RALI : FX 3

DATE OF EFFECT : 26/08/1998

Sequence Number : 137 (125) (96) (12)

Radiocommunications Assignment and Licensing Instruction

MICROWAVE FIXED SERVICES

FREQUENCY COORDINATION

AUSTRALIAN COMMUNICATIONS AND MEDIA AUTHORITY

SPECTRUM PLANNING BRANCH, SPECTRUM ENGINEERING SECTION

CANBERRA

January 2008

RADIOCOMMUNICATIONS ASSIGNMENT AND LICENSING INSTRUCTIONS

Suggestions for improvements to Radiocommunications Assignment and Licensing Instructions may be addressed to the Manager, Spectrum Engineering, Spectrum Planning Branch, Australian Communications and Media Authority, P.O. Box 78, BELCONNEN ACT 2616.

Amendment Authorisation

The following amendments to RALI FX3 are authorised:

Date of Effect	Page Date*	Description of Amendment
24 October 2014	October 2014	Changes as a results of IFC 31/2014 to Appendix 1 channel plans-1.8 GHz, 2.1 GHz, 2.2 GHz, 2.5 GHz (change to spectrum licensing), 6 GHz, 6.7 GHz, 8 GHz, 10 GHz, 11 GHz, 13 GHz, 15 GHz, 22 GHz, new 28 GHz and consequential updates to Appendix 3
18 January 2008	January 2008	The following changers were made to remove references to the 58 GHz Band as this band has been included in FX20 "Millimetre Wave Point to Point (Self-coordinated) Stations". Main Text – Deleted references to 58 GHz Band. – Deleted reference to MDS. Appendix 1 – Deleted references to 58GHz Band in preamble and deleted 58 GHz Band RF Channel Arrangements. Appendix 10 – Deleted 58 GHz Band Notional Antenna Appendix 11 – Deleted 58 GHz Band Antenna Compliance requirements.
11 August 2006	August 2006	Front pages: amended to reflect current organisational names etc. Main Body: amended to reflect current organisational names, minor editorial changes. Appendix 1 - RF Channel Arrangements and Assignment Instructions amended as follows : Preamble: updated embargo references, reinstated 2.2 GHz band, minor editorial changes. 1.8 GHz band: added reference "Strategies for WAS" paper, added requirement for Advisory Note BL in candidate WAS bands, added reference embargo 38 and consequential changes, amended reference embargo 26 and consequential changes, added reference MS 31 and consequential changes, minor editorial changes. 2.1 GHz band: added reference "Strategies for WAS" paper, added requirement for Advisory Note BL in candidate WAS bands, added reference embargo 26 and consequential changes, added reference embargo 38 and consequential changes, added reference to FX 19 and consequential changes, added reference 2.1 GHz Band Plan and consequential changes, added reference MS 31 and consequential changes, minor editorial changes. 2.2 GHz band: reverted to April 2004 version, added reference "Strategies for WAS" paper, added requirement for Advisory Note BL in candidate WAS band, added need to coordinate with 2.1 GHz services, added references embargoes 23/26 and consequential changes, added reference to MSS band plan, added reference MS 31 and consequential changes, minor editorial changes. 2.5 GHz band: added reference "Strategies for WAS" paper, added requirement for Advisory Note BL in candidate WAS band, added reference embargo 43 and consequential changes,

		minor editorial changes. 3.8 GHz band: added reference "Strategies for WAS" paper, added requirement for Advisory Note BL in candidate WAS band, added reference embargo 42 and consequential changes, added need to coordinate 4 GHz fixed services / FSS / radiolocation, amended ITU-R recommendation to latest revision, minor editorial changes. 5 GHz band: added reference "Strategies for WAS" paper, added requirement for Advisory Note BL in candidate WAS band, amended ITU-R recommendation to latest revision, minor editorial changes.
6 September 2005	September 2005	Appendix 1 – RF Channel Arrangements and Assignment Instructions updated as follows: Revision of assignment instructions in 2.1 GHz band and removal of assignment instructions in 2.2 GHz band due to Embargo 23. Removal of MDS A band plan and references to MDS A within 2.1 and 2.2 GHz bands.
8 April 2005	April 2005	Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows: Summary table amended to remove MDS A band and to reflect changed frequency range of 2.5 GHz ENG band. 1.5 GHz and 1.5 GHz DRCS bands - updated notes concerning point-to-multipoint systems in defined rural and remote areas. Requirement to apply Advisory Note BL to all assignments in the 1452-1492 and 1518-1535 MHz frequency ranges 2.5 GHz ENG band –pre- 7 March 2005 channel arrangements removed. 8.3 GHz band – modified to reflect inclusion of channel 2 within ABC TOBN licence. 13 GHz band – clarified application of no interference, no protection condition on TOB assignments 18 GHz band - Removal of Notes allowing assignments under the previous channel arrangements that were superseded in 1996. Note relating to Embargo 25 has been revised and Note about Advisory Note BL has been revised. Minimum path length requirements have been revised.
7 April 2004	April 2004	The following changes were required as a result of the introduction of the antenna compliance regime based on front-to-back ratio and cross-polar discrimination: Main text Sections 3.1.4, 3.2.4 and 4.2.2 were updated. Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows: Introductory text updated to reflect change from notional antenna regime to antenna requirements under Appendix 11. Notional antenna pattern envelopes removed from all band modules, as necessary, and placed in Appendix 10 Annex A.

		Appendix 6 updated to remove case studies referring to notional antennas. Appendix 10 (including Annex A) added detailing notional antennas regime and consolidating radiation pattern envelopes. Appendix 11 added detailing antenna compliance requirements. Consequential update to Table of Contents (Appendices) to reflect addition of Appendix 10 and 11. Also a number of minor changes and editorials were made throughout the document.
16 September 2003	September 2003	Appendix 1 – RF Channel Arrangements and Assignment Instructions updated as follows: Group A MDS band updated to reflect revised dates in *"2.1 GHz Band Frequency Band Plan 2002";* 2.1 GHz Band updated to reflect revised dates in *"2.1 GHz Band Frequency Band Plan 2002";* 2.2 GHz Band updated to reflect revised dates in *"2.1 GHz Band Frequency Band Plan 2002"* and some simplifications due to removal of text that described transitional arrangements that are now in place. Other parts have also been updated as follows: Summary table of Microwave Fixed Service Bands – Typical Utilisation Parameters.
17 December 2002	December 2002	Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows: Changes to the 1.8 GHz Band to introduce coordination requirements with 2 GHz spectrum licences, remove reference to coordination with private CTS, add reference to coordination with FWA services and remove Advisory Notes F4, BL and BN.
23 August 2002	August 2002	Section 3.2.2 - text added to reflect output power restrictions to FS operating in the band 18.6-18.8 GHz as specified in Article 21.5A Appendix 1 – RF Channel Arrangements and Assignment Instructions updated as follows: 18 GHz band - updated to include note on power restriction above. 2.5 GHz ENG band – revised start date for new channelling arrangements and inclusion of a note concerning no protection from spread spectrum devices in the band 2463-2483.5 MHz.
. 3 June 2002		Appendix 1 – RF Channel Arrangements and Assignment Instructions updated as follows:
	June 2002	Group B MDS band deleted (now spectrum licensed – no apparatus licensing in this band);
	June 2002	Group A MDS band updated to reflect introduction of *"2.1 GHz Band Frequency Band Plan 2002";*
	June 2002	2.1 GHz Band updated to reflect the introduction of the *"2.1 GHz Band Frequency Band Plan 2002"* and the *"Mobile-Satellite Service (2 GHz) Frequency Band Plan 2002";*
	June 2002	2.2 GHz Band updated to reflect the introduction of the *"2.1*

		GHz Band Frequency Band Plan 2002".
		Other parts have also been updated as follows:
	June 2002	Summary table of Microwave Fixed Service Bands – Typical Utilisation Parameters.
15 January 2002		Appendix 1 – RF Channel Arrangements and Assignment Instructions updated as follows:
	January 2002	Change to the 38 GHz Band notional antenna radiation pattern envelope (RPE). The RPE was altered between 0 to 5.5 degrees.
13 December 2001		Appendix 1 – RF Channel Arrangements and Assignment Instructions updated as follows:
	December 2001	Change ABC designated channels (channels 4, 7, 15 and 18) to S (shared) channels and change arrangements for access between 7250 and 7375 MHz by non-Defence licensees.
19 October 2001		Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows:
	October 2001	Remove reference to Manager, Radiocommunications Licensing Policy Team on the first page.
	October 2001	Add 2.2 GHz entry to table "Microwave Fixed Service Bands - Typical Utilisation Parameters".
	October 2001	Remove Advisory Notes F4, BL and BN in the 2.1 GHz Band.
	October 2001	Remove Advisory Notes BN and BL and reference to Embargo 23 in the 2.2 GHz Band.
	July 2001	Correct page date error for RPE [Page Date August 1998] and reinstate correct version of protection ratio correction factors graph [Page Date October 1999] in 7.5 GHz Band.
	June 2001	Correct page date error on page 2 [Page Date June 2001], correct page date error for RPE and protection ratio tables [Page Date August 1998] and reinstate correct version of protection ratio correction factors graph [Page Date October 1999] in the 13 GHz Band.
		Other parts have been updated as follows:
	October 2001	Consequential update to Table of Contents (Appendices) to reflect Appendix 7 title change.
	October 2001	Consequential update to Part 4.2.5 to reflect Appendix 7 title change.
	October 2001	Additions to References due to 2.1 and 2.2 GHz Band references.
	October 2001	Correction to unwanted signal power formula in Part 4.2.3.
	October 2001	Change "Amendment History" to "Amendment Authorisation".
28 September 2001		Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows:
	September 2001	Changes to the 2.1 GHz Band to accommodate the new 2.2 GHz Band, introduce coordination requirements with 2 GHz and 2.3 GHz spectrum licences, update coordination requirements with MDS A services, introduce coordination requirements with

	September 2001 September 2001	Defence aeronautical mobile telemetry systems, update protection ratio tables, and update channel availability. Add the 2.2 GHz Band. Appendix 7 updated to incorporate advice for coordination of fixed services in the 2.1 and 2.2 GHz Bands with 2 GHz spectrum licences.
21 August 2001	 June 2001 June 2001 June 2001 June 2001 July 2001 June 2001 June 2001	Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows: Change to the 2.5 GHz Band method of channel designation from centre frequency and channel width to lower and upper frequency bounds. Change to the 7.2 GHz Band method of channel designation from centre frequency and channel width to lower and upper frequency bounds. Change to the 8.3 GHz Band method of channel designation from centre frequency and channel width to lower and upper frequency bounds. Change to the 13 GHz Band method of channel designation from centre frequency and channel width to lower and upper frequency bounds for TOB. 7.5 GHz Band updated to accommodate higher demand for wider bandwidth channels - channel raster and protection ratio tables. Annex A updated to accommodate ITU-R Recommendation P.837-3. Table "Microwave fixed services bands - typical utilisation parameters" updated. Table "Index of RF Channel Arrangements" deleted.
22 January 2001	 January 2001 January 2001	Appendix 1- RF Channel Arrangements and Assignment Instructions updated as follows: Table "Microwave fixed services bands - typical utilisation parameters" updated to reflect spectrum licensing in the 3.4 GHz Band and the Group B MDS Band. Channel arrangements for the 3.4 GHz Band updated.
29 May 2000	 May 2000 May 2000 May 2000 May 2000	Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows: Corrections to Notes text and addition of Advisory Notes in 1.8 GHz Band. Correction to Reference 8 title and addition of Advisory Notes in 2.1 GHz Band. Addition of text to reflect new band plan and Embargo 23 in the Group A MDS Band. Addition of text to reflect spectrum licensing and Embargo 26 in the Group B MDS Band.
20 April 2000	March 2000	Appendix 3 updated to include interim guidelines for digital

		fixed services, based on ETSI and FCC emission criteria.
14 February 2000	February 2000	Part 4 - 'Frequency Coordination' page 29 amendment of the net effective antenna gain equation and page 31 amendment of the summation of individual interference entries equation.
January 2000		Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows:
	January 2000	The 1.8 GHz Band amended to take account of additional spectrum allocated for spectrum licensing.
	January 2000	The 7.2 GHz Band amended to include a reference to Embargo 30.
	January 2000	Appendix 7 amended to take account of additional spectrum allocated for spectrum licensing.
29 October 1999		Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows:
	October 1999	Protection ratio correction factor curves updated for the 1.5, 1.5 DRCS, 1.8, 2.1, 3.8, 6, 6.7, 7.5, 8, 10, 11, 13, 15, 18, 22, 38 and 50 GHz Bands.
	October 1999	Antenna RPEs for the 18 and 38 GHz Band redefined.
	October 1999	Appendix 6 references to MS 28 replaced by reference to the information paper "Principles for Decision Making".
	October 1999	Part 1 references to MS 28 replaced by reference to the information paper "Principles for Decision Making".
	October 1999	References updated to include the information paper "Principles for Decision Making".
	October 1999	Correction to text in section 2.1 of Appendix 5 (117.5°E changed to 171.5°E).
	October 1999	Appendix 9 'Adaptive Transmit Power Control' and Annex A to Appendix 9 'ATPC Example Calculations' added.
	October 1999	Consequential amendments to the Table of Contents, sections 3.2.2 and 4.2.2 due to the introduction of Adaptive Transmit Power Control.
31 May 1999		Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows:
	May 1999	The 1.8 GHz Band and the 2.1 GHz Band updated regarding tenure of new and renewed fixed service licences in the bands.
	May 1999	The 58 GHz Band added.
	May 1999	Consequential amendments to the References list.
12 January 1999	December 1998	Appendix 8 'Coordination of DRCS Outstations with Point-to-Point Links' and Annex A to Appendix 8 '1.5 GHz DRCS Outstation Characteristics' added.
	December 1998	Consequential amendments to Part 3.4.1.

