Technical Framework Development

2.5 GHz Spectrum Licence Band

TLG-Discussion Paper No. 2
Design Requirements for the Technical Framework
Determination of Unacceptable Interference / System Models / Propagation Models / Levels of Protection / Device Boundary Criterion

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1 Background

This discussion paper deals with the parts of the technical framework that appear in the Section 145 Determination of Unacceptable Interference. Section 145 of the *Radiocommunications Act 1992*, is located in Part 3.5 of *the Act*. This Part of *the Act* deals with the registration of radiocommunications licences, and the details that must be recorded in the register of radiocommunications licences for the authorisation of the use of a radiocommunications transmitter.

Section 145 of *the Act* authorises the Australian Communications and Media Authority (ACMA) to refuse registration of a transmitter for operation under a spectrum licence if the ACMA is satisfied that the operation of the transmitter could cause unacceptable interference to the licensed operation of other radiocommunications devices. Subsection (4) of Section 145 provides that the ACMA may determine, by written instrument, what are unacceptable levels of interference for the purposes of refusing to register transmitters under a spectrum licence. The Radiocommunications (Unacceptable Levels of Interference-2.5 GHz Band) Determination, made under Section 145, will be that written instrument.

The Section 145 determination is used by the ACMA to set out device registration requirements. These typically include a requirement that the device boundary of a registered transmitter - calculated using a device boundary criterion - must lie within the geographic boundary of the licence. However, in cases where this is not possible, licensees are free to register agreements between parties sharing the geographic boundary for the device boundary to exceed it.

The Section 145 determination can also be used to reinforce arrangements that support the operation of low power mobile devices such as hand held devices or low power indoor fixed devices without registration[1] by declaring them not to cause unacceptable interference (under certain conditions). The Section 145 determination is also used to set out arrangements for

[1] The licence will contain a statutory condition exempting mobile and fixed indoor devices from device registration requirements, see subsection 69 (2) of *the Act*. However while not mandatory, registration could be desirable in some circumstances and the section 145 determination arrangements ensure that this is possible.

group registration of transmitters with similar characteristics such as multi channel base stations. Group registration reduces costs and records management requirements.

2 Introduction

This discussion paper looks further at the following items of the technical framework that are used to develop the Section 145 determination:

- system models;
- propagation modelling;
- level of protection;
- device boundary criteria; and
- other device registration arrangements.

Each of these items will be considered by examining overseas requirements and the proposed requirements to be included in the 2.5 GHz technical framework. An outline of the reasoning leading to selection of the proposed models and requirements has been provided for information. Note that this paper deals primarily with co-channel or co-frequency issues.

This is a discussion paper and the views and suggestions of the members of the technical liaison group are sought as to the relevance and suitability of the proposed models and requirements.

3 System Models

System models are used to simplify the analysis of the technical framework with regard to the reference technologies. The five reference technologies proposed in the previous discussion paper were:

ENG	Single frequency	ITU-R F.1777
UMTS (UTRA)	Two frequency (FDD)	3GPP TS 25.xxx
LTE (E-UTRA)	Two frequency (FDD)	3GPP TS 36.xxx
TD-SCDMA	Single frequency (TDD)	ITU-R M.2039
WiMAX	Single frequency (TDD)	ITU-R M.2116

The adoption of these models also simplifies testing of the technical framework compatibility with other services outside the band. The development of the system models does not exclude the use of other technologies under the licence. The adoption of these system models is simply a tool for the development of the framework.

3.1 Cellular System Models

The cellular IMT2000/IMT-Advanced systems are typically characterised by the use of lower (30 m) omni directional (base) transmitter / receiver sites communicating with either mobile omni antenna devices at 1.5 m or fixed low gain antenna at house roof height (3 m). Systems requirements typically do not permit co-channel cells to operate without a buffer region between them unless synchronisation or other interference management arrangements are agreed between the licensees.

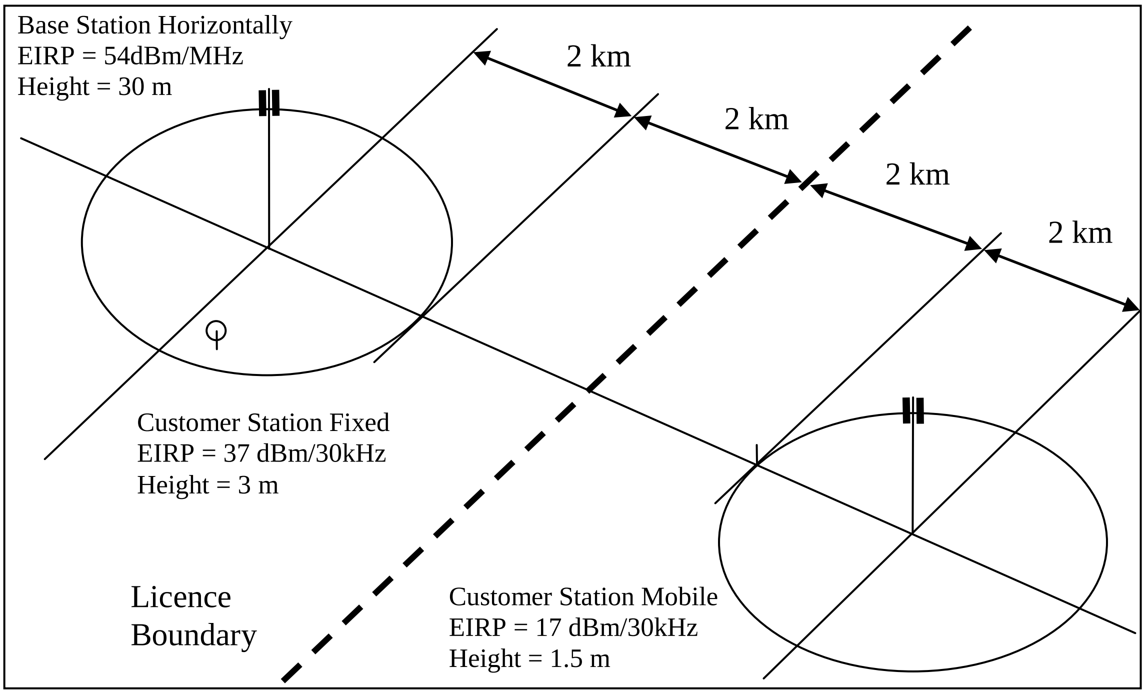

Figure 1 FDD/FDD boundary model (Without agreement)

Figure 1 shows the proposed FDD Macro cell model for the case of two co-channel FDD systems without agreements between the licensees. Note that cell coverage depends on the type of modulation and the mobile clutter environment and can vary between 0.2 and 8 km. The dominant interference mode is high site to low site because of the FDD uplink and downlink frequency separation arrangements. Figure 2 shows the proposed modelling of the co-channel boundary conditions between TDD systems or between mixed systems.

There are potentially two co-channel cases. The first is where the TDD system is operating in the FDD base station transmit portion of the band (2620-2690 MHz) and the second is where the TDD system is operating in the FDD mobile station transmit portion of the band (2500-2570 MHz). In the first case where the TDD system is operated in the FDD base station transmit band there are three co-channel receivers at risk, the two mobile receivers (FDD and TDD) and the TDD base station receiver.

The interference risk to the mobile receivers from the base stations will be similar to the interference risk between co-channel FDD systems in adjacent areas, as the propagation path is high site to low site. The TDD Mobile to FDD mobile interference case is considered to be unlikely between adjacent co-channel areas as the mobiles will typically operate with significant physical separation at the edge of their respective cells. The mobile stations would typically also have no line of sight between them because of low antenna heights and their proximity to the boundary would be transient.

The risk of interference from the FDD base station to the TDD base station receiver dominates in this case due to the high site to high site propagation path. The high site to high site propagation paths are commonly associated with greater interference risk as they have significantly lower path losses for the same distance when comparison to a high site to low site propagation paths. This is due to the absence of ground clutter effects etc.

In the second case where the TDD system operates in the FDD mobile transmit portion of the band the dominant interference risk to the FDD base station receiver from the TDD base station transmitter again a high site to high site interference situation.

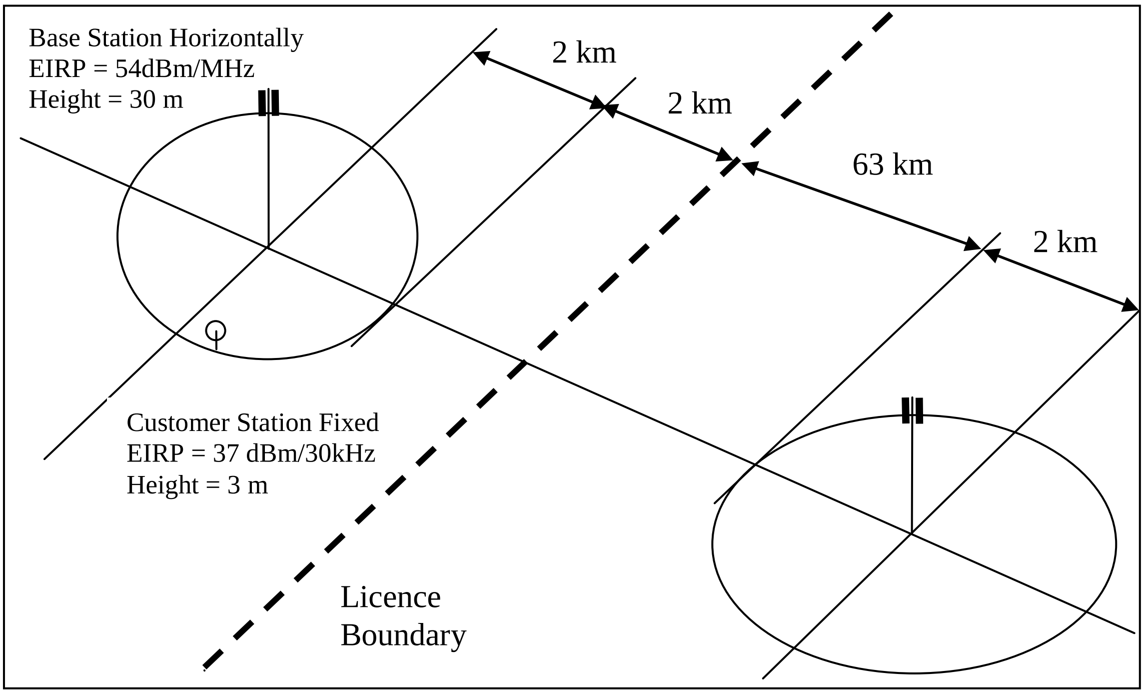

Figure 2 – FDD / TDD boundary model (Without agreement betwen licensees)

The interference risk from a TDD base station in the FDD mobile station transmit segment (2500-2570 MHz) can be minimised by introducing a deployment constraint in the band. A deployment constraint that would limit fixed transmitter antenna height to 3 m or less within 10 km and to 10 m or less within 65 km of the licence boundary would effectively force the interference path from the TDD base station to the FDD base station from a high site to high site path to a low site to high site path similar to the FDD case close to the licence boundary. At greater distances from the boundary the local horizon and distance will provide the necessary loss.

The interference risk to the TDD base station receiver operating in the FDD base station transmit segment (2620-2690 MHz) from an adjacent area cochannel FDD base station transmitter can be managed in a similar way by a deployment constraint on receiver height in this band segment. For example a deployment constraint limiting receiver height to 3 m or less within 10 km and to 10 m within 65 km of the licence boundary.

Potentially fixed point-to-point systems can be operated under the 2.5 GHz Spectrum Licence the proposed deployment constrains support their use in low density areas. Cellular or point to multipoint (point to area) configuration in the above models however represent the most likely configuration in high density areas.

Proposed Cellular system model parameters from ITU-R Reports M.2030, M.2039, M.2113, M.2116 and ECC Report 119 and 131 and CEPT Report 19 are tabled below:

Transmitter – Base Station	CEPT Report 19	UMTS	TD-SCDMA	E-ULTR	WiMax
Transmitter power	44 dBm /5MHz	43 dBm /3.84MHz	34 dBm /1.28MHz	43 dBm /5MHz	36 dBm /5MHz
Antenna gain (includes loss)	17dBi	17 dBi	15 dBi 8Elem. Smart	17 dBi	18 dBi

Max EIRP	61 dBm /5MHz	60 dBm /3.84MHz	49 dBm /1.28MHz	60 dBm /5MHz	54 dBm /5MHz
Max EIRP	54 dBm /MHz	54 dBm /MHz	48 dBm /MHz	53 dBm /MHz	47 dBm /MHz
Antenna gain toward Horizon	14 dBi	14 dBi	12 dBi	14 dBi	15 dBi
Hor. Rad. True Mean Power	36 dBm / 30kHz	36 dBm / 30kHz	33 dBm / 30kHz	35 dBm / 30kHz	29 dBm / 30kHz
ACLR@ 5MHz	45.5 dB	45 dB	70 dB	45 dB	53.5 dB
10 MHz	99 dB	50 dB	70 dB	45 dB	66 dB

Receiver – Base Station	CEPT Report 19	UMTS	TD-SCDMA	E-ULTR	WiMax
Antenna gain	17 dBi	17 dBi	15 dBi	17 dBi	18 dBi
NF		5 dB	7 dB		3 dB
P_N		-103dBm / 3.84MHz	-106dBm / 1.28MHz		-104 dBm /5MHz
Required I/N		-6 dB	-6 dB		-6 dB
Max Interfer. At the receiver	-115 dBm / MHz	-115 dBm / MHz	-113 dBm / MHz		-117 dBm / MHz
Blocking		-40 dBm	-40 dBm	-43 dBm	
ACS @ 5 MHz	43 dB	46 dB	46 dB		70 dB
10 MHz	99 dB	58 dB	58 dB		70 dB

Transmitter – User Terminal	CEPT Rep.19 Mobile	UMTS Mobile	TD-SCDMA Mobile	E-ULTR Mobile	WiMax Mobile
Tx Power	35 dBm /5MHz	21 dBm /5MHz	21 dBm /1.28MHz	23 dBm /5MHz	20 dBm /5MHz
Antenna Gain	0 dBi	0 dBi	0 dBi	0 dBi	3 dBi
Max EIRP	35 dBm /5MHz	35 dBm /3.84MHz	36 dBm /1.28MHz	23 dBm /5MHz	23dBm /5MHz
Max EIRP	29 dBm /MHz		35 dBm /MHz	16 dBm /MHz	
ACLR@ 5MHz	33.5dB	33 dB	33 dB	30 dB	37 dB
10 MHz	45 dB	43 dB	43 dB	30 dB	51 dB

Receiver – User Terminal	ECC Rep.131	UMTS Mobile	TD-SCDMA Mobile	E-ULTR Mobile	WiMax Mobile
Antenna gain	0 dBi	0 dBi	0 dBi	0 dBi	3 dBi
NF	9 dB	9 dB	9 dB		5 dB
P_N	-105 dBm /MHz	-99 dBm /3.84MHz	-104 dBm /1.28MHz		-101 dBm /5MHz
	-6 dB	-6 dB	-6 dB		-6 dB
Max Interfer. At Receiver		-105 dBm /3.84MHz	-110 dBm /1.28MHz		-107 dBm /5MHz

Max Interfer. At Receiver	-111dBm /MHz	-111 dBm /MHz	-111 dBm /MHz		-114 dBm /MHz
Blocking		-44 dBm	-44 dBm		
ACS @ 5 MHz		33 dB	33 dB	33 dB (10MHz)	40 dB
10 MHz		43 dB	43 dB		59 dB

4. Propagation Modelling

The propagation model chosen for the technical framework appears in the Section 145 determination as part of the device boundary criterion. The propagation model selected for this part of the technical framework needs to be:

- suitable for both FDD and TDD cellular systems (e.g. antenna height range);
- a generic model that does not require detailed information on terrain or land usage;
- not too complex; and
- suitable for use in the 2.5 GHz band.

The propagation model does not need to be suitable for the detailed planning of services, and licensees are free to use any model for their own planning needs. The selected propagation model will be the basis of the device boundary criterion on which the ACMA may decide to reject the registration of a transmitter to be operated under the spectrum licence.

4.1 Propagation modelling used overseas

The propagation modelling in CEPT Report 19 where the European BEM model is developed, uses Free Space Loss for short distance (100 m) high site to high site situations (not co-frequency) and ITU-R Recommendation P.1546[2] for longer range co-frequency cases. ECC Report 119 that looks at TDD FDD sharing in the 2.5 GHz band utilises Free Space, Duel Slope and ITU-R P.1411 a short range model for distances around 1 km.

ECC Report 131 that develops the BEM model for user terminal devices utilises the Extended Hata Urban model based on the Modified Hata model found in ERC Report 68 for propagation between the base station and the mobile station and Free Space for all distances less than 40 m. The Extended Hata and Modified Hata models are based on the Hata mobile model an empirical model (based on the measurements of Okumura) that provides a good measure of the effects of building clutter and antenna height effects in urban/suburban areas. While typically associated with mobile applications it is also applicable for fixed paths.

The ITU-R P.1546 model is a point to area model typically used in broadcasting. It covers a very broad frequency range from 30 to 3000 MHz, a number path types including over warm sea paths and a range of time availability from 1 to 50%. ITU-R P.1546 indicates that Okumura-Hata (Urban) produces similar results at distances up to 10 km. ITU-R P.1546 is a however a significantly more complex model requiring the use look up tables and detailed clutter information.

[2] International Telecommunications Union Radiocommunications sector (ITU-R) Recommendation on Propagation (P) 1546 -3 “Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3000 MHz”, Geneva 2007.

4.2 Proposed Propagation model

The proposed propagation model for calculating the device boundary for the purposes of registration in this new framework has been drawn from that used in the 2 GHz spectrum licensed band. It is based on the Hata model as detailed in ERC Report 68 (Feb 2000), Annex B.a.1. See Appendix 1. The model has been used by Study Groups 1 and 3 of the International Telecommunication Union radiocommunications sector (ITU-R) for high site-to-low site propagation modelling in various UHF sharing studies. The model as noted above has close links to the modelling used in the various European studies.

The base Hata model set out in ERC Report 68 was modified in the 2 GHz technical framework by providing a different model at effective antenna heights above 500 m. This is because the roll off of height gain factor in the Hata model could lead to a negative height gain factor on longer paths. The model proposed for the 2.5 GHz framework will simply limit the maximum effective antenna height to 500 m. This removes the need for two formula without introducing significant variation for a small number of sites (<1%).

The model has been chosen in preference to ITU-R P.1546 model because it is easier to implement and describe in the section 145 Determination. The choice of urban rather than suburban brings the results of the Hata model closer to those of ITU-R P.1546 and reduces the necessary set back distance. The variations between the two models occur at the distance extremes that are less likely to be of issue.

The following graph shows typical attenuation levels for the free space, Hata Suburban, Hata Urban and ITU-R P.1546 models for a base station antenna height of 30 m and mobile station heights of 1.5 and 3 m for 50% of locations and 10% time, a clutter height of 15 m, over land paths.

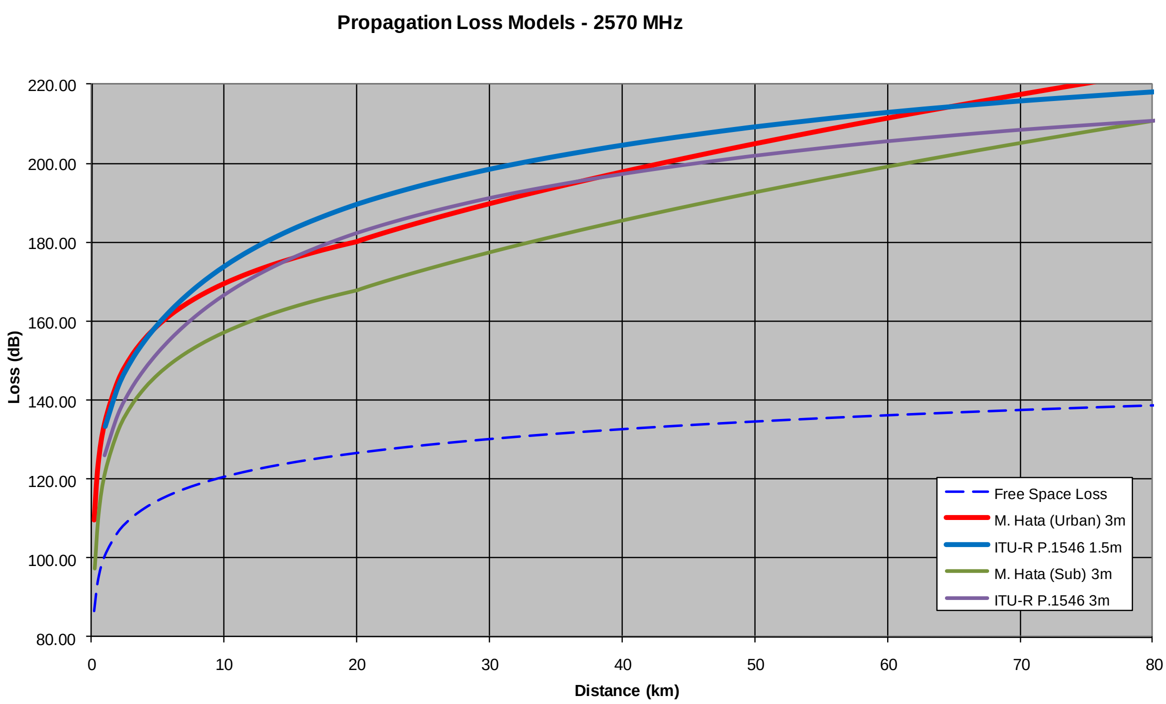

Figure 3 – Propagation Loss Models

5. Level of Protection

The level of protection is the benchmark level of protection given to receivers from co-channel emissions from transmitters. This benchmark level is also used in the calculation of the device boundary criterion used to determine if a transmitter is likely to cause unacceptable interference for the ACMA registering a transmitter for use and therefore limits emissions over the geographic boundaries of the licence.

This level in the spectrum licence technical framework is typically based on factors including receiver sensitivity, system noise floors, protection ratios, margins and allowances. FDD system arrangements make the interference path a high site to low site or a low site to high site propagation path. This type of propagation path has higher losses compared to free space high site to high site paths. This reduces the necessary separation distance from the interference source. See Figure 2.

Where a TDD system is involved the dominant interference is between base station and base station, a high site to high site interference path. Propagation loss on high site to high site paths is generally considered free space for short paths (co-geographic area). It is proposed to use deployment constraints based on antenna height to ensure the propagation for co-frequency TDD systems is high site to low site or mobile to mobile.

The Protection This Level of Protection Does Not Provided

It should be noted that this Level of Protection is co-channel and will not necessarily provide the protection from interference from devices operating in frequency adjacent spectrum licences in the same geographic area. Receiver blocking and desensitisation are examples of this type of interference however these interference mechanisms should only occur for stations located within the site interference management requirements of the licence.

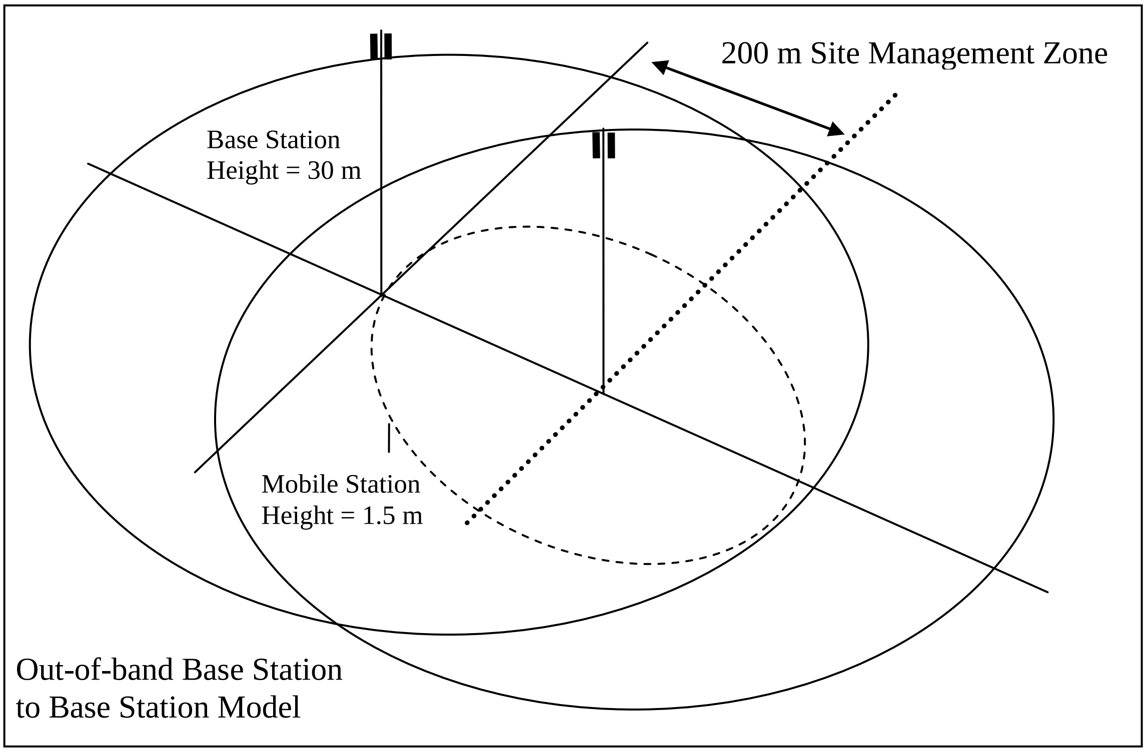

Figure 4 – Adjacent frequency same area case.

As an example, adjacent frequency TDD base station receivers located close to FDD base station transmitters are at risk of suffering interference due to blocking or desensitisation due to the presence of high level signals in the adjacent spectrum rather than from out-of-band emissions falling in the receiver bandwidth even with the inclusion of a TDD guard band.

The licence as in the past will contain a requirement for licensees to self manage site interference issues within 200m of a transmitter operated under the licence. It is necessary when planning a site for a transmitter to be operated under the spectrum licence to coordinate with existing stations located in other bands. Guidelines for this coordination are examined in the next discussion paper. The ACMA will act as the final arbiter where necessary, taking into account these guidelines, existing regulatory arrangements and the technical framework of this spectrum licence.

5.1 Levels of protection overseas

CEPT Report 19 makes use of several protection levels within its studies. The one of most relevance to the level of protection used in the Australian spectrum licensing is the maximum interference power density at the receiver Irx = -115 dBm/MHz[3]. This figure is for base station receivers. ECC Report 131 that extends the BEM model for terminal stations uses two terminal station interference protection levels: -105 dBm/MHz for 3 dB noise floor increase and -111 dBm/MHz for 1 dB noise floor increase.

ECC Report 119 includes maximum interference power levels for receivers of the various technologies. These limits vary from -111 dBm/MHz to -117 dBm/MHz, based on a I/N of -6 dB (1 dB noise floor increase) and are tabled in section 3.2 above. In determining the proposed level of protection to adjacent licence areas consideration must be given to high site to low site interference and high site to high site interference where TDD systems are involved.

Using the modelling described previously for the high site to low site path, a path loss figure and minimum separation distance can be calculated as set out below.

Co-channel High Site to Low Site Interference (base to mobile) Calculation			
	Best Case	Typical	Worst Case
Receiver Interference level (UE)	-111 dBm/MHz	-111 dBm/MHz	-114 dBm/MHz (WiMax)
Receiver Antenna gain	0 dBi	0 dBi	3 dBi
Level incident on Antenna	-111 dBm/MHz	-111 dBm/MHz	-117 dBm/MHz
Base Station Horiz. EIRP	47 dBm/MHz	54 dBm/MHz	54 dBm/MHz
Required path loss	**158** dB	**165 dB**	**171** dB

[3] CEPT Report 19 Annex IV section A4.2 pg 70.

Required Separation Distance			
Frequency	2570 MHz	2570 MHz	2570 MHz
Antenna Heights	Tx 30 m, Rx 1.5 m	Tx 30 m, Rx 1.5 m	Tx 30 m, Rx 1.5 m
Hata/COST 231 urban	3.5 km	5.6 km	8.4 km

The same can be done for the high site to high site (TDD) situation:

Co-channel High Site to High Site Interference Calculation		
	Typical	Worst
Receiver Interference Level	-115 dBm/MHz	-117 dBm/MHz
Receiver Antenna Gain - losses	14 dBi (17-3dB)	15 dBi (18-3dB)
Level Incident on Antenna	-129 dBm/MHz	-132 dBm/MHz
Base station EIRP	51 dBm/MHz	54 dBm/MHz
Required Path Loss	**180** dB	**186** dB
Required Separation Distance		
Frequency	2570 MHz	2570 MHz
Antenna Heights	30 m, 30 m	30 m, 30 m
Smooth Earth	68 km	71 km
Hata /COST 231 urban	60 km	69 km

These distances are well beyond the radio horizon (22 km) so the off-axis gain due to down tilt has been used. The distances are in-line with the model in Figure 2 on page 4.

5.2 Proposed Level of Protection

The choice of a level of protection is a balance between the set back requirements and the protection of receivers for adjacent co-frequency licensees. The requirement is used principally in determining registration requirements for base stations. The CEPT Report 19 level of -115 dBm/MHz provides base station receiver protection. However in the high site to low site FDD model it is typically the mobile receiver at risk from the base station. The levels in Report 131 of -105 dBm/MHz or -111 dBm/MHz for mobile receiver protection could be used for the level of protection however it is not intended to register mobile receivers.

	Base to Mobile	Mobile to Base
Receiver Interference Level	-111 dBm/MHz	-115 dBm/MHz
Receiver Antenna Gain	0 dBi	17 dBi
Level Incident on Antenna	-111 dBm/MHz	-132 dBm/MHz
Base station EIRP	54 dBm/MHz	29 dBm/MHz
Required Path Loss	165 dB	161 dB

The selected interference protection level must take into account the various technologies weighted towards base station protection as the base station is at a higher risk of interference because of their relative antenna height and fixed location. The level of protection in the surrounding bands varies from -105 dBm in the 2.3 GHz band to -118 dBm in the 2 GHz band. The level of protection is -111.6 dBm in the 3.4 GHz band.

This analysis suggests the adoption of a proposed level of protection at the registered base station receiver of -115 dBm/MHz but leads to the question: What is the appropriate level at the boundary for the purposes of the Device Boundary Criterion? The answer to this question will be provided later in this paper.

The proposed level of protection at the base station receiver is -115 dBm / MHz.

6. Device Boundary Criterion

The device boundary of a transmitter, calculated using the device boundary criterion, must lie within the geographic boundary of the licence otherwise the transmitter may be declared under the Section 145 determination to cause unacceptable interference. The device boundary aims to minimise co-channel interference across the geographic boundary of the licence.

It does this by regulating the maximum radiated power level of transmitters located near the boundary of the licence. Alternatively it can be seen as a tool for calculating the necessary set back of transmitters from the boundary of the licence to minimise the interference risk to receivers in the adjacent licence geographic area.

ACMA intends to introduce new methods for determining a transmitter device boundary. These methods simplify the calculation of average site heights from the terrain database with changes expected to be included in all new or renewed spectrum licences technical frameworks.

Details of the proposed changes can be found in a discussion paper on general TLG SharePoint site. The following is therefore an outline of the process for the purposes of this discussion paper. The device boundary is drawn up by applying the device boundary criterion to the radio propagation paths along 180 azimuth radials or 2 degrees about the proposed transmitter site.

The device boundary criterion value is calculated at 500 m intervals outward along each radial out to a maximum distance of 70 km. The position of the device boundary is located on the radial at a distance where the value of the device boundary criterion diminishes to zero or first becomes a negative value or at a distance of 70 km where the radial does not cross the licence boundary.

The device boundary criterion is the difference between the horizontally radiated power of the transmitter including the level of measurement uncertainty and the modelled propagation loss of the path combined with the level of protection at the geographic boundary of the adjacent licence area. The 70 km limit provides a simplified practical limit beyond which the risk of interference falls to within the uncertainty of mobile operation for all practical transmitter heights across Australia in this band including that for TDD operation.

6.1 Overseas Framework Limits

CEPT Report 19 recommends the use of a field strength at the edge of the service area in the absence of any other agreed value of 21 dBuV/5MHz/m at 10% time, 50% of locations at 3 m above the ground calculated using ITU-R P.1546 as a trigger value for coordination to prevent harmful interference between co-frequency areas. This field strength level equates to a path loss of 185 dB as calculated using ITU-R P.1546 for a 30 m high station antenna with an e.i.r.p of 61 dBm/5MHz at a distance of about 15 km from the boundary.

6.2 Proposed Boundary Criterion

The CEPT Report 19 boundary limit leads to boundary separation distance (15 km) significantly greater than those calculated in the previous section of this report for the separation of adjacent FDD systems (8.4 km). The associated path loss (185 dB) is however within the range calculated in the previous section for the high site to high site scenario (180-186 dB). This suggests that the level has been chosen to capture the TDD case, although the 3 m height and the 15 km set back from the boundary does not directly reflect this.

Direct adoption of this coordination trigger limit would result in the need for more coordination between co-channel FDD systems near the geographic licence boundaries. The adoption of the previously mentioned deployment constraints for TDD systems available under the Australian spectrum licence technical framework to capture the TDD situation would allow a reduction in the potential amount of coordination for FDD operators.

It is therefore proposed to adopt a device boundary criterion based on the receiver interference modelling based on the path attenuation levels calculated in section 5.2 above rather than the boundary field strength level in CEPT Report 19. This will significantly reduce the level of direct coordination necessary between licensees using FDD systems. It is proposed as previously mentioned to handle the situation where a co-channel TDD system (base station transmitter in the uplink band) through a set of deployment constraints.

The level of path loss from the typical base station to the mobile receiver in section 5.2 is 165 dB. Using the Hata model for a 30 m base station and 1.5 m mobile occurs at a distance of ~6 km (5.6 km actual). The distance to the boundary (rather than the receiver in the model) is 4 km and using a mobile height of 3 m at the boundary (as in the CEPT 19 ITU-R P.1546 path modelling) the Hata model calculates a path loss is 155 dB.

The boundary criterion is based on a horizontal radiated power measured in a 30 kHz rectangular bandwidth. Converting the 54 dBm/MHz figure for the horizontally radiated power of model gives 39 dBm/30kHz. This leads to the following calculation for the level at the boundary:

39 dBm/30kHz – 155 dB = -116 dBm/30kHz at the boundary.

The Hata propagation model from ECR Report 68 has been simplified for use in the device boundary criterion by adoption of a reference frequency of 2570 MHz and a receiver antenna height at the boundary of 3 meters. It is similar in form to that found in the 2 GHz and 2.3 GHz technical frameworks. The propagation loss is based on the latest version of the formula in ERC Report 68 not the earlier version in the 2 GHz framework.

Device boundary criterion (2.5 GHz)

The device boundary criterion (2.5 GHz) is the value of the mathematical expression:

$$= HRP - MP$$

where:

HRP is the maximum horizontally radiated power in EIRP dBm/30kHz for each bearing ϕ_n determined with an error of ± 0.5 dB;

MP is the sum of the level of protection at the boundary and the path propagation loss calculated as set out below, being a function of $he_m(\phi_n)$ and $d_m(\phi_n)$,

where:

$he_m(\phi_n)$ is the effective antenna height of the transmitter measured in metres for segment m (m being any integer from 1 to 200) for each bearing ϕ_n;
for $he_m(\phi_n) > 500$ m, $he_m(\phi_n)$ will be made = 500 m; and

$d_m(\phi_n)$ is the distance in m·1 kilometres steps, calculated for segment m and measured in kilometres with an error of less than ± 0.01 km, for each bearing ϕ_n.

$MP(he_m(\phi_n), d_m(\phi_n))$ is measured in units of dB and is calculated as below.

For $0 < d_m(\phi_n) \leq 20$ km:

$$MP = 159.29 - 13.82 \text{ x } \log(\max[30; he_m(\phi_n)]) - \min([0;20 \text{ x } \log(he_m(\phi_n)/30)]) - 4.63 + \{44.9 - 6.55 \text{ x } \log(\max[30;he_m(\phi_n)])\} \text{ x } \log(d_m(\phi_n)) - 116 \text{ dB}$$

For $20 < d_m(\phi_n) \leq 100$ km:

$$MP = 159.29 - 13.82 \text{ x } \log(\max[30; he_m(\phi_n)]) - \min([0;20 \text{ x } \log(he_m(\phi_n)/30)]) - 4.63 + (\{44.9 - 6.55 \text{ x } \log(\max[30;he_m(\phi_n)])\} \text{ x } (\log(d_m(\phi_n))\hat{}\alpha) - 116 \text{ dB}$$

where: $\alpha = (1 + [0.54 + 0.00107 \text{ x } he_m(\phi_n)] \text{ x } [\log(d_m(\phi_n)/20)]^{0.8})$

The effective antenna height is determined with reference to the height above ground of the antenna and the relative ground height difference between the antenna site height and the average height about the point where the boundary criteria is calculated. The method of this effective height calculation from the data in the reference database is discussed in the broader TLG group papers due to proposed changes to the terrain database and method of site height averaging. See the TLG discussion paper on Radiocommunications (Unacceptable Levels of Interference) Determinations on the TLG SharePoint site.

7. Other Device Registration Arrangements

These other device registration arrangements typically include arrangements that:

- declaring the use of indoor or low power mobile transmitters within the licence area as not causing unacceptable interference;
- defining a group of transmitters or receivers for the group registration;
- the simplification of the registration requirements for devices located well away from the geographic boundary;
- restrictions on the use of balloon mounted devices; and
- set out deployment constraints to encourage high site / low site frequency selection.

7.1 Proposed Registration Requirements

The proposed registration arrangements to be added to the framework are similar to those found in other spectrum licence technical frameworks. They include arrangements to:

- declare that low power (typically mobile or fixed indoor) transmitters with an EIRP of less than 35 dBm / 5MHz that meet emission mask requirements of the licence as not causing unacceptable interference within the licence area;
- permit group registration of co-located transmitters (and receivers) of similar characteristics (EIRP, emission designator, antenna height and frequency);
- permit group registration of low height (<10 m) restricted power (<35 dBm/5MHz) transmitters of similar characteristics working to common high site receiver;
- declare that the boundary criteria has been met by all transmitters located more than 70 km from the licence boundary; and
- exclude balloon mounted transmitters and antenna.

It is also proposed to place a limit on emissions above the horizon to assist in protecting adjacent services including ENG, radioastronomy and radar services. This limit will not impact typical base stations deployments where antenna down tilt is used as has been assumed in developing this technical framework and in the European studies referenced.

7.2 Proposed Deployment constraints

To accommodate TDD systems within the framework it is proposed to have deployment constraint on the mobile transmit segment 2500-2570 MHz that the maximum height of a transmitter within 10 km of the boundary must be less than 3 m and within 10 and 65 km of the boundary a transmitter must have an effective antenna height relative calculated at the boundary of no greater than 10 m. This forces a low site to high site co-channel interference path near the geographic boundary for both FDD and TDD systems.

In the case of FDD systems there will be no significant impact as the height of the mobile will be typically less than 10 m. The impact on co-channel TDD or point to point systems is to keep transmitters low close to the boundary but to allow them to operate without restriction away from the boundary. The necessary guard space required for full height co-channel TDD base stations will typically only be available in regional or remote areas. The out-of-band emission limits of the licence in this segment typically will require a base station to operate at lower power or with internal guard bands.

In the FDD base transmit segment 2620-2690 MHz rather than restricting the transmitter height it is proposed to provide interference protection to receivers with antenna effective heights to no greater than 3 m within 10 km of the boundary and 10 m within 10 and 65 km of the boundary. This forces interference paths to high site to low site in the proximity of the boundary. This allows FDD base stations to be located closer to the boundary without coordination while still providing for the management of TDD or point to point systems should they be used in this segment.

The European BEM introduced a guard or restricted use block between blocks wherever one or more of the systems is a co-channel TDD system. The proposed arrangements for the Australian 2.5 GHz band have not included a separate type of block or licence (restricted use or guard block) apart from those within the mid band gap. The necessary guard bands will need to be found within the spectrum purchased by a licensee for co-channel TDD use. The initial sale as paired spectrum will favour FDD use and thereafter existing FDD systems will be protected by the need for new TDD operators to coordinate with existing registered FDD receivers.

8. Comment Period

The comment period for this initial release of the discussion paper closes 12th of September 2011. Comment should be placed on the 2.5 GHz Spectrum Licence TLG SharePoint site.

Sub-annex B.a (Reference [3])

Propagation model

A number of propagation models are provided in the tool. They are depending on the environment chosen for the scenarios :

- general environment : open area, suburban or urban area,
- environment for the interferers : indoor or outdoor,
- environment for the victim receiver : indoor or outdoor.

The domain of validity for the models is described in the table below:

Below 30 MHz	No model available. Curves of Rec. ITU-R P368 is suited for high power transmitters and large distances and is therefore not adapted to interference calculations.
Between 30 MHz and 3 GHz	Modified Hata path loss calculations. Care should be taken when propagation distances are expected to be above 20 km. Indoor-indoor and indoor-outdoor models also suitable.
Above 3 GHz	Modified Hata model not advised. Spherical diffraction model is suitable for open area environment. No model available for suburban and urban environment. Indoor-indoor and indoor-outdoor models also suitable.

To improve the flexibility of the tool, a "generic" model (L = A + B log(d) + Cd) <u>both for the wanted signal path and the interfering path</u> can also be entered by the user. The user of the tool is then to enter the parameters A, B, C of the median attenuation formula and the distribution of the variation in path loss Dv. As a default distribution, a lognormal distribution is to be proposed with a standard deviation to be entered by the user. Then we have :

$$f_{propag}(d) = L + T(Dv)$$

Also, more elaborate models can be implemented by the user using a simple script.

B.a.1. Modified Hata model

$$f_{propag}(f, h_1, h_2, d, env) = L + T(G(\sigma))$$

L = median propagation loss (dB)
σ = deviation of the slow fading distribution
f = frequency (MHz)
$H_m = \min(h_1, h_2)$
$H_b = \max(h_1, h_2)$
d = distance (km), preferably less than 100 km.
env = (outdoor/outdoor), (rural, urban or suburban), (propagation above or below roof)

If H_m and/or H_b are below 1 m, a value of 1 m should be used instead. Antenna heights above 200 m might also lead to significative errors.

Propagation below roof means that both H_m and H_b are above the height of roofs. Propagation is above roof in other cases (H_b above the height of roofs).

Calculation of the median path loss L :

<u>Case 1</u>: $d \leq 40\ m$

$$L = 32.4 + 20 \log(f) + 10 \log[d^2 + (H_b - H_m)^2 / 10^6]$$

<u>Case 2</u>: $d \geq 100$

$$a(H_m) = (1.1 \log(f)- 0.7) \cdot \min\{ 10; H_m \} – (1.56 \log(f) – 0.8) + \max\{ 0; 20 \log(H_m / 10)\}$$

$$b(H_b) = \min\{ 0;\ 20 \log(30)\}$$

$$\alpha = \begin{cases} \alpha = 1 & d \leq 20 \text{ km} \\ \alpha = 1 + (0.14 + 1.87 \times 10^{-4} \times f + 1.07 \times 10^{-3} \times H_b)(\log(d / 20))^{0.8} & 20 \text{ km} < d < 100 \text{ km} \end{cases}$$

Subcase 1: Urban

- $30\ MHz < f \leq 150\ MHz$

$$L = 69.6 + 26.2 \log(150) – 20 \log(150 / f)$$
$$- 13.82 \log(\max\{ 30; H_b \}) + \alpha . [44.9 – 6.55 \log(\max\{ 30; H_b \})\log(d)$$
$$- a(H_m) – b(H_b)$$

- $150\ MHz < f \leq 1500\ MHz$

$$L = 69.6 + 26.2 \log(150)$$
$$- 13.82 \log(\max\{ 30; H_b \}) + \alpha . [44.9 – 6.55 \log(\max\{ 30; H_b \})\log(d)$$
$$- a(H_m) – b(H_b)$$

- $1500\ MHz < f \leq 2000\ MHz$

$$L = 46.3 + 33.9 \log(f)$$
$$- 13.82 \log(\max\{ 30; H_b \}) + \alpha . [44.9 – 6.55 \log(\max\{ 30; H_b \})\log(d)$$
$$- a(H_m) – b(H_b)$$

- 2000 MHz < f < 3000 MHz

$$L = 46.3 + 33.9 \log(f) + 10 \log(f / 2000)$$
$$- 13.82 \log(\max\{ 30; H_b \}) + \alpha . [44.9 – 6.55 \log(\max\{ 30; H_b \})\log(d)$$
$$- a(H_m) – b(H_b)$$

Subcase 2 : Suburban

$$L = L(urban)$$
$$-2 . \{ \log[(\min\{ \max\{ 150; f \}; 2000 \}) / 28] \}^2 – 5.4$$

Subcase 3: Open area

$$L = L(urban)$$
$$-4.78 . \{ \log(\min\{\max\{ 150; f \}; 2000\}) \}^2 + 18.33 . \log(\min\{ \max\{150; f \}; 2000\})$$
$$-40.94$$

<u>Case 3</u>: $40\ m < d < 100\ m$

$$L = L(40) + \frac{[\log(d) – \log(40)]}{[\log(100) – \log(40)]} \times [L(100) – L(40)]$$

When L is below the free space attenuation for the same distance, the free space attenuation should be used instead.

Assessment of the standard deviation for the lognormal distribution

<u>Case 1</u>: $d \leq 40$ m :

$\sigma = 3.5$

<u>Case 2</u>: $40\ m < d \leq 100$ m :

$$\sigma = 3.5 + \frac{(12 – 3.5)}{100 – 40} \times (d – 40)$$ for propagation above roofs,

$$\sigma = 3.5 + \frac{(17 – 3.5)}{100 – 40} \times (d – 40)$$ for propagation below roofs

<u>Case 3</u>: $100\ m < d \leq 200$ m :

$\sigma = 12$ for propagation above roofs,

$\sigma = 17$ for propagation below roofs

Case 4: $200 < d \leq 600$ m:

$$\sigma = 12 + \frac{(9 - 12)}{(600 - 200)} \times (d - 200) \text{ for propagation above roofs,}$$

$$\sigma = 3.5 + \frac{(9 - 17)}{(600 - 200)} \times (d - 200) \text{ for propagation below roofs}$$

Case 5: $600 \text{ m} < d$:

$\sigma = 9$ dB