duplex slots)	8 (ie. 4 duplex slots)

Table 3: DECT and PHS Technical Parameters

[20] Average powers are per occupied time slot (ie. for a DECT system with two time slots occupied: avg pwr = 20 mW).

Interference scenarios

5.3. The ACA has previously had to consider the compatibility requirements between CTS and the spectrum-licensed band below 1880 MHz. In that instance the relationship considered was between DECT (the only CTS technology able to operate at that frequency boundary) and DCS1800, the assumed technology for the 1.8 GHz band. European (ERC) studies had shown that an appreciable interference risk existed between uncoordinated DECT stations and DCS1800, a narrow band, relatively high power TDMA technology, the dominant scenario being DCS1800 base transmit blocking of DECT. The risk is significant when the frequency separation between carriers of each technology is less than about 5 MHz. After additional studies and consultation with industry, the ACA determined that the most effective way of ensuring reasonably equitable spectrum access for users of each band was to impose a limit on the allowable radiated power of spectrum licensed devices in the upper 2.5 MHz segment of the 1.8 GHz band.[21] This limit is now specified in the *Radiocommunications (Unacceptable Levels of Interference - 1800 MHz Band) Determination 1999* and is set 25.5 dBm per 30 kHz.

5.4 In considering the interference issues for the top end of the CTS band at 1900 MHz, the spectrum licence technology assumed is TDD, as described in TLG paper 1. DECT again needs to be considered and PHS also needs to be included.

<u>DECT-IMT2000</u>. This scenario has been examined to an extent in Europe in ERC Report 65[22], for the case of UMTS and DECT. The interference was evaluated using Monte-Carlo simulations and a minimum coupling loss approach. This report showed that interference between two base stations of UMTS and DECT is very unlikely to occur, mainly due to the inherent wide separation between the two closest carriers of each technology. In rare cases where two stations are in very close proximity, DECT dynamic frequency selection would overcome interference. ERC 65 concluded that provided DECT is not used for FWA applications (as is the case in Australia), the probability of unacceptable interference is so low that a guard band is not required between the two technologies.

The ACA notes also that for the IMT2000 bands in the UK, a guard band was not included at the 1900 MHz boundary, unlike the arrangements included for some other parts of the 2 GHz bands, implying that no undue concerns were held about this issue in the UK. (The ACA has conducted a further general assessment of this scenario, using best available updated system models for the IMT-2000 technologies. This confirms that no in band power limit seems to be required).

<u>PHS-IMT2000</u>. Adjacent band operation of IMT-2000 TDD with PHS is manageable, but imposes a risk on PHS services when TDD mobiles are in close proximity to PHS bases stations. This situation is unique to Australia, due to the close (frequency) proximity of the PHS and IMT-2000 TDD spectrum allocations. The ACA is not aware of any studies investigating PHS and IMT-2000 TDD.

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[21] See Spectrum Planning Report 6/99 "Compatibility Requirements for Frequency Adjacent Services (DCS 1800/DECT) in the 18 GHz Band"
[22] "Adjacent band compatibility between UMTS and other services in the 2 GHz band"; May 1999

The ACA has conducted an assessment of adjacent band compatibility between the two services for the Australian arrangement. The main difference to the DECT situation is that PHS is a relatively narrow channel (300 kHz) technology with the top channel edge being only 200 kHz from the spectrum licence frequency boundary. This compares with a gap of about 2 MHz for the DECT situation. Further, the top channel is designated as one of two fixed control channels critical to PHS operation (PHS does not have dynamically assigned control channels as DECT does). Thus PHS has different susceptibility characteristics to DECT and needs to be considered separately.

The compatibility study is at Attachment 1 to this paper. The following measures to protect PHS have been included in this 2 GHz technical framework and were considered in the study:

- an in-band limit has been proposed for TDD mobiles (as part of s145 interference Determination), for frequencies within 500 kHz of the PHS/TDD band edge at 1900 MHz. This limit reduces the chances of the upper PHS channels being blocked by the in-band TDD mobile signal;
- very strict out-of-band limits on all TDD transmitters operating at the PHS/TDD boundary (at 1900 MHz) have been imposed via the out-of-band Core Conditions (see Discussion Paper #2-v2).

The study found that TDD mobiles at 1900 MHz would still have a high likelihood of causing out-of-band interference to PHS Base stations when in close proximity. The study suggested further measures to be included in the upcoming Class Licence for PHS to prevent unreasonable interference to PHS systems. Interference to TDD base stations and mobiles was not considered likely.
[The ACA is in consultation with PHS interests in regard to this matter].

Protection requirements

5.5. *Interim*: Provided that a spectrum licensee complies with the in-band emission limits specified in the ***Radiocommunications (Unacceptable Levels of Interference - 2 GHz Band) Determination 2000*** and with all relevant core conditions of the spectrum licence, then unacceptable interference is taken not to be caused to any private CTS device**.**

6. Space Services

6.1 The band 2025-2110 MHz is allocated *inter alia* to the Space Services (earth to space, space to space) and the 2110 - 2120 MHz band to the deep space service (also uplink). Space service segment receivers in these bands need to be protected from spectrum licensed services emissions, in accordance with relevant ITU-R Recommendations. These recommendations will be detailed in the formal advisory guidelines. This issue has been considered in earlier studies by the ERC (ERC Report 65) with the conclusion that the risk of interference to these space services is very slight, even from high-density UMTS systems.

6.2. The band 2200-2290 MHz is allocated *inter alia* to the Space services (space to earth, space to space) and in the 2290-2300 MHz band to Deep Space (downlinks). Licensed Earth stations of this service operate in the Canberra region (Tidbinbilla) and in WA (New Norcia). Spectrum licensees at 2 GHz will be required to protect these stations in accordance with relevant ITU-R Recommendations, to be included in advisory guidelines. In particular, spectrum licensees implementing HAPS based services should pay regard to the location of such stations, in meeting this requirement. (Noting the 30 MHz isolation between the IMT and space service bands due to MSS allocations, it is considered that terrestrial IMT interference to space services is very unlikely). The ACA encourages direct liaison between space station operators and spectrum licensees during the system planning phases of spectrum licence usage when in the vicinity of such stations.

Protection requirements

6.3. The protection requirements for space service station receivers operating in the above bands are set out in relevant ITU Recommendations, including ITU-R IS 847, IS 849, SA 1154, M1456.
[At this time, consultation is occurring between ACA, Space service interests and HAPS interests in determining all the necessary requirements to meet this provision.]

Attachment 1:

Compatibility Study between PHS and TDD IMT-2000

7 September 2000

In Australia PHS operates in the band 1895 – 1900 MHz. Unpaired spectrum for IMT-2000 TDD services at 1900 – 1920 MHz in the city areas is being auctioned in early 2001. As can be seen in figure 1, there is very little frequency separation between the two services. Figure 1 also shows the two likely TDD technologies to be employed in the 1900 – 1920 MHz band and DECT and GSM 1800 allocations.

<u>Scenarios Considered</u>

- PHS base station Tx to a TDD Base/mobile Station Rx
- PHS mobile station Tx to a TDD Base/mobile Station Rx
- TDD base station Tx to a PHS Base/mobile Station Rx
- TDD mobile station Tx to a PHS Base/mobile Station Rx

As the TDD carrier is higher powered and of wider bandwidth, the TDD transmitter to the PHS Base Rx was the dominant interference scenario. (We have considered the TDD mobiles to be the dominant interferer, as they can roam freely within their 'cell'.)

<u>Assumptions</u>

1. Fixed control channels at channel 12 (lower) and channel 16 (upper) are assumed, as detailed in the Australian standard for PHS.
2. Only limited RF specifications are published in the Japanese PHS standard, with little information about PHS receiver blocking characteristics. It is assumed that the blocking level at 1.4 MHz offset will be significantly higher than the level at 600 kHz offset.
3. The receiver characteristics for PHS are assumed to be identical for both mobile and base stations. The C/I was not specified and is assumed to be 5 dB.

<u>Results</u>

Out-of-band interference (ie TDD out-of-band transmission to PHS in-band reception) is the more severe interference mechanism, rather than blocking to PHS receivers. Interference budgets are in Appendix A.

Interference to the lower control channel (ch. 12) could possibly cause total PHS system failure, due to no control channels being available (as the upper control channel is assumed to fail first). Interference to the upper control channel (ch. 16) may only reduce the PHS system capacity.

TDD Mobile v PHS Base Lower Control Channel (Ch. 12) – Out-of-band

Propagation Model	Required separation distance between PHS and IMT-2000 (m)
M1125 Indoor (same floor)	29
M1125 Indoor(1 floor separation)	7
M1125 Pedestrian*	22

TDD Mobile v PHS Base Upper Control Channel (Ch. 16) – Out-of-band

Propagation Model	Required separation distance between PHS and IMT-2000 (m)
M1125 Indoor (same floor)	109
M1125 Indoor(1 floor separation)	26
M1125 Pedestrian*	58

TDD Base v PHS Base Upper Control Channel (Ch. 16) – Blocking

Propagation Model	Required separation distance between PHS and IMT-2000 (m)
M1125 Indoor (same floor)	172
M1125 Indoor(1 floor separation)	42
M1125 Pedestrian*	83

* More stringent than Hata Urban Propagation Model

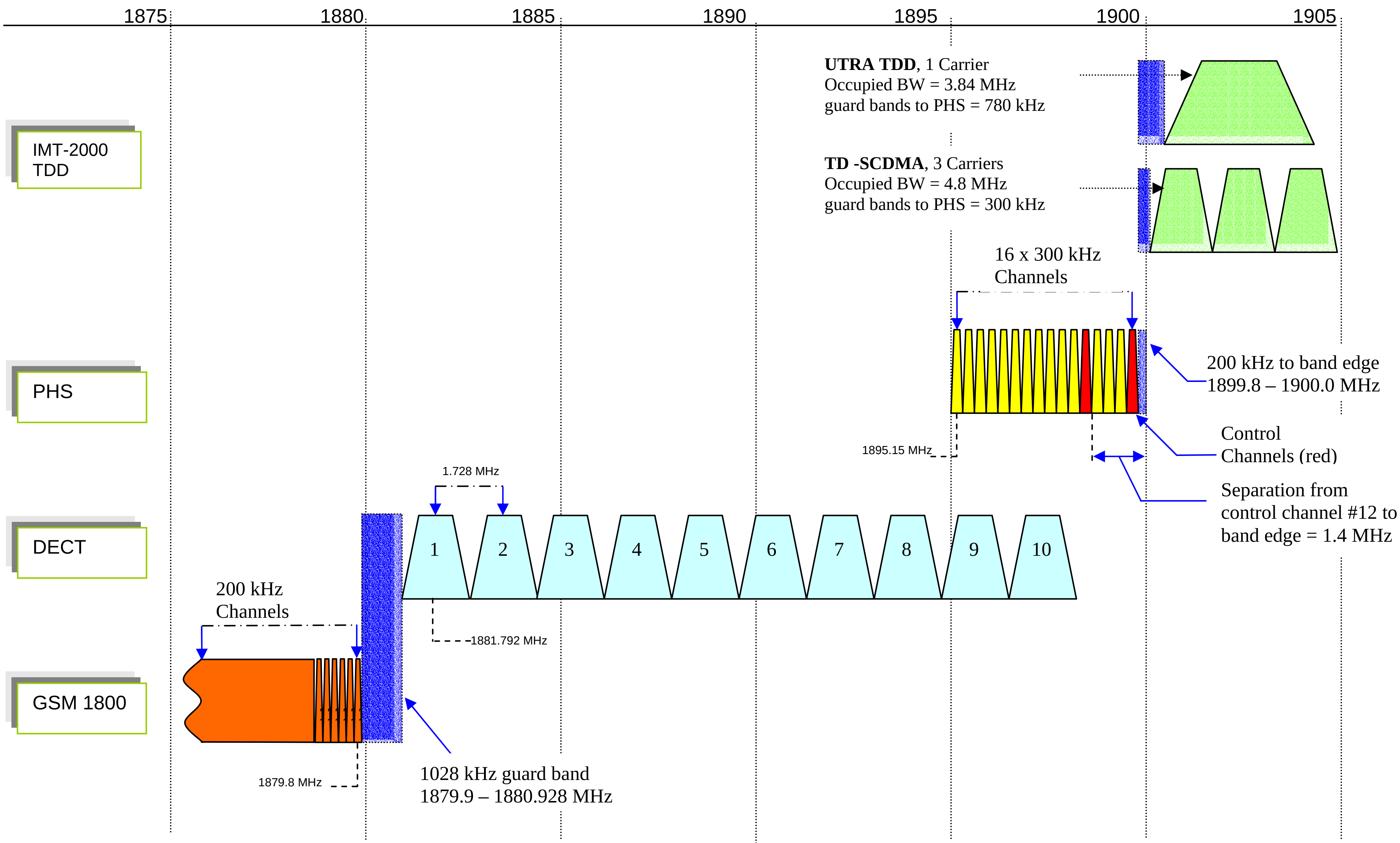
Conclusions

It appears that further measures should be considered to prevent interference between PHS and IMT-2000 TDD services around 1900 MHz, as they are likely to be operated in a similar (indoor) environment possibly in close proximity. Such measures may include:

1. changing the PHS control channel from #16 to #1, providing more resistance to out-of-band interference and minimising chance of total system failure; OR
2. imposing a coordination requirement on PHS base stations and IMT-2000 TDD base stations.

Co-site operation (eg. within the same floor of the same building) of PHS and IMT-2000 TDD base stations also needs to be discouraged. (of course, TDD mobiles will always roam freely)

Figure 1: Australian proposed arrangements: IMT-2000 TDD v PHS



Appendix A: Interference budgets for IMT 2000 to PHS

UTRA TDD Mobile Tx to PHS Base Rx: Out-of-Band

IMT-2000 TDD Tx	Transmitter		**TDD Mobile**	**TDD Mobile**
	Out-of-band Power (EIRP) @ PHS channel considered - from discussion paper #2	dBm/30kHz	-16	-33
PHS Rx - Base	Control Channel considered		**Ch 16 @ 1899.65 MHz**	**Ch 12 @ 1898.45 MHz**
	RX Sensitivity	dBm	-97	-97
	BW	MHz	0.3	0.3
	RX Sensitivity	dBm/30kHz	-107	-107
	C/I (Assumed)	dB	5	5
	Antenna Gain	dBi	2.14	2.14
	Max unwanted OOB level	dBm/30kHz	-114.14	-114.14
Required path loss		(dB)	98.14	81.14
Required Separation Distances using various Propagation models				
	M.1225 Indoor (same floor)		109 m	29 m
	M.1225 Indoor (one floor away)		26 m	7 m
	M.1225 Pedestrian		58 m	22 m

UTRA TDD Tx to PHS Base Rx: Blocking

IMT-2000 TDD Tx	Transmitter		**TDD Base**	**TDD Mobile**
	Power (EIRP) - from discussion paper #2	dBm/30kHz	40 @ **1900.2 MHz**	4 @ **1900.2 MHz**
PHS Rx - Base	Control Channel considered		**Ch 16***	**Ch 16***
	Max unwanted level (as above)	dBm/30kHz	-114.14	-114.14
	Selectivity	dB	50	50
	assumed Blocking Level*	dBm/30kHz	-64.14	-64.14
Required path loss		(dB)	104.14	68.14
Required Separation Distances using various Propagation models				
	M.1225 Indoor (same floor)		172 m	10.5 m
	M.1225 Indoor (one floor away)		42 m	2.6 m
	M.1225 Pedestrian		83 m	10 m

* The actual Blocking Level may be slightly higher, as these levels are based on Rx selectivity.

** Ch. 12 blocking specifications were not available, but can be assumed to be better than Ch. 16, therefore less critical than out-of-band interference.

APPENDIX F: DISCUSSION PAPER NO. 5

Technical Liaison Group (2 GHz IMT-2000 Bands)

Compatibility Requirements to Manage Out of Band Interference in Receivers in the 2 GHz Spectrum Licensed Bands

DOCUMENT RELEASE INFORMATION

Version	Date Released	Remarks
1	11 August 2000	Initial Release
2	8 September 2000	Revised notional receiver and compatibility requirement.
3	15 September 2000	Revised definitions of receiver performance -- now more in line with ITU definitions as in IMT-2000 family of standards.

1. PURPOSE

This discussion paper proposes a compatibility requirement for the management of out-of-band interference in receivers operated in spectrum licensed space at 2 GHz. The compatibility requirement is intended to be included in Advisory Guidelines and form the basis for both the development of coordination procedures and settlement of interference for devices operating under frequency-adjacent licences.

The compatibility requirement is directed at the management of interference to spectrum licensed receivers in the 2 GHz band caused primarily by fixed transmitters operating under apparatus licences. The requirement could also be used as a guide for the settlement of interference between spectrum licensees. The compatibility requirement does not apply to transmitters operating under class licences.

2. INTRODUCTION

Out-of-band interference, which often refers to a number of non-linear types of interference such as receiver intermodulation, blocking and spurious receiver response, may also occur across the frequency boundaries of licences. For example, receiver intermodulation may cause interference when a receiver is in the presence of two or more unwanted signals at frequencies outside the frequency band limits of the relevant spectrum licence.

Out-of-band interference is difficult to predict because the levels and frequencies of unwanted emissions depend on both the proximity nearness and operating frequencies of transmitters and receivers that are close in terms of frequency and distance. In addition, out-of-band interference:

- can extend for many MHz either side of the frequency boundary of a spectrum licence;
- is dependent on the quality of the receiver as well as the levels of transmitter emission; and
- is difficult tocannot be accurately modelled.

Because the interference can extends for many MHz, it is also possible for devices operating under non-adjacent spectrum licences to interfere with each other.

If emission limits were used to manage out-of-band interference for devices in close proximity, the interference modelling inaccuracy would require large probability margins to be added to those limits. Such These margins would place severe constraints on use of the spectrum because the frequency boundaries of a licence extend throughout the entire geographic area of a licence. Therefore, we cannot use emission limits to manage out-of-band interference for the entire geographic area of a spectrum licence (including communal sites) because that would lead to a severe loss of utility of the spectrum on both sides of the frequency boundary.

An alternative to Instead of making large tracts of spectrum space unusable through the imposition of emission limits, the interference can be managed through procedures based on a compatibility requirement for existing receivers. Because the performance level of receivers affects both the level of interference and is likely to vary widely for receivers operating under spectrum licences, a minimum level of receiver performance has to be specified in conjunction with the compatibility requirement.

3. RECEIVERS TO WHICH THE COMPATIBILITY REQUIREMENT APPLIES

The compatibility requirement is used to manage out-of-band interference occurring in certain receivers operating in space managed under spectrum licensing. These situations may occur across the frequency boundaries at the edges of spectrum licence bands and be caused by transmitters operated under apparatus that are issued after the signing of a Marketing Plan for the 2 GHz band.

The compatibility requirement does not apply to all receivers operating in spectrum licensed space. Its application depends on whether the receiver:

- is registered first-in-time with regard to the transmitters causing interference;
- has a level of performance equal to or better than a specified minimum level; and
- is a receiver of a certain type.

3.1 First-in Time Registration

The different policies applied to in-band and out-of-band compatibility requirements reflect the different volumes of spectrum space affected by interference. Out-of-band interference affects services over a small distance compared to the large distances over which in-band interference may occur. Provided the device details of all licences recorded in the ACA's national data base are reasonably accurate, equitable access to spectrum may be achieved in the presence of out-of-band interference by application of both an appropriate coordination procedure and an interference settlement policy based on first-in-time device registration.

The coordination procedure would operate on device details recorded in the Register at a given point in time. The first-in-time policy for interference settlement will involve varying the details of the last recorded 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 are acceptable in that they do not degrade the service performance requirements of the first service.

3.2 Receiver Minimum Performance Level

The degree of out-of-band interference depends on the interference susceptibility of a receiver. Emission levels from transmitters should not have to be reduced when the performance of the receiver is not adequate. Therefore, before establishing a compatibility requirement for receivers it is necessary to establish a benchmark receiver performance. Transmitter emission levels will then be judged against the receiver benchmark performance. Note that under spectrum licensing, a licensee may choose to operate a receiver of any performance level. The compatibility requirement is not afforded to receivers with a performance level below the minimum level, however, should transmitter emission levels be excessive in relation to the benchmark receiver model then action would normally be required to reduce these to the necessary level.

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 2 GHz spectrum licensed.

3.3 Types of Receivers

The compatibility requirement **does not apply to mobile 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.

4. MINIMUM RECEIVER PERFORMANCE

A minimum level of receiver performance is given in Attachment A.

The minimum performance level for a receiver relates to:

- selectivity;
- intermodulation immunity; and
- blocking.

; and
spurious response immunity.

Note: Any frequency offsets (below) are specified with respect to the carrier centre frequency of the transmitter communicating with the receiver. All levels (in this section) are referenced to the antenna connector of the equipment.

The accuracy of measuring equipment, measurement procedure and any corrections to measurements necessary to take account of practical filter shape factors would normally be in accordance with good engineering practice.

For testing purposes (if required), a minimum wanted signal of -120 dBm per 1 MHz (or equivalent) should be used where possible, otherwise Receiver Sensitivity Level + 3dB.

4.1 Receiver Adjacent Channel Selectivity

Adjacent Channel Selectivity means a measure of the ability of a receiver to receive a wanted signal in the presence of an unwanted adjacent channel signal at a given frequency offset.

This degradation is usually caused by emissions from the unwanted signal falling within the IF bandwidth of the receiver. For the 2 GHz notional receiver, receiver selectivity is specified by an 'adjacent channel selectivity', as in IMT-2000 equipment standards. The minimum receiver performance is based on the WCDMA standard, as this would be the widest bandwidth carrier of the key IMT-2000 technologies.

The minimum adjacent channel selectivity is **45 dB**, measured at an offset of **5 MHz**.

4.2 Receiver Intermodulation Response Rejection

Models for this type of degradation are based on the RF selectivity of a receiver and a conversion ratio. The interference power may either be calculated from knowledge of these parameters and compared with the compatibility requirement, or by a specified 'intermodulation rejection level'. Two-signal third order, two-signal fifth order and three-signal third order intermodulation interference scenarios are normally checked in a coordination study. For the 2 GHz notional receiver, Intermodulation Response Rejection is specified by an 'intermodulation rejection level', as in IMT-2000 equipment standards. Again, the minimum receiver performance is based on the WCDMA standard, being the widest bandwidth carrier of the key IMT-2000 technologies.

Intermodulation Response Rejection means a measure of the capability of a receiver to receive a wanted signal in the presence of two or more unwanted interfering signals which have a specific frequency relationship to the wanted signal.

The minimum intermodulation rejection level **is -54 dBm per 1 MHz**, at an offset **of 20 MHz or more**.

4.3 Receiver Blocking

This type of degradation is not the same as that involving receiver selectivity (although both effects can sometimes occur simultaneously) and is usually caused by reciprocal mixing of the off-tune signal with the receiver's local oscillator and/or changing the operating point of the RF-amplifier or mixer stages. The interference power is not easily modelled and a minimum blocking performance is specified.

Receiver blocking means a measure of the ability of a receiver to receive a wanted signal in the presence of a high level unwanted interferer on frequencies other than those of the adjacent channels.

The minimum unwanted signal level to cause receiver blocking is:

- a signal level of **-46 dBm per 1 MHz** with a frequency offset of **10 MHz or more**; and
- a signal level of **-21 dBm per 1 MHz** for **frequencies outside the band 1880 to 2190 MHz.**

4.4 Receiver Spurious Response Immunity

Spurious response immunity is no longer specified in the Advisory Guideline. The receiver blocking and selectivity requirements are considered sufficient to manage this type of emission. No spurious response immunity requirement is found in the majority of the IMT-2000 standards, and the ITU document IMT[RKEY] is in line with our approach.

5. COMPATIBILITY REQUIREMENT

The compatibility requirement is:

- an unwanted signal level that is never more than -126 dBm for more than 1% of the time in any 1 hour period;

when measured as mean power within a 30 kHz rectangular bandwidth that is within the frequency band of the spectrum licence.

[NOTE: The maximum unwanted signal level is the target interference level at the fixed receiver, and the 30 kHz rectangular bandwidth provides a method of normalising the requirement for different transmitter power spectral densities.]

The compatibility requirement is intended to form the basis of technological neutral coordination procedures for the management of out-of-band interference. While the details of the compatibility requirement may not be directly applicable to all equipment, application of the coordination procedures is intended to provide equitable protection for all types of receivers. For example, in developing coordination procedures, the interference probability iofs *'1% of the time in any 1 hour period'* is intended to be used to establish a Decibel margin for converting average propagation loss models to 99% of the time.

Attachment A: Receiver Minimum Level of Performance

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

NOTE: Numbers in the Tables in Square brackets are taken for the 3.4 GHz spectrum licence model - for illustrative purposes here only. IMT 2000 characteristics to be determined.

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

Table 2 sets out the minimum RF selectivity for a receiver. The frequency offsets are specified with respect to the upper and lower limits of the frequency band of the spectrum licence in which spectrum space the receiver operates.

Frequency Offset (MHz)	Loss (dB)
[0]	[0]
[3.5]	[3]
[8]	[10]
[15]	[20]
[22]	[30]
[30]	[40]

[42]	[50]
[85]	[70]

Table 2. Receiver RF filter Characteristics

Equipment manufacturers should ensure that coordination procedures based on this minimum level of performance provide for reasonable protection of their individual receivers from out-of-band interference caused by frequency-adjacent transmitters, without a need for excessive guard bandwidths internal to a spectrum licence, and advise the TLG of any perceived significant inequity. What is reasonable and equitable depends on the relative levels of spectrum utility for different equipment having regard to both data capacity and equipment quality (cost).

Table 3 sets out the minimum conversion ratios for several 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]