	December 1998	RALI AC1 removed from Reference list.
	December 1998	Minor amendment to text in Part 3.1.7, clarifying analogue versus digital protection criteria.
13 October 1998		Appendix 1 - RF Channel Arrangements and Assignment Instructions updated as follows:
	October 1998	New assignment note added to the 3.4, 3.8 and 11 GHz Bands.
	October 1998	New interleaved channel pattern added to the 11 GHz Band.
	October 1998	New protection ratio correction factor graphs added to the 3.8, 6.7 and 11 GHz Bands.
	October 1998	3.4 GHz Band updated reference to FX 14.
	October 1998	Part 3.4.3 updated reference to FX 14.
	October 1998	Reference list added reference to FX 14.
	October 1998	Appendix 4 amended.
	October 1998	Annex A to Appendix 6 amended.

* The Page Date appears at the bottom of each page and indicates the date that the page was last updated.

AMENDMENT AUTHORISATION:

Approved 24/10/2014

Mark Arkell
Manager
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Australian Communications & Media Authority

File: ACMA2005/350

Update History - pre August 1998

SECTION	DATE	COMMENTS
RALI	16/12/97	Sequence Number 125 (96) (12), RALI pages preceding Section 1 were updated.
	23/01/97	Sequence Number 96 (12), RALI updated.
	02/10/92	Sequence Number 12, New RALI.
1 RF Channel Arrangements (previously Channel Arrangements)	10/02/98	Attachment added relating to 1.8 GHz coordination with spectrum licences. The Introduction and 1.8 GHz RF Channel Arrangements and Assignment Instructions have also been updated to reference the new attachment.
	12/12/97	18 GHz Band - Notes 3 and 4 were added to the Assignment Instructions.
	24/09/97	2.1 GHz Band updated.
	15/09/97	1.8 GHz Band updated.
	04/08/97	18 GHz Band updated. 22 GHz Band updated.
	January 1997	8.3 GHz Band updated.
	November 1996	Complete update of Section 1.
	14/11/1996	New RF channel arrangements for the 18 GHz Band.
	09/10/1995	New RF channel arrangements for the 31 GHz Band.
	12/09/1995	New Section 1.
	28/07/1995	New channel arrangement for the 8.3 GHz band.
	28/07/1995	New channel arrangement for the 7.2 GHz band.
	10/10/1994	New interim channel arrangement for the 49 GHz band.
	05/08/1994	New channel arrangement for the 5 GHz band.
	03/05/1993	New attachment to the 13 GHz band channel arrangement.
	30/11/1992	New channel arrangement for the 7.5 GHz band.
	08/10/1992	New channel arrangement for the 15 GHz band.
2 Standard Method of Frequency Coordination		
3 Rules for System Planning and Frequency Coordination	05/08/1994	New notional antenna pattern for the 5 GHz band.
	30/11/1992	New notional antenna pattern for the 7.5 GHz band.
4 Interference Criteria	30/11/1992	New 15 GHz protection ratios.
	08/10/1982	New 15 GHz protection ratios.

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this Radiocommunications Assignment and Licensing Instruction (RALI) FX 3 "*Microwave Fixed Services Frequency Coordination*" document is to describe procedures for the frequency coordination of terrestrial microwave fixed services and to specify key technical radiocommunication policy requirements applicable to these services within the general spectrum management context.

The document is primarily intended for use by Australian Communications and Media Authority (ACMA) and Accredited[1] frequency assigners engaged in the assignment of frequencies for microwave fixed services. As the RALI document specifies important planning rules, recommendations and useful information for the coordination and licensing of microwave fixed services, it will also be of particular interest to telecommunication network operators, system planners and equipment manufacturers/importers.

This RALI replaces RALI FX 3, sequence number 125, dated 16 December 1997.

The information in this document reflects the Australian Communications and Media Authority's statement of current policy in relation to the frequency coordination of microwave fixed services. Users of RALI FX 3 are advised that, recognising that the ITU-R continues to study and make recommendations regarding radiocommunications and associated regulatory and spectrum management issues, this document is subject to ongoing revision. In the application of the policy, ACMA and accredited assigners are required to take all relevant matters into account and to decide each case on its merits[2]. Any consistent anomalies or cases where relevant issues are considered inadequately addressed within the scope of the RALI, should be brought to the attention of the Manager, Spectrum Engineering Section, Spectrum Planning Branch, Australian Communications and Media Authority, PO Box 78 BELCONNEN ACT 2616.

1.2 SCOPE

Microwave fixed services include point-to-point and point-to-multipoint radio systems utilised for the transmission of voice, video and data information. The definition and nature of microwave fixed service systems is further described under Part 2 "*Background*". The scope of the RALI is generally limited to the coordination of homogeneous line-of-sight fixed services operating in specified frequency bands (Refer to Appendix 1), although some of the criteria and methodology may also be useful for the coordination of other types of fixed services.

In general, the coordination of microwave fixed services with other types of radiocommunication services (including Multipoint Distribution Systems (MDS),

[1] Refer to RALI AC 1 "*Requirements for Accredited Frequency Assigners - Assigning Fixed Point-to-Point Microwave Services*".
[2] In accordance with ACA Information Paper "*Principles for Decision Making*".

special types of fixed service systems and inter-service coordination[3]) is detailed in other documents, as identified in the References section of the RALI. However, specific guidance is provided to facilitate the protection of geostationary space services operating within bands shared with fixed terrestrial services, as required under the International Telecommunication Union (ITU) Radio Regulations. Detailed guidance is also provided with respect to the coordination of apparatus licensed fixed services with spectrum licensed radiocommunication services operating within particular frequency bands.

Although the RALI specifies a number of important rules and guidelines which need to be taken into account as part of the system planning process, it is not intended to serve as a link planning document as such. The scope of the specified planning rules and coordination guidelines is limited to the matters considered necessary for the efficient utilisation of the radiofrequency spectrum, management of interference and compliance with relevant domestic and international radiocommunications regulatory requirements. For general link planning purposes, reference should be made to other relevant publications, such as the "*ITU-R Handbook on Digital Radio-Relay Systems*", Geneva 1996 which provides detailed guidance on most aspects of fixed service link planning.

1.3 OUTLINE

The document comprises four main parts:

- Part 1 - (this part) the introduction, detailing the purpose and scope of the RALI;
- Part 2 - provides background information and a brief overview of the general regulatory and technical planning environment for microwave fixed services;
- Part 3 - details specific coordination and system planning rules, necessary for the optimisation of spectrum usage and the management of interference; and
- Part 4 - outlines a basic method of frequency coordination for terrestrial microwave fixed services.

Appendix 1 "*RF Channel Arrangements and Assignment Instructions*" details criteria specific to each of the fixed link frequency bands currently supported in Australia. Further appendices and annexes provide additional supporting material, including some of the more detailed frequency coordination methodologies, interference protection and emission criteria.

The arrangements detailed in this document are based on relevant ITU-R work, studies conducted by the ACMA (and its predecessors) and accepted Australian industry practices. References to the appropriate ITU-R recommendations, RALIs and other documents are incorporated throughout the document and are consolidated in the Reference section of the document.

[3]eg. Cordless Telecommunication Services (CTS), satellite services and Spectrum Licensed services.

2. BACKGROUND

This part of the RALI FX 3 provides background information and a brief overview of the general regulatory and technical planning environment for microwave fixed services.

2.1 MICROWAVE FIXED SERVICE

In accordance with the "*Australian Radiofrequency Spectrum Plan*" (the Spectrum Plan) a "fixed service" is defined simply as "a radiocommunication service between particular fixed points[4]". Thus the basic definition potentially encompasses a very broad range of point-to-point and point-to-multipoint radiocommunication services. The terms "microwave fixed service" and "fixed links", although not formal, are adopted in this document in order to distinguish the types of wideband systems operating in the "microwave" frequency range (about 1 to 60 GHz) from the generic service definition. Other terms, such as "radio-relay systems" are also commonly utilised to denote particular sub-types of microwave fixed services, as outlined in the next sub-part.

2.1.1 Applications

Currently supported microwave fixed service applications may be classified into a number of sub-types, usually defined by their operational application and typically falling into the following main categories:

- trunk radio-relay systems - supporting high speed common carrier networks;
- local network access links **-** usually small to medium capacity, typically used for serving regional, rural and remote areas;
- thin route networks **-** typically small to medium capacity and often used by public and private utility operators and mobile telecommunication operators;
- customer links **-** typically small capacity providing mainly in-house voice and data communications, usually over relatively short distances; and
- studio-to-transmitter and outside broadcast links **-** as typically used by the network broadcasters.

An ever increasing proportion of the above described fixed services support digital communication requirements, with data rates from a few hundred kilobits per second for some local access and telemetry systems and customer links to a current maximum of 155 Mbit/s in support of broadband applications. Analogue microwave fixed services are generally limited to the outside broadcast and limited numbers of older television distribution applications but even in those applications moves are being made toward digital operation.

2.1.2 Spectrum Suitability

Given the basic transmission capacity requirements of modern communication networks and the nature of the radiofrequency spectrum, wideband (≥512 kbit/s) fixed

[4] This definition is also consistent with that given in the ITU Radio Regulations.

service links are generally operated in the microwave region of the spectrum between about 1 to 60 GHz. The spectrum below about 1 GHz is rarely used for such links because of the bandwidth demand imposed by the transmission requirement and in any case this spectrum is already devoted to use by various other radiocommunication services, in particular the broadcasting and mobile services. The upper bound for fixed links is currently considered to be about 60 GHz, due to inherent propagation limitations and cost factors associated with millimetrewave radio technology.

The lower microwave bands, between about 1 to 10 GHz, have traditionally been preferred for long haul radio-relay applications due to their favourable propagation characteristics. Consequently, these bands are well utilised and congested at many locations, including the major telecommunication trunk routes and the larger metropolitan population centres. These lower microwave bands also accommodate the bulk of the population of the older analogue links still in service. Additionally, the
1-3 GHz bands are subject to increasing pressure to accommodate new terrestrial and satellite based mobile telecommunication and broadcasting services.

The bands above about 10 GHz are subject to increasing attenuation and link availability constraints due to rain intensity related outage events. In practice, this equates to decreasing achievable hop lengths. However, these bands offer capacity to support short hop high density applications such as mobile network backbones, customer megalinks and other urban network applications. Re-use distances are significantly smaller and available antenna isolation greater in these higher bands, thus optimising their utility in the high-density urban environment.

2.1.3 Allocations, Band Planning and Channel Arrangements

Australian fixed service frequency allocations are specified in the Spectrum Plan and generally conform to the ITU Radio Regulations fixed service allocations for Region 3.

As outlined in the Spectrum Plan, all of the fixed service allocations between 1 GHz and 60 GHz are also allocated to one or more other services. Not all fixed allocation arrangement options are able to be implemented in all countries, nor would this be sensible. National policies generally determine the use to which each band is put; some bands are reserved for the exclusive use of one service allocation whilst others may be available on a shared basis to one or more of the allocated services. The specific utilisation of each band is subject to particular implementation arrangements, including relevant intra-service and inter-service sharing and coordination considerations, normally derived from ITU agreed criteria. Fixed service microwave bands are generally planned to align with well defined ITU recommendations or other recognised regional standards and to accommodate readily available products. Accordingly, most of the Australian Radio Frequency (RF) Channel Arrangements (as detailed in Appendix 1) are closely aligned with the appropriate ITU-R recommendations.

Internationally, fixed service recommendations are developed by ITU-R Study Group 9, which is tasked with the study of the technical and operational aspects of fixed services. Australian participation in the work of Study Group 9 is coordinated by the ACMA, on advice from the Australian Radiocommunication Study Group 9

(ARSG9). ARSG9 meets regularly to consider international fixed service developments and proposals and contribute to the work of the ITU Radiocommunication Sector. Membership is open to all parties interested in the fixed services; members include private and public sector organisations (eg. the telecommunication carriers, the ACMA and other major fixed link users including defence and broadcasters, equipment manufacturers and other industry bodies).

2.1.4 Equipment Standards

No definitive Australian radiocommunication standards or regulatory type approval procedures are in place, or seen as necessary, for microwave fixed service radiocommunication equipment. However, it is expected that such equipment:

- comply with the arrangements detailed in this document (with particular reference to Part 3.2 "*Radio Equipment Considerations*");
- are operated in compliance with the technical conditions specified in the relevant ACMA licence; and
- be manufactured to conform with the requirements of the International Radio Regulations, relevant ITU Recommendations and/or other recognised world-wide or regional standards.

2.1.5 Licensing

Microwave fixed services are normally licensed, under Part 3.3 of the *Radiocommunications Act 1992*, as Apparatus Licences of the Fixed Licence type[5]. Fixed link licences are also subject to the requirements of the "*Radiocommunications Licence Conditions (Fixed) Licence Determination No.1 of 1997*".

A summary of the applicable Apparatus Licence fees is provided in the ACMA document "*Radiocommunications Apparatus Licence Fees and Charges*", which also incorporates an overview of the Apparatus Licence Fee Framework and the available licence types.

[5] Where necessary, special Apparatus Licence arrangements may be invoked, such as in the case of the Multipoint Distribution Stations and Television Outside Broadcast stations. However, in particular cases other licensing categories may apply, eg. in some circumstances fixed link operation may be covered under a relevant Class Licence or Spectrum Licence.

3. COORDINATION AND SYSTEM PLANNING RULES

This part of the RALI details assignment instructions, coordination and general system planning rules considered necessary for the management of interference and the optimisation of spectrum usage for microwave fixed services. The rules are established as a reasonable balance between the cost of implementing services, unnecessary spectrum denial and the likelihood of interference, with particular relevance to identified (see Part 3.3.2) High Spectrum Demand Areas (HSDA).

In considering the application of assignment instructions and planning rules, assigners are reminded of the need for consistency and transparency, with particular reference to applications seeking exceptions to, or the relaxation of, specific assignment policy requirements. Overall guidance regarding such considerations is provided in Appendix 6 "*Application of Assignment Policy Rules*".

3.1 ASSIGNMENT INSTRUCTIONS

Assignment instructions, as detailed in Appendix 1 for each microwave fixed service band, define particular assignment criteria and address other considerations specific to the utilisation of each band. Instructions and/or advice are normally included for utilisation, (channel) assignment priority, minimum path length and minimum antenna performance requirements, with the object of optimising spectrum utilisation. Specific notes are also provided in the assignment instructions to cover any special requirements (eg. a requirement to apply particular Special Conditions or Advisory Notes) and references relevant to such considerations**.**

The following sub-parts provide general guidance regarding the purpose and scope of particular assignment instructions.

3.1.1 Typical Use

This specification identifies the types of fixed link applications typically supported in a given frequency band, in terms of technology (analogue/digital) and system capacity.

The choice of an appropriate frequency band and channel raster is important and should ideally match the proposed communication need in terms of achievable path length and system performance objectives (ie. the highest possible frequency band should be utilised), with the link occupied bandwidth optimised against the available channelwidth. Nevertheless, provided that a proposal:

- meets the relevant coordination and licensing criteria;
- complies with the relevant regulatory provisions; and
- does not unreasonably impact on spectrum availability for other users

the prospective licensee is at liberty to choose the appropriate frequency band that meets their operational requirement.

3.1.2 Assignment Priority

The assignment priority defines the order in which the available channels in a particular channel raster should be assigned, with a view to optimising[6] the loading of radiofrequency channels in a given frequency band.

Where an initial choice of a channel in the assignment priority is precluded through unsuccessful coordination, the next channel in the priority sequence is to be attempted. In general, optimum spectrum utilisation is achieved by maximising the re-use of channels in the order of the assignment priority sequence and is often referred to as the vertical loading (of radiofrequency channels) principle. In practice this means assigning the first channel in the specified priority which passes the coordination criteria.

3.1.3 Minimum Path Length

The minimum path length defines the smallest end-to-end distance for a single-hop link which may be supported in a particular frequency band.

At the lower end of the microwave spectrum, line-of-sight path lengths of the order of 60 -100 km are achievable, depending upon system gain and link performance objectives. As mentioned in Part 2 of this RALI, the available path length decreases with increasing frequency and propagation losses. For radio-relay systems a decrease in available path length equates to additional infrastructure and system costs in the form of additional repeaters. Accordingly, the lower microwave frequency bands should be assigned primarily to systems requiring the use of long link paths, where fade margins are often critical. For microwave fixed services with link paths shorter than the specified minimum path length, higher frequency bands should to be utilised.

Note: The minimum path length requirement will not normally be relaxed within designated HSDA locations.

3.1.4 Antenna Requirements

Antenna requirements specify the minimum allowed antenna performance for antennas used in the fixed service bands.

As outlined in Part 4.2.2, wanted and unwanted signal levels are directly dependent upon antenna performance. The antenna may be considered to be the single most important component of a fixed service system in terms of frequency coordination and in determining the overall extent of spectrum denial to other services. Generally, antennas with higher levels of discrimination to off-axis signals facilitate more opportunity for frequency re-use.

The antenna requirements detailed in Appendix 11 have been developed to provide simple, unambiguous criteria against which antenna compliance can be easily determined. This method removes elements of subjective judgement and facilitates a transparent and light touch approach to antenna assessment.

[6] Sometimes other reasons (eg. interservice considerations) may dictate a particular priority.

The criteria outlined in Appendix 11 were developed following studies on antenna manufacturer data, analysis of antenna usage within individual frequency bands and locations, and extensive statistical analysis of antenna performance correlations. Appendix 11 sets performance requirements that may allow the use of smaller antennas (as opposed to Appendix 10 criteria which tended to imply a minimum aperture size), as long as the overall performance of the chosen antenna meets specified front-to-back ratio and cross-polar discrimination requirements. This approach ensures that a required level of frequency re-use (i.e. spectrum efficiency) is maintained, while providing licensees with greater flexibility in terms of antenna selection.

Table 1 in Appendix 11 generally allows for the use of standard, non shrouded antennas in non-HSDA areas, and imposes a requirement for the use of high performance, shrouded antennas in the HSDA. Certain frequency bands (3.8, 6.0, 6.7 & 8.0 GHz) are important trunk bands. Accordingly, the Appendix 11 Table 1 criteria have been chosen to facilitate a high level of spectrum re-use in these bands.

Note: The antenna compliance arrangements described in Appendix 11 represent a change from the previous practice of assessing candidate antennas against a defined “notional antenna RPE”. To allow a transition period for the introduction of the Appendix 11 arrangements, over the period 31 March 2004 and 31 March 2005, antennas may be assessed against either the Appendix 11 arrangements or the earlier arrangements (for convenience those notional antenna arrangements have been consolidated in Appendix 10).

3.1.5 Notes and Special Assignment Instructions

The notes provided with the Assignment Instructions given in Appendix 1, specify particular (band specific) criteria and provide important advice regarding any special requirements. References may be made to legal instruments (e.g. the Spectrum Plan, formal Band Plans) or other RALIs (e.g. to relevant spectrum embargo notices or coordination guidelines).

<u>The onus is on the frequency assigner to take account of and comply with the relevant requirements specified in the reference documents</u>.

3.1.6 References

Usually the source ITU-R recommendation (or other recognised standard) for the RF Channel Arrangement adopted for the implementation of the particular band is given. In addition, the full titles of any specific reference documents identified in the Assignment Instructions are also detailed in Appendix 1.

Note: ITU recommendations for RF channel arrangements often specify different (sometimes numerous) channelling options. Accordingly, although based on the same source recommendations, there can be significant differences between the Australian arrangements detailed in Appendix 1 and those adopted by other countries.

3.1.7 Protection Ratios and Interference Criteria

Protection ratios, as defined in Appendix 1 and applied under the basic method of frequency coordination detailed in Part 4, specify the default interference criteria for systems operating in each microwave fixed service frequency band[7]. The discrete protection ratio criteria are to be used when more detailed information on system protection requirements is not available. In essence:

- co-channel and adjacent channel protection ratios are defined for digital and, for the bands supporting significant populations of FM video and FDM telephony links, analogue fixed service systems; however,
- in the bands for which analogue system protection ratios are not explicitly defined, the protection ratios and correction factors specified for digital systems shall apply irrespective of the modulation type employed. In effect, no additional protection will be afforded to analogue systems operating within these bands.

Given that these protection ratios address the requirements of a broad range of fixed service systems, situations may arise where an overly conservative coordination result is obtained using these criteria. In these cases, a more detailed approach, taking account of system specific interference criteria, may be appropriate. In general, a coordination approach based on the direct application of threshold degradation and/or noise interference criteria[8] is potentially more efficient in terms of optimising channel loading and overall spectrum productivity.

In cases where an RF channel arrangement is overlaid with a pre-existing arrangement or other overlaid arrangements for which no specific protection ratios are defined:

- Where the potential interfering and victim spectra overlap, the relevant co-channel criteria should be applied;
- In the case of non-overlapping but adjacent spectra, the relevant adjacent channel criteria should be applied; or
- Where sufficient detailed information regarding the potentially interfering emission and the victim service characteristics is available, the FDR[9] criteria outlined in Spectrum Planning Report SPP 4/95 "*Frequency Dependent Rejection (FDR) Software*" may be used as the basis for a more detailed analysis.

3.1.8 Protection Ratio (path length) correction factors

The protection ratios specified for digital systems (in Appendix 1) for each fixed service band are normalised for a particular path length and geoclimatic zone. Accordingly, appropriate corrections must be applied to the tabulated protection ratio values in order to account for the victim system actual path length and geographic location. In the absence of more detailed statistical data for local worst month multipath fading and/or rainfall intensity, the geoclimatic contour maps provided in Annex A to Appendix 1 may be used.

[7] Excepting certain bands/channel rasters designated for TOB or other itinerant use applications.
[8] Interference mechanisms and performance criteria are the subject of ongoing ACA work, the results of which will be included in Appendix 2.
[9] Frequency Dependent Rejection, which takes into account the victim receiver selectivity response.

3.2 RADIO EQUIPMENT CONSIDERATIONS

Although the ACA does not mandate regulatory type approval procedures for microwave fixed service radiocommunication equipment, it is expected that such equipment be manufactured to conform with the requirements of the International Radio Regulations, relevant ITU recommendations and/or other credible recognised world-wide or regional standards. More specifically, in order to meet the minimum requirements for licensing, microwave fixed service equipment must comply with the arrangements detailed in this document, including the following regulatory criteria for spectral efficiency, transmit power limits, emission criteria and antennas.

3.2.1 Spectrum Efficiency

Microwave fixed service equipment supporting a digital baseband signal (i.e. digital systems) intended for operation in Australia in the bands below 19.7 GHz are required to comply with a minimum spectrum efficiency criteria of 1 bit per second per Hertz (1 bit/s/Hz). No explicit spectral efficiency criterion applies to analogue FDM or FM video systems.

3.2.2 Transmit Power and Adaptive Transmit Power Control (ATPC)

In accordance with International Radio Regulation 21.5(3) and ITU-R Recommendation SF.406 "*Maximum Equivalent Isotropically Radiated Power of Radio-Relay System Transmitters Operating in the Frequency Bands Shared with the Fixed-satellite Service*", the power delivered by a transmitter measured at the antenna connection[10] of a station in the fixed service shall not exceed:

- +43 dBm (20 Watts) in the bands between 1 GHz and 10 GHz; and,
- +40 dBm (10 Watts) in the frequency bands above 10 GHz, except in the band 18.6-18.8 GHz where the limit is +27 dBm (0.5 Watts) in accordance with International Radio Regulation 21.5A.

It should be noted that in the band 18.6-18.8 GHz, multiple transmitters, operating on different RF carrier frequencies, individually respecting the above output power limit can be connected to a single antenna of a fixed service.

Microwave fixed services operated in Australia must conform with the above power limits and the EIRP limit criteria detailed in Appendix 5 "*Geostationary Satellite Orbit Avoidance*".

In general, transmit power levels should be adjusted to ensure that radiated power levels do not significantly exceed that necessary for compliance with link availability and performance objectives. Transmit power levels may be controlled through the judicious application of fixed attenuators or, with the emerging generation of fixed service radio equipment, direct programming and Adaptive Transmit Power Control (ATPC).

ATPC is a desirable equipment feature of digital systems with significant benefits[11] for the system operator and spectrum manager. In essence, ATPC allows transmitter operation at less than maximum power for most of the time, with increased power applied only (for short percentages of time) during periods of fading. The rules and

[10] ie. At the actual waveguide flange or coaxial connection point of the antenna itself.
[11] As outlined in Chapter 4.3.4.2 of ITU-R "*Handbook on Digital Radio Relay Systems*", Geneva 1996.

conditions governing the operation of microwave fixed service systems fitted with ATPC is detailed in Appendix 9 "*Adaptive Transmit Power Control*".

3.2.3 Emission Criteria

In general, the relative power spectral density of a given radiofrequency emission[12] is determined by the baseband information rate, the modulation technique employed and system implementation (eg. DSP techniques and filtering). Such emissions may be defined as consisting of two components

- the major "wanted signal" portion of the transmitted spectra, normally defined as the necessary bandwidth[13]. The necessary bandwidth is a key parameter in frequency coordination and its value is recorded in the ACA's RADCOM database as part of the emission designator field used to characterise the nature of a given radiocommunication service; and
- a remainder (unwanted emissions), falling outside of the necessary bandwidth. Unwanted emissions include out-of-band and spurious emissions, as defined in the International Radio Regulations.

In general, it is expected that the necessary bandwidth of a fixed service emission is wholly contained within the RF channel limits of the relevant Appendix 1 channel arrangement. However, for high capacity digital systems operating in specific bands (3.8, 6.7 and 11 GHz), the necessary bandwidth is permitted to exceed the relevant RF channel limits by up to 20%.

Wanted and unwanted emission criteria for microwave fixed services are subject to review. Pending development of Appendix 3, enquiries regarding this matter should be directed to the Spectrum Engineering Section, Spectrum Planning Branch.

3.2.4 Antennas

Minimum antenna performance requirements for Australian microwave fixed services are specified in Appendix 11 for each frequency band and are further discussed under Part 3.1.4 "*Antenna Requirements*". Antennas are a critical component within the overall interference environment and their characteristics play a large part in determining overall frequency re-use for fixed services. Accordingly, it is essential that licensees should furnish detailed radiation pattern envelope (RPE) data for their (discrete and equipment integral) antenna products that are to be used in proposed assignments. Parameters should include an antenna's physical diameter and on-axis gain as well as the antenna 360° radiation pattern envelope for both co-polar and cross-polar orientation, in order to facilitate their use in detailed frequency coordination and sharing studies.

In order to promote standardisation and electronic working methods (and in the absence of relevant ITU criteria), the "*Standard Format for Electronic Transfer of Terrestrial Antenna Pattern Data*" file data format developed by the National

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[12] Defined in the ITU Radio Regulations as the radiation produced by a radio transmitting station.
[13] Necessary bandwidth is defined in the International Radio Regulations as "*the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions*".

Spectrum Managers Association (NSMA[14]) may be utilised, with a view to facilitating simple, accurate and expedient transfer of coordination data between manufacturers, frequency assigners and users. Although not a formal standard, the format is recognised and supported by most major antenna manufacturers.

3.3 RADIOCOMMUNICATION SITE AND SYSTEM PLANNING CONSIDERATIONS

Site selection and detailed radiocommunication system engineering issues are normally matters within the jurisdiction of the system planner and prospective licensee. Nevertheless, a number of geographic and other link planning considerations are of concern from a regulatory perspective and require detailed treatment due to their potential impact on the overall interference environment.

Accordingly, in order to facilitate timely system commissioning and to avoid potentially costly redesign work, the matters discussed in the following sub-parts need to be considered and taken into account within the early phases of link planning.

3.3.1 Geographic Coordinates

As outlined under Part 4.2.2, the coordination of microwave fixed services is predicated upon the accurate determination of the relative spatial (distance and azimuth) relationships between potential victim and interfering services.

Since the reliability of predicted signal levels will be affected by the uncertainty of the geographic coordinates used, it is important that the link end-point location coordinates are derived and recorded accurately. The endpoints in the context of microwave fixed services are defined as the coordinates at the centre or main axis of the antenna support structure (ie. pole or tower). In the case of particularly large support structures (ie. where the radius distance from the antenna to the axis is greater than 10 metres) the coordinates of the actual antenna are to be recorded, consistent with the specified (see below) level of accuracy of coordinate data.

Geographic coordinates for radiocommunication sites are recorded in the Australian Map Grid (AMG) format, a Universal Transverse Mercator projection of latitudes and longitudes on the Australian Geodetic Datum (AGD). Conversion algorithms between latitude and longitude and AMG coordinates are detailed in "*The Australian Geodetic Datum Technical Manual (National Mapping Council 1986)*".

The ACMA's "*Site Entry Rules*" Business Operating Procedure (BOP) document provides guidance regarding the derivation and recording of radiocommunication site data and specifies that site data entered into the ACMA's RRL database should aim for an accuracy of +/- 10 metres (equivalent to approximately 0.3 of a second of latitude). However, this may be relaxed to +/- 100 metres in rural and remote areas in cases where better data may be unobtainable.

3.3.2 High Spectrum Demand Areas (HSDA)

Spectrum demand and high usage density typically coincide with population centres and the trunk route corridors between such centres. Designated High Spectrum

[14] NSMA (USA) Working Group 16, refer to http://www.nsma.org.

Demand Areas (HSDA) define geographic boundaries within which the overall link density is high and where demand mandates a tightly managed assignment strategy, including strict compliance with the spectrum productivity related assignment and system planning rules specified in this document.

Metropolitan HSDAs are circular areas defined by radii centred on the town or city GPO coordinates, as specified in Table 3.1 and shown in Figure 3.1.

Location	**Location AMG coordinates**			**HSDA radius (km)**	
	Zone	**Easting**	**Northing**	***f*** **< 10 GHz**	***f*** **≥ 10 GHz**
Sydney	56	334100	6250900	140	95
Melbourne	55	320630	5812740	140	95
Brisbane	56	502810	6961540	130	85
Adelaide	54	280575	6132250	70	45
Perth	50	392022	6464195	100	65
Canberra	55	693400	6093700	90	60
Newcastle	56	384696	6355416	130	85

Table 3.1. Designated High Spectrum Demand Areas (HSDA)

Although HSDAs are not explicitly defined for the major trunk routes, coordination and planning rule criteria should also be closely observed along the intercapital trunk and other routes making extensive use of the bands below 10 GHz.

Note: The Table 3.1 microwave fixed service HSDA definitions are not the same as, and are not necessarily intended to be consistent with, the definitions given in the ACA's "*Radiocommunications Apparatus Licence Fees and Charges*" document.

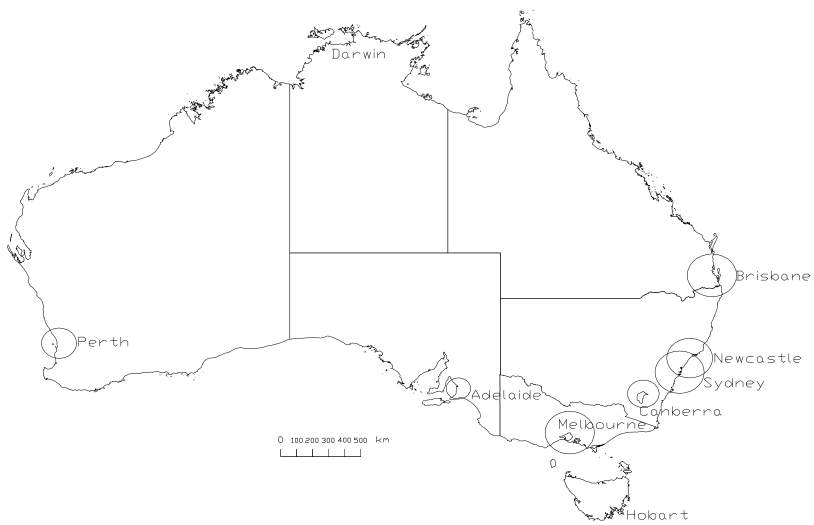

Figure 3.1. Designated HSDA for microwave fixed service bands below 10 GHz.

3.3.3 Compatibility (Site Sense)

The majority of microwave fixed services are bidirectional and for this reason radiofrequency channel arrangements are defined in paired blocks of “go” and “return” channels (i.e. designated 1/1', 2/2' ...), separated in frequency by a fixed “transmit/receive duplex spacing”, in accordance with the principles defined in ITU-R Recommendation F.746 “*Radio-frequency Channel Arrangements for Radio-Relay Systems*”.

In order to maximise the isolation between collocated transmitters and receivers operating in the same band, at any given site, frequencies are assigned from either the lower (site sense “low”) or the higher (site sense “high”) frequency block. Accordingly, where a given site has been designated as “transmit high” then all transmit frequencies at that site will be in the upper frequency block and the corresponding paired duplex receive frequencies in the lower “receive low” block. Figure 3.2 provides a simple (arbitrary) example of a network with consistent site sense allocation.

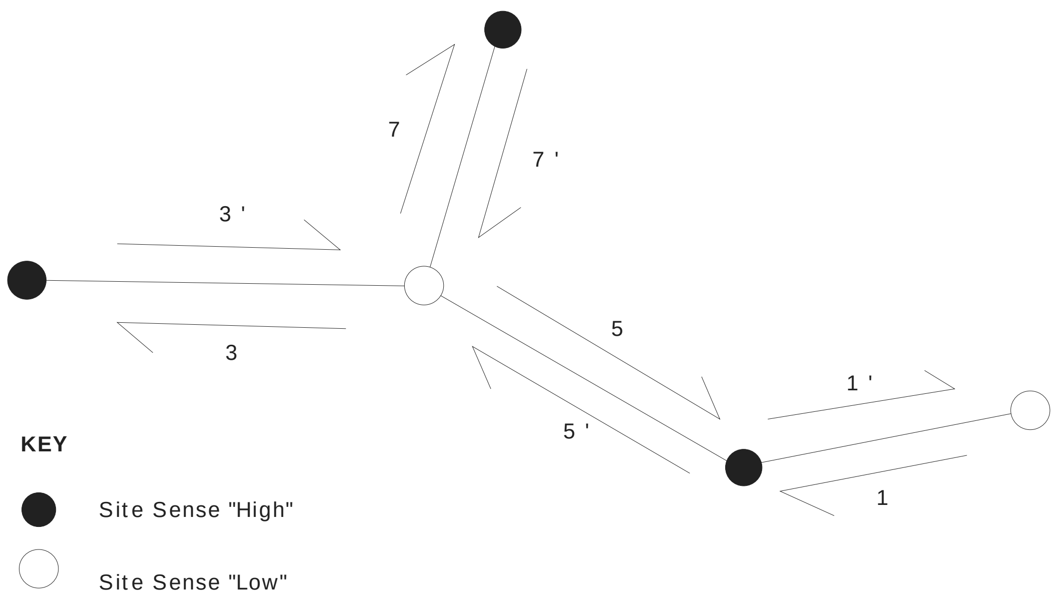

Figure 3.2. An arbitrary example of a site sense consistent network.

The collocation of transmitters and receivers using the same frequency block must be avoided, since the high levels of adjacent channel energy are highly likely to cause receiver desensitisation[15]. The extent of desensitisation depends upon the absolute frequency separation between a transmitter and the victim receiver and its effect may range from a small reduction in available system fade margin through increasing baseband noise to severe blocking where the receiver becomes essentially inoperative.

[15] ie. results in a reduction in the dynamic range of the receiver.

The following cases outline the site sense considerations most often encountered in practice:

- for an isolated single-hop link, the choice of relative transmit/receive site sense is not usually of particular importance;
- in the case of a radio-relay trunk route or any multi-hop system, site sense alternates at each hop, with the initial choice of upper or lower frequency block selection typically influenced by any sites where the new route interconnects with existing systems for which a site sense has already been established; and
- network node sites, or "prime" sites where multiple systems converge. Consistent application of site sense is particularly important at node sites, since conflicts invariably preclude the use of otherwise available radiofrequency channels.

In addition, the harmonic relationships between co-sited equipment operating in different frequency bands must be taken into account, i.e. multiples of the transmit frequencies from a lower band falling within the receive frequency block of a higher band represent a particularly severe source of interference.

Incorrectly applied site sense may lead to extensive and unreasonable spectrum denial, particularly at high demand prime radiocommunication sites which are often shared between a number of operators. Accordingly, appropriate consideration at the route/network planning stage is vital in ensuring that potential problems of this nature are avoided. Nevertheless, in certain circumstances it may not be possible to maintain site sense when making a new frequency assignment (eg. when a new link connects existing sites with identical pre-established site sense). In this case and other situations where individual circumstances warrant the violation of normal site sense practice, the proposed assignment strategy should be carefully examined with a view to minimising the adverse impact of such an assignment. In many cases, through judicious site sense planning and choice of assigned channels, a site sense violation can be effectively "transferred" to a part of the network (site) where the potential impact on other existing and future systems may be minimised.

If a mixed site sense is proposed at a shared radiocommunication facility (or adjacent facilities), it is the licence applicant's responsibility to advise and to negotiate with any potentially affected parties, including the site owner(s) or their designated representative(s). In cases where operators are unable to reach agreement, the site owner(s) may choose to arbitrate or to impose an outcome. In the event of an unresolved disagreement between respective site owners, the parties involved may seek the advice of the ACMA.

Other on-site interference and compatibility issues (intermodulation, broadband noise) are outside the scope of this frequency coordination document and fall under the scope of individual site engineering practice. For guidance regarding such site engineering related matters, reference may be made to Australian Standard AS 3516.2 "*Siting of radiocommunications facilities - Part 2 Guidelines for fixed, mobile and broadcasting facilities at frequencies above 30 MHz*" and general radio and telecommunication engineering references.

3.3.4 Link Diversity Options

Link diversity arrangements and other measures are utilised to improve system performance, typically to combat the effects of multi-path fading and to expand the application of link arrangements over hops with difficult propagation conditions. As outlined in ITU-R Recommendation F.752 "*Diversity Techniques for Radio-Relay Systems*", the traditional microwave fixed service diversity techniques are generically described as frequency diversity and space diversity:

- frequency diversity, employing two or more frequencies to send identical information over the same propagation path. The frequency separation[16] must be large enough to ensure that the effects of multipath fading on the two discrete signals are sufficiently de-correlated; and
- space diversity, usually implemented with two or more receiving antennas with a vertical separation large enough to provide separate signal paths in which the impairments due to multi-path fading are sufficiently de-correlated.

In addition to the above recommendation, Chapter 4.3 of the ITU-R "*Handbook on Digital Radio Relay Systems*" provides useful guidance regarding the various diversity options and countermeasures available to the system planner, including an extensive listing of relevant references.

From a spectrum utilisation perspective, the use of frequency diversity represents an inefficient use of a limited spectrum resource, especially at locations where spectrum availability is a concern and where other viable diversity options are available.

As discussed in Annex 1 to ITU-R Recommendation F.1093 "*Effects of Multipath Propagation on the Design and Operation of Line-of-Sight Digital Radio-Relay Systems*", space diversity is one of the most effective methods of combating multipath fading and improvements in path reliability offered by space diversity are at least equivalent to that of frequency diversity. Accordingly, from a spectrum utilisation perspective, the application of space diversity techniques should be considered in preference to frequency diversity.

In view of the above considerations, the use of frequency diversity is permitted only in situations where individual circumstances warrant the application of hybrid/multiple diversity methods (eg. extended hops over water or remote areas where spectrum demand is low) or where systems employ more than one active channel over a single path (i.e. one standby channel can be used for N active channels, where $N > 1$).

Note: <u>The limitation on the application of frequency diversity will not normally be relaxed within designated HSDA locations</u>.

3.3.5 Passive and "RF" repeaters

For the system planner, passive repeaters are sometimes a useful option in cases where the direct propagation path is severely obstructed (typically near end), but

[16] Typically 3 to 5 % of the RF operating frequency.

where another site, with path clearance to both ends of the wanted communication link, can be used to direct sufficient signal energy around the obstacle to satisfy the overall system gain requirement. The most common types of passive repeaters include “back-to-back” antennas and “billboard” reflectors. A typical back-to-back configuration is demonstrated in Figure 3.3, where antennas with different azimuths are simply coupled together.

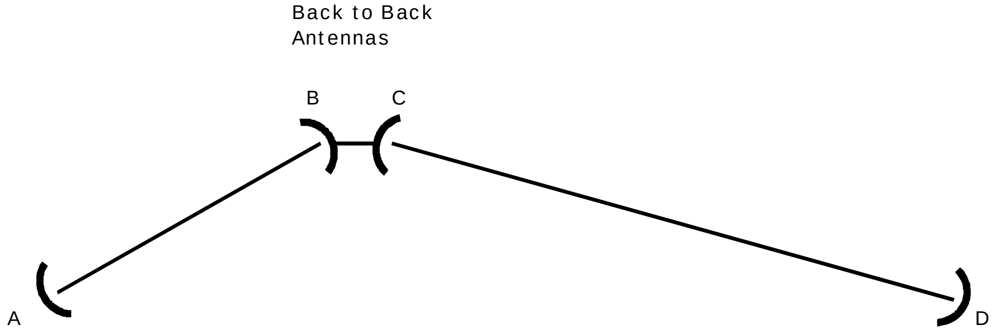

Fig 3.3 Passive repeater employing back-to-back antennas.

The total path losses via the repeater are calculated as the sum of losses (in dB) of the two individual hops. The transmit signal level (at the antenna connector) of the second hop is equal to the received signal level (at the antenna connector) of the first hop, less the attenuation (typically around 0.5 dB) of the intermediate feeder and connectors. The unwanted signal is the sum of the interferences received via each receiving antenna. For each potential interference source, separate calculations are required for each antenna involving separate discrimination angles. In order to reduce coupling to the direct (potentially interfering) propagation path, the antennas of the two radio paths are always orthogonally polarised.

Figure 3.4 demonstrates a passive repeater configuration implemented by the installation of a flat “billboard” reflector of a size commensurate with practical dimensional constraints and the need to obtain a reasonable system fade margin.

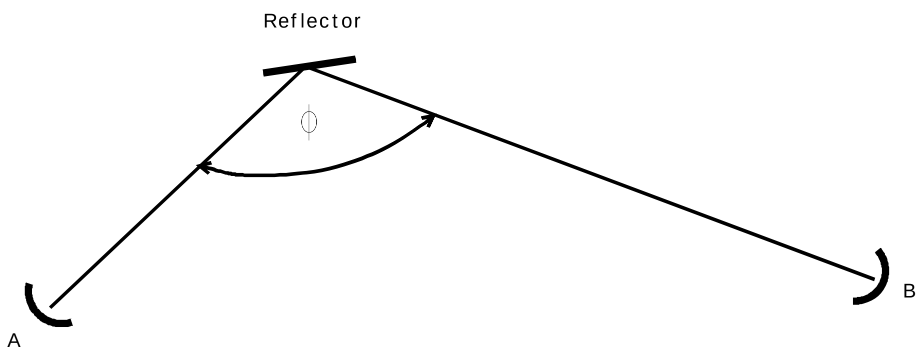

Fig 3.4 “Billboard” reflector passive repeater.

As with the back-to-back antenna case, path losses are calculated separately for each hop and interference can occur via the direct paths and the reflector. The gain of the reflector is given[17] by:

$$G = 21.45 + 20\log(f) + 10\log\left[A\cos\left(\frac{\phi}{2}\right)\right] \qquad \text{(dB)}$$

where:
f - frequency in GHz
A - actual area of the reflector in m^2; and
ϕ - angle between the incident and reflected beams

Passive repeaters offer practical and economic communication solutions in many situations. Nevertheless, their application is typically constrained by path geometry and terrain considerations. In addition to the need to obtain adequate system gain under normal operating conditions, the planner must ensure that the direct path signal (ie. an unwanted signal) remains well below the system threshold during periods of abnormal propagation.

RF repeaters are sometimes utilised to improve overall system gain of the otherwise "passive" or non-frequency translating repeater. The typical RF repeater consists of a class A linear amplifier inserted between the antenna ports of the intermediate repeater. Bidirectional RF amplification with a single amplifier block may be achieved using appropriate passband filtering, circulators and careful design, ensuring that sufficient isolation exists between "go/return" directions for stable operation.

From a spectrum utilisation and interference management perspective, passive and RF repeaters exhibit several potentially undesirable characteristics:

- Given the constraints on system gain (high overall path loss), systems utilising passive repeaters operate with characteristically low margins, necessitating significantly more stringent interference protection levels than other links;
- Such systems are susceptible to (cumulative) interference entering at multiple locations and azimuths;
- Since passive repeaters are "non-frequency translating", significant problems can arise with respect to established network "site sense" criteria (see Part 3.3.3), particularly in situations where the passive repeater itself is collocated with other radiocommunication services operating within the same band; and
- RF repeaters will amplify any signal above the noise floor within the passband of its filters, including unwanted signals from other systems.

[17] In accordance with "*Economic and Technical Aspects of the Choice of Transmission Systems*", Appendix to Section B IV3 of the Handbook, ITU Geneva 1971.

All of these factors contribute (in varying degrees) to spectrum denial. Accordingly, the ACMA will not normally support the use of passive or RF repeaters within designated HSDA, at prime[18] radiocommunication sites or other locations where their use may unreasonably impact upon the availability of spectrum to other users.

3.4 POINT-MULTIPOINT FIXED SERVICES

Several Australian fixed service allocations are designated for use by point-to-multipoint fixed services:

- The 1.5 GHz (1427-1535 MHz) Point-to-Multipoint Services band, supporting rural and remote area public telecommunication services[19]; and
- The 3.4 GHz (3425-3492.5 MHz) band, supporting Wireless Local Loop (WLL) services.

3.4.1 Rural telephony (1.5 GHz DRCS) systems

DRCS point-to-multipoint systems are extensively deployed in rural and remote areas of Australia, facilitating the delivery of basic telecommunication services to locations where other service delivery mechanisms are impractical or too costly to implement. Australian rural telephony systems principally utilise the 1.5 GHz (1427-1535 MHz) DRCS band, although in some areas 500 MHz and "hybrid" 500/1500 MHz systems also operate. Spectrum within the band 1427-1535 MHz is shared between DRCS and regular point-to-point fixed services and, in accordance with the RF Channel Arrangements detailed in Appendix 1, separate but overlaid arrangements are specified for point-to-point and multipoint systems. As noted in Appendix 1, the operation of DRCS and other 1.5 GHz radiocommunication services is subject to the provisions of the "*1.5 GHz Band Plan*", December 1996.

Given the inherent spectrum denial of DRCS hub stations (due to their omnidirectional antennas) and the unmanageable nature of potential interference between point-to-point links and uncoordinated DRCS outstations, the deployment of 1.5 GHz point-to-multipoint systems is not normally permitted within designated HSDA and operation in other areas with high point-to-point link densities should be avoided. All applications seeking point-to-multipoint operation within the band 1427-1535 MHz and which encroach upon designated HSDA must be referred to the Manager, Spectrum Planning and Engineering Team, Radiofrequency Planning Group for policy advice.

Specific guidance regarding the coordination of DRCS point-to-multipoint outstations with point-to-point links is provided in Appendix 8 "*Coordination of DRCS Outstations with Point-to-Point Links*".

[18] ie. Main trunk route or other shared use radiocommunication sites.
[19] Digital Radio Concentrator System (DRCS).

3.4.2 3.4 GHz Fixed Point-to-Multipoint services

The 3.4 GHz (3425-3492.5 MHz) band supports arrangements for point-to-multipoint telecommunication systems, facilitating radio based "wireless local loop" (WLL) customer access network connections between a population of customer units and a parent telephone exchange.

For detailed coordination and licensing arrangements for these 3.4 GHz services, reference should be made to RALI FX 14 "*Point to Multipoint Fixed Services in Specified Parts of the 3.4-3.59 GHz Band*" and RALI MS 3 "*Spectrum Embargos*" Embargo No. 26.

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4. FREQUENCY COORDINATION

This part of the RALI FX 3 provides an overview of the coordination process, outlines a basic method of frequency coordination for homogeneous microwave fixed services and suggests more detailed approaches which may facilitate successful coordination and improved spectrum utility. Guidance is also provided for the coordination of microwave fixed services with other types of radiocommunication services.

The basic method and other approaches outlined in this part seek to identify the key technical considerations which need to be taken into account as part of the coordination process. Other than the requirement of compliance with any mandatory assignment instructions[20], spectrum management related planning requirements and good engineering practice, the coordination methodology outlined is not intended to be prescriptive. It is accepted that there will be some variation in the implementation of coordination methods, which in some instances may be manual but more often are reliant on the application of integrated database tools, additional information and computer based modelling techniques.

4.1 AN OVERVIEW OF THE COORDINATION PROCESS

The purpose of the microwave fixed service frequency coordination process is to determine the compatibility of a proposed new fixed link service with existing services operating on a particular channel frequency in a given geographical area. Depending upon individual circumstances, coordination may be required for a single new link or a complete network/radio-relay route. For the purposes of description, the coordination of multiple fixed links may be considered as simply an extension of the principles given for a single fixed microwave service.

Accurate information regarding the technical and operational characteristics of the proposed new system and any potentially affected services must be available before the coordination process can be properly invoked. Data for existing licensed services may be obtained from the ACMA's RRL database. The technical details of any proposed new link will normally be provided by the prospective licensee as part of a licence application. Typically, the following should be considered as the minimum data set necessary to initiate the most basic level of coordination:

- the applicant's preferred frequency band;
- geographic coordinates (location) of the transmit and receive sites;
- system type/capacity/emission details;
- nominal mean (coordinated) transmit power; and
- antenna type and characteristics.

[20] As specified in Appendix 1 for each fixed link frequency band.

The accuracy of the coordination data should be consistent with the level of confidence necessary for a proper assessment against the applicable interference management criteria. In cases where the available information falls short of the necessary level of confidence to constitute a valid assessment, further advice should be sought from the licence applicant. However, it is recognised that it is often difficult to obtain timely detailed information and under some circumstances it may be acceptable, depending upon the level of spectrum utility sought, to make conservative assumptions regarding specific coordination parameters.

The following sub-parts outline the basic method of frequency coordination.

4.2 BASIC METHOD OF FREQUENCY COORDINATION FOR TERRESTRIAL FIXED SERVICES

The basic method of frequency coordination applicable to proposed new terrestrial fixed service systems is outlined as follows:

1. Identify all homogeneous microwave fixed services operating within the coordination area of the proposed new service that may affect or be affected by the deployment of the proposed new service;
2. Calculate the wanted signal and interference levels to/from the proposed new service and the existing services within the coordination area;
3. Evaluate the compatibility of the proposed new link by comparing the calculated levels of interference against the relevant interference management criteria;
4. Check the compliance of the proposed assignment against the relevant specific assignment instructions and general spectrum policy requirements; and
5. Consider any relevant inter-service and non-homogeneous fixed service coordination requirements, including geostationary orbit protection in the bands shared with space radiocommunication services.

An overview of the basic method of frequency coordination is given in the flowchart in Figure 4.1. A detailed discussion of the method and related considerations is provided in the following sub-parts.

In addition to the coordination methodologies and requirements discussed in this part of the RALI, the user is also reminded of the need to consider and take account of the general radiocommunication policy requirements detailed in Part 3 "*Coordination and System Planning Rules*".

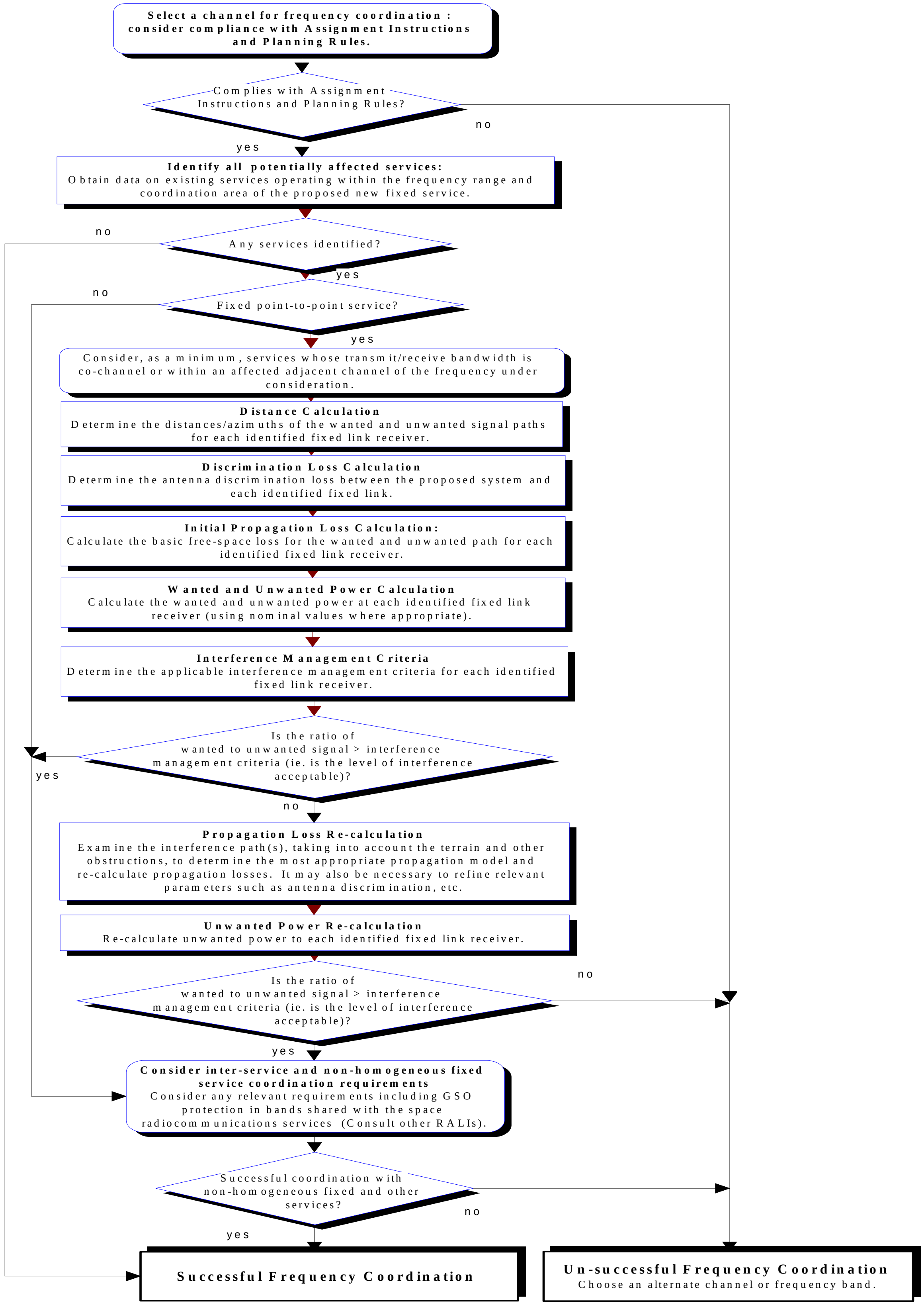

Figure 4.1. An overview of the basic method of frequency coordination.

4.2.1 Identifying potentially affected services

In order to effectively identify existing microwave fixed services which may affect, or be affected by, the deployment of a proposed new service it is necessary to establish:

- the frequency limits applicable to the coordination - normally being at least one full channelwidth[21] on either side of the channel centre frequency being coordinated
(ie. co-channel and the first adjacent channel, with channelwidth as defined in the relevant RF Channel Arrangement); and
- a coordination area, geographically defining the extent of necessary coordination.

The purpose of identifying a coordination area is to facilitate a reduction in the size of the dataset of services to be coordinated, by excluding from further consideration the services located outside of a defined coordination area and for which detailed interference studies should be unnecessary. A coordination area is defined by a radius distance, centred upon the respective sites of the proposed new link (i.e. a separate coordination area is defined for each end of the link). Recommended minimum coordination radius distances for the 1.5 to 50 GHz bands are given in Table 4.1.

f (GHz)	Coordination Radius (km)
$1.5 \leq f < 10$	200
$10 \leq f < 20$	150
$20 \leq f$	100

Table 4.1 Recommended minimum coordination distances.

In practice, the generic distances in Table 4.1 should be adequate for most cases. However, the given coordination radii represent a necessary compromise between the need to identify significant potential interference sources/victims and the burden of unnecessary coordination[22]. Thus, a small but finite probability exists that a proposed new fixed link may interfere with or receive interference from a station located beyond the above defined coordination distance. Clearly, that risk is greater in situations where high (victim and/or interferer) site elevations are involved. In such cases, it is appropriate to extend the coordination area in the direction of the boresight azimuth of the proposed new service.

No universal coordination area model exists which can be confidently used under all circumstances and variations in approach may be necessary to account for local factors such as band specific equipment, terrain and geoclimatic statistics. In some cases, where these factors are known and well defined, it may be useful to develop a detailed coordination area model adapted for, and taking account of, local topography and propagation conditions. An example of such an approach is described in ITU-R

[21] Also taking account of any overlap with superseded or overlaid existing channel arrangements.
[22] Note: This is not necessarily of great concern, eg. if computer based coordination methods are used then doubling the coordination radius distance may only result in a marginal increase in overall processing time.

Recommendation F.1095 "*A Procedure for Determining Coordination Area Between Radio-Relay Stations of the Fixed Services*". The majority of microwave fixed services are bidirectional, utilising separate go/return channels as defined in the relevant RF Channel Arrangements. Accordingly, the interference scenario is unique for each direction of transmission and interference to/from the proposed new system needs to be evaluated separately for each operating frequency.

A typical example of a potential interference scenario (for one direction of transmission, ie. a single frequency) is presented in Figure 4.2, where link 'AB' designates an existing service and link 'CD' is a proposed new service. The potential interference paths (AD & CB), with the corresponding transmit and receive antenna discrimination angles (θ and ϕ respectively) relative to the respective antenna "boresight" azimuths are also shown. Since fixed links predominantly employ directional antennas, the relative azimuths of the interference source and the victim antennas are a key factor in establishing the relationship between interference and the wanted signal.

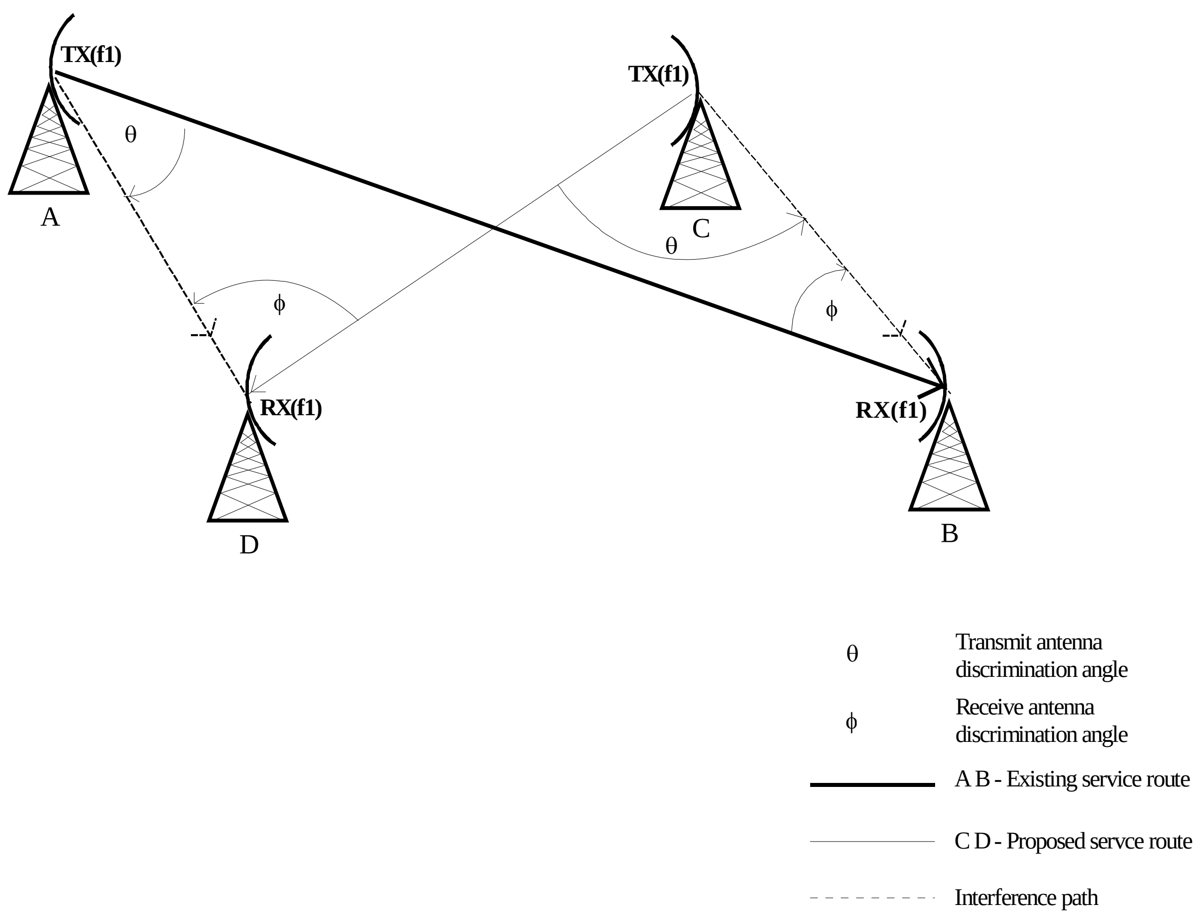

Figure 4.2. Example of wanted signal (AB, CD) and interference paths (AD, CB)

In practice, the typical coordination scenario is much more complicated than the simple example shown and care needs to be taken to ensure that all potentially significant interference source paths are adequately identified and assessed. The effective interference power level at any potential victim receiver is equal to the sum of the individual interference entries (see Part 4.2.3). However, unless two or more entries are of a similar order (i.e. of equivalent power), the worst case interferer will typically emerge as the dominant element of the coordination.

Note: Calculation algorithms for path distance, antenna azimuths and other relevant coordinate geometry related information are detailed in the "*Australian Geodetic Datum Technical Manual*", National Mapping Council 1986. Input data into such calculations should take account of the considerations outlined in Part 3.3.1 "*Geographic Coordinates*".

4.2.2 Calculating received signal levels

The received (wanted or unwanted) signal power can be expressed as:

$$P_r = P_t + G_t - L_t - L_b + G_r - L_r$$

where :

P_r - RF signal power at the input to the receiver (dBm);

P_t - RF signal power at the output of the transmitter (dBm);

G_t - gain of the transmitting antenna in the azimuth of the receiver (dBi);

L_t - feeder and branching losses associated with the transmitter (dB);

L_b - total transmission loss between the transmit and receive antennas (dB);

G_r - gain of the receiving antenna in the azimuth of the transmitter (dBi);

L_r - feeder and branching losses associated with the receiver (dB).

The above parameters are discussed in detail in the following sub-parts.

Transmit power (P_t)

The transmit power[23] is the nominal mean (coordinated) power level to which the transmitter is set during system commissioning. The level is measured at the transmitter output port, but the actual power level thus obtained must be reduced by an amount equal to any fixed attenuator fitted between the output port and the antenna feed system. Note that for fixed systems operating with ATPC, the coordinated transmit power may be significantly less than the system maximum transmit power – refer to Appendix 9 "*Adaptive Transmit Power Control*" for details.

[23] Hard limits apply in respect to the maximum power that may be delivered to the antenna of a fixed service system (refer to Part 3.2.2).

Net fixed losses (L_t and L_r)

Includes transmission line and any branching losses associated with combiners, connectors and any special antenna feed system configuration (eg. hot standby) arrangements. These fixed losses may be considered insignificant and disregarded in the case of terminals with integral antennas.

However, for systems utilising separate feeder/antenna arrangements, transmission line and branching losses are significant and their magnitude can potentially determine the success or failure of individual instances of coordination. Waveguide is normally associated with microwave fixed services, but air and foam dielectric coaxial feeders are also common in the lower bands.

The end-to-end attenuation of a transmission line is dependent upon the frequency of operation, the length of the line and the actual type of line used. Accordingly, transmission line attenuation should be calculated using the manufacturers loss per unit length (normally dB/metre) specification for the actual waveguide/coaxial feedline used, at the frequency of operation. Thus fixed losses may be calculated as:

$$L = \alpha d + B \qquad \text{(dB)}$$

where:

L = net fixed loss (dB) at the transmit (L_t) or receive (L_r) end of a link;

α = specific attenuation (per metre) of the feeder, as per manufacturers data;

d = length of the feeder run (metres); and

B = Total branching losses (dB), as per manufacturers specification.

If the length of the feeder run (from the antenna flange to the equipment) is not already established, then a reasonable estimate may be obtained using:

$$d = h_a - h_g + l_1 + l_2 \qquad \text{(metres)}$$

where:

h_a = height of the antenna on the tower;

h_g = height of the feeder gantry above the base of the tower;

l_1 = length of the feeder gantry from the tower to the hut; and

l_2 = length of the feeder tail to the waveguide flange/coaxial connection.

Note: The ACMA's current RRL assignment database does not record such fixed losses. Accordingly, under the basic method of coordination and pending the incorporation of such information into the database, the assumption must be made that wanted and unwanted signals are attenuated to the same degree (ie. the same C/I ratio is maintained) and accounted for through reciprocity.

Antenna parameters (G_t , G_r)

Microwave fixed services normally utilise linearly polarised parabolic antennas with a circularly symmetric response about their main axis of radiation (boresight azimuth). Antenna response is typically described in terms of a Radiation Pattern Envelope (RPE), providing an estimate of antenna gain relative to its on-axis gain (G_o), for the full (360°) range of azimuths and for the two orthogonally polarised components of the radiated signal.

In evaluating a system link budget (ie. the wanted signal level), only the on-axis gains (G_o) of the co-polar transmit and receive antennas need to be considered since reciprocal azimuths are involved, ie. the net effective link antenna gain (transmit + receive) is simply the sum $G_t + G_r$. The value of G_o may or may not be the same in each case, depending upon the actual antennas used at each end of a link.

However, in the case of an interference path, the effective gains of the interfering and victim antennas in the direction of the interference path may be expressed in terms of the on-axis gain (G_{ot} and G_{or} for the transmitter and receiver respectively) and a reduction factor proportional to a discrimination angle:

$G_t = G_{ot} - G_\theta$ (at the transmitter); and

$G_r = G_{or} - G_\phi$ (at the victim receiver).

Here the parameters θ and ϕ refer to the difference between the respective boresight and interference path azimuths, as shown in the example in Figure 4.2. The actual discrimination (dB) value for a given angle is obtained using the antenna RPE.

In cases where the interference source and victim antennas are cross-polarised, both of the orthogonal components of antenna gain need to be considered, corresponding to:

- the cross-polar response of the victim receive antenna to the component of signal radiated on the intended polarity by the transmitting antenna; and
- the co-polar response of the victim receive antenna to the component of signal radiated on the unintended polarity by the transmitting antenna.

Thus in the cross-polar case, it is necessary to evaluate the co-polar and cross-polar components of the transmit and receive angles at their respective discrimination angles. The net effective antenna gain (transmit + receive) in the direction of the interference path is given by:

$$(G_t + G_r) = 10\log\left(10^{\frac{(G_{tH} + G_{rH})}{10}} + 10^{\frac{(G_{tV} + G_{rV})}{10}}\right) \quad \text{(dB)}$$

where the terms G_{tH}, G_{rH} and G_{tV}, G_{rV} are parameters for the respective horizontally (H) and vertically (V) polarised components of the transmit and receive antenna gain in the interference path azimuth.

Calculating transmission loss (L_b)

The total transmission loss (L_b) between two ideal antennas, can be summarised[24] as consisting of two principal components:

- a (time invariant) basic free space loss (L_{bf}); and
- additional attenuation due to terrain, atmospheric absorption and other physical attributes associated with a particular propagation path (L_m).

The total transmission loss is then given by:

$$L_b = L_{bf} + L_m \qquad \text{(dB)}$$

For the basic method, path clearance over the wanted signal path is assumed and for an initial assessment, often only the free-space loss (coupled with antenna discrimination) over the wanted and unwanted signal paths needs to be considered. If the corresponding level of interference complies with the specified interference management criteria, then more complex propagation analyses involving the L_m component need not be initiated. The free-space loss may be calculated using the formula:

$$L_{bf} = 32.4 + 20\log f + 20\log d \quad \text{(dB)}$$

where: f - frequency (MHz); and
d - distance (km).

In cases where the levels calculated with the free-space model exceed the relevant interference management criteria, detailed propagation models characterising the nature of the L_m component may be invoked. Application of the appropriate propagation model/s is important in obtaining an accurate representation of this component of transmission loss. Fixed service propagation models based on relevant ITU-R recommendations are outlined in Appendix 4 "*Fixed service propagation modelling*"

4.2.3 Assessing received signal levels against interference management criteria

For the basic method of frequency coordination, a generic interference management methodology and criteria based on the concept of a Protection Ratio (PR) is adopted. The PR defines a minimum ratio of the relative levels of wanted and unwanted (interference) signals at the input port of the (potential) victim receiver. The protection ratios required for the coordination of analogue and digital systems are defined in Appendix 1 for each microwave frequency band.

The wanted-to-unwanted signal power ratio at the input of a potential victim receiver is given by:

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[24]As outlined in ITU-R Recommendation P.341-4 "*The concept of Transmission Loss for Radio Links*".

$$\frac{W}{U}\text{(dB)} = \text{Wanted signal power (dBm) - Unwanted signal power (dBm)}$$

The unwanted signal power represents an aggregate interference level the value of which is obtained through the summation of individual interference entries:

$$U = 10\log\left(\sum_{1}^{k} 10^{\frac{U_k}{10}}\right) \quad \text{(dBm)}$$

where k=1 defines the case where a single source is deemed dominant.

The wanted to unwanted signal ratio is then compared against the relevant protection ratios defined in Appendix 1. For a successful coordination, this ratio must be greater than the protection ratio, ie. the following relation must be satisfied:

$$\frac{W}{U} \geq \text{*PR}$$

* NOTE: For digital systems, appropriate corrections must be applied to the normalised (for a specific path length) PR values given in the Appendix 1 tables, using the correction factor graphs also provided in Appendix 1 for each frequency band. The correction takes account of the victim system's actual path length and its geographic location in terms of the relevant worst month multipath fading statistics P_L (%) and/or rainfall intensity rate R (mm/hr), as determined using the geoclimatic contour maps[25] provided in Annex A to Appendix 1.

4.2.4 Compliance with assignment instructions and planning rules

In addition to the assessment of interference levels and interference management criteria, it is necessary to ensure that the proposed new fixed link service complies with the relevant assignment instructions (including any special notes) specified in Appendix 1 and the planning rules detailed in Part 3 (eg. "site sense", diversity options). Where specific references are included as part of an assignment instruction (eg. to other administrative instructions or statutory instruments, which includes embargoes and legally binding band plans), then the requirements of such documents must also be taken into account, unless clearly of an advisory nature (eg. RF channel arrangement source recommendations).

A discussion of the application of Assignment Instructions and other relevant spectrum management and fixed service engineering policy matters is provided under Part 3 "*Coordination and System Planning Rules*". Additionally, circumstances under which variations in the (RALI) specified fixed service policy may be supported, are discussed in Appendix 6 "*Application of Assignment Policy Rules*".

[25] As reproduced from ITU-R Recommendations P.453-5 "*The Radio Refractive Index: its formula and Refractivity Data*" and P.837 "*Characteristics of Precipitation for Propagation Modelling*".

4.2.5 Coordination with other types of radiocommunication services

Most of the spectrum allocations utilised by microwave fixed services are shared with various other (fixed and non-fixed) types of radiocommunication services[26]. Accordingly, in addition to the specific coordination procedures and criteria defined in this document for the homogeneous fixed microwave service, it is also necessary to consider:

- the potential for interference to/from other types of radiocommunication services (ie. inter-service coordination and/or coordination with other types of non-homogenous fixed services[27]); and
- the potential for interference to/from space radiocommunication services operating in the Geostationary Orbit (GSO) and compliance with the relevant provisions of Article 21 of the ITU Radio Regulations (on "orbit avoidance").

Non-homogenous fixed and inter-service coordination

Specific RALIs exist to address some instances of the coordination of microwave fixed services with non-homogenous fixed or other radiocommunication services, eg. RALI MS 26 "*Coordination of Microwave Fixed Services with Earth Stations*". References to relevant RALI documents are incorporated within the assignment instructions for each (Appendix 1) microwave fixed service band and a consolidated list of such RALIs is included in the Reference section of this document. In addition to the protection of the GSO (see Appendix 5) specific guidance on two particular cases of coordination between the fixed service and non-homogenous fixed/other services, is provided in the following appendices:

- Appendix 7 "*Coordination of Apparatus Licences with Spectrum Licences: 1.8, 2.1 and 2.2 GHz Fixed Services*"; and
- Appendix 8 "Coordination of DRCS Outstations with Point-to-Point Links". Refer also to Part 3.4.1 "*Rural Telephony (1.5 GHz DRCS) Systems*".

[26] As detailed in the "*Australian Radiofrequency Spectrum Plan*".
[27] For example, Multipoint Distribution Systems (MDS).

Due to the diversity and complexity of sharing situations which may arise, it is not possible to provide rigorous and explicit procedures covering all coordination requirements. In these cases, coordination defaults to the identification of all non-homogeneous services in the band in question, followed by a manual assessment of their impact on the interference environment.

Criteria defining the protection requirements of microwave fixed services are provided in relevant ITU-R recommendations. In particular, ITU-R Recommendation F.758 "*Considerations in the development of criteria for sharing between the terrestrial fixed service and other services*" provides some useful generic guidance in this regard. Guidance regarding the protection requirements of other radiocommunication services may be obtained from the recommendations specific to that service, such as the SF Series of recommendations which address sharing issues between the fixed service and the fixed-satellite service.

<u>Geostationary Satellite Orbit avoidance</u>

Fixed services operating in the same frequency band/s as satellites in the geostationary orbit are required to ensure that (fixed service) emissions do not cause harmful interference to sensitive satellite receivers. Additionally, fixed service receivers may suffer interference from space station emissions, depending upon the fixed service receiver antenna azimuth/elevation and the power flux density (pfd) of the space station emission at the location under consideration. Appendix 5 "*Geostationary Satellite Orbit Avoidance*" describes the restrictions on fixed service azimuth and EIRP for all frequency bands in general, as well as for particular frequency bands within which tighter restrictions apply. Additionally, a methodology is described which facilitates a basic assessment of the long-term interference to the fixed service which may be caused by emissions from satellites operating in the GSO.

4.3 CONSIDERATIONS WHICH MAY FACILITATE SUCCESSFUL COORDINATION

An unfavourable comparison of the wanted-to-unwanted signal power ratio against the applicable protection ratio would indicate that coordination is not possible under the given set of circumstances. In this case, the only available course of action may be to attempt coordination within another channel or frequency band. However, it must be remembered that the basic method of frequency coordination represents a generic approach, intended to accommodate the criteria consolidated from a wide range of fixed service systems. Accordingly, in many cases where an initial assessment results in only a marginal failure against the relevant protection ratio, a successful coordination may be facilitated through the application of measures such as those described in the following paragraphs.

4.3.1 Detailed Interference Analyses

Detailed interference analyses may incorporate:

- a re-calculation of the transmission losses attributed to the interference path, based on detailed terrain (ie. path profile) analyses and the application of relevant propagation models, in accordance with the principles outlined in Appendix 4;

- a more rigorous interference management criteria assessment based on the specific characteristics and protection requirements of the individual victim system undergoing coordination;
- consideration of the relationship of the victim and interfering system power spectral density functions, with consequent FDR (as outlined in Spectrum Planning Report SPP 4/95); and
- a careful reconsideration/refinement of the other assumptions and factors used as part of the initial assessment (eg. antenna angular and cross-polar discrimination, fixed losses and other factors relevant to a particular case).

4.3.2 Interference Countermeasures

The incorporation of appropriate countermeasures as part of the detailed link planning process may provide a critical contribution towards facilitating a successful coordination. For example, such countermeasures may be implemented at the interference source (transmit) and/or at the victim (receive) locations by:

- ensuring that full advantage is taken of antenna cross-polar discrimination, if not already taken into account;
- increasing the system gain of the victim service, typically by installing antennas with higher on-axis gain (ie. larger diameter parabolic dishes);
- increasing antenna discrimination in the azimuth of the interference path, for example through the utilisation of higher performance antennas and/or by deliberately exploiting near end path clearance to advantage (ie. antenna location shielding); and
- reducing transmit power at the interfering system transmitter (i.e. by placing a fixed attenuator between the transmitter output port and the antenna feed/branching network), in cases where significant excess fade margin is available over the wanted signal path (of the interfering system) or through the use of ATPC.

Of course the viability of the above (and other) countermeasures will depend upon individual circumstances and should be considered in conjunction with the system planner as part of the overall detailed link design.

RALI Authorisation

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Barry Matson
Executive Manager
Spectrum Planning and Standards Group
Australian Communications Authority

GLOSSARY

BER - Bit Error Rate

CTS - Cordless Telecommunications Services

DRCS - Digital Radio Concentrator System

DSP - Digital Signal Processing

EIRP - Effective Isotropic Radiated Power

ENG - Electronic News Gathering

FDM/FM - Frequency Division Multiplex/Frequency Modulation

FDR - Frequency Dependant Rejection

GSO - Geostationary Orbit

HSDA - High Spectrum Demand Areas

LOS - Line of Sight

MDS - Multipoint Distribution Station

PDH - Plesiochronous Digital Hierarchy

RADCOM - The ACMA Radiocommunications licensing database

RPE - Radiation Pattern Envelope

SDH - Synchronous Digital Hierarchy

STL - Studio-to-Transmitter Link

TDM - Time Division Multiplex

TDMA - Time Division Multiple Access

TOB - Television Outside Broadcast

WLL - Wireless Local Loop

REFERENCES

This section consolidates the references incorporated as part of the RALI FX 3 "*Microwave Fixed Services Frequency Coordination*" document, including detailed Appendices. The following listing incorporates references to ACMA statutory and administrative instruments, ITU Radio Regulations, relevant recommendations and other standards. Further references and information resources are also provided for material which may have been used during the development of the RALI and/or which may be considered otherwise useful in the fixed service coordination context.

ACMA

"*Radiocommunications Act 1992*".

"*Australian Radiofrequency Spectrum Plan*".

"*Radiocommunications Licence Conditions (Fixed) Licence Determination No.1 of 1997*".

"*1.5GHz Band Plan*", December 1996.

"*1.9 GHz Band Plan*", 14 March 1996.

"*2.1 GHz Band Frequency Band Plan 2002*", 17 September 2003.

"*Mobile Satellite Service (2GHz) Frequency Band Plan 2002*", 23 April 2002.

"*Radiocommunications Apparatus Licence Fees and Charges*".

Spectrum Re-allocation Declaration No. 3 of 1997.

Spectrum Re-allocation Declaration No. 4 of 1997.

Information Paper "*Principles for Decision Making*".

"Radiocommunications (Spectrum Re-allocation) Declaration No. 2 of 2000."

"Radiocommunications (Spectrum Designation) Notice No.1 of 2000" [January 2000].

ACMA RALIs

FX 9 "*Frequency Coordination of Fixed Links with Regional MDS Services*".

FX 14 "*Point to Multipoint Fixed Services in Specified Parts of the 3.4-3.59 GHz Band*".

FX 18 "*Frequency Coordination and Licensing Procedures for Fixed Wireless Access Services Sharing the 1.9 GHz Band with Fixed Links*".

MS 3 "*Spectrum Embargoes*".

MS 11 "*Licence Text in RADCOM (Incorporating Special Conditions and Advisory Notes)*".

MS 24 “*Apparatus Licence Periods*”.

MS 25 “*Frequency Coordination and Licensing Procedures for Cordless Telecommunications Services Sharing the 1.9 GHz Band with Fixed Links*”.

MS 26 “*Coordination of Microwave Fixed Services with Earth Stations*”.

ACMA SPECTRUM PLANNING POLICY DOCUMENTS

SP 1/90, “*Spectrum and Licensing Arrangements for Outside Broadcast Television Services*” March 1990.

SP 5/90, “*Notional Antenna Radiation Patterns*”, Department of Transport and Communications, July 1990.

SPP 3/95, “*Television Outside Broadcast (TOB) Service - 7.2 GHz and 8.3 GHz RF Channel Arrangements*”, July 1995.

SPP 4/95, “*Frequency Dependent Rejection (FDR) Software*”, May 1995.

SPP 4/96, “*Interim Channel Arrangements for the 18 GHz Band - A Discussion Paper*”, September 1996, and Addendum 1 to that paper, “*New Interim Arrangements in the 18 GHz Band*”.

SP 10/01, *"Coordination Information for Defence Aeronautical Mobile Telemetry Systems Operating in the 2200 to 2300 MHz Frequency Range"*.

SP 08/01, *“Microwave fixed services: Survey of commercially manufactured (1.5-58 GHz) parabolic antennas”* June 2001

SP05/03, *“Proposal for Spectrum Efficient Antenna Performance Regulatory Criteria for use in the Fixed Service Microwave Bands”, June 2003*

SP 04/04, *“Spectrum Efficient Antenna Performance Regulatory Criteria Proposal - Summary and Discussion of Responses”*, April 2004

ITU DOCUMENTS

ITU Radio Regulations.

"*ITU-R Handbook on Digital Radio-Relay Systems*", Geneva 1996.

"*Economic and Technical Aspects of the Choice of Transmission Systems*", Appendix to Section B IV3 of the Handbook, ITU Geneva 1971.

ITU-R F-Series (Fixed Service) Recommendations

F.283-5 "*Radio-frequency channel arrangements for low and medium capacity analogue or digital radio-relay systems operating in the 2 GHz band*".

F.382-6 "*Radio-frequency channel arrangements for radio-relay systems operating in the 2 and 4 GHz bands*".

F.383-5 "*Radio-frequency channel arrangements for high capacity radio-relay systems operating in the lower 6 GHz band*".

F.384-5 "*Radio-frequency channel arrangements for medium and high capacity analogue or high capacity digital radio-relay systems operating in the upper 6 GHz band*".

F.385-6 "*Radio-frequency channel arrangements for radio-relay systems operating in the 7 GHz band*".

F.386-4 "*Radio-frequency channel arrangements for radio-relay systems operating in the 8 GHz band*".

F.387-6 "*Radio-frequency channel arrangements for radio relay systems operating in the 11 GHz band*".

F.497-4 "*Radio-frequency channel arrangements for radio-relay systems operating in the 13 GHz frequency band*".

F.595-4 "*Radio-frequency channel arrangements for radio-relay systems operating in the 18 GHz frequency band*".

F.635-2 "*Radio-frequency channel arrangements based on a homogeneous pattern for radio-relay systems operating in the 4 GHz band*".

F.636-3 "*Radio-frequency channel arrangements for radio-relay systems operating in the 15 GHz band*".

F.637-2 "*Radio-frequency channel arrangements for radio-relay systems operating in the 23 GHz band*".

F.701 "*Radio-frequency channel arrangements for analogue and digital point-to-multipoint radio systems operating in frequency bands in the range 1.427 to 2.690 GHz (1.5, 1.8, 2.0, 2.2, 2.4 and 2.6 GHz)*".

F.746 "*Radio-frequency Channel Arrangements for Radio-Relay Systems*".

F.747 "*Radio-frequency channel arrangements for radio-relay systems operating in the 10 GHz band*".

F.749-1 "*Radio-frequency channel arrangements for radio-relay systems operating in the 38 GHz band*".

F.752 "*Diversity Techniques for Radio-Relay System*".

F.758 "*Considerations in the development of criteria for sharing between the terrestrial fixed service and other services*".

F.1099 "*Radio-frequency channel arrangements for high-capacity digital radio-relay systems in the 5 GHz (4400-5000 MHz) band*".

F.1093 "*Effects of Multipath Propagation on the Design and Operation of Line-of-Sight Digital Radio-Relay Systems*".

F.1095 "*A procedure for determining coordination area between radio-relay stations of the fixed service*".

F.1098-1, *" Radio-frequency channel arrangements for radio-relay systems operating in the 1 900 - 2 300 MHz Band".*

F.1100 "*Radio-Frequency Channel Arrangements for Radio-Relay Systems Operating in the 55 GHz band*".

F.1247 "*Technical and operational characteristics of systems in the Fixed Service to facilitate sharing with the Space Research, Space Operation and Earth-Exploration Satellite Services operating in the bands 2025-2110MHz and 2200-2290 MHz*".

F.1249 "*Maximum Equivalent Isotropically Radiated Power of transmitting stations in the Fixed Service operating in the frequency band 25.25-27.5 GHz shared with the Inter-Satellite Service*".

ITU-R P-Series (Propagation) Recommendations

P.310-9 "*Definitions of terms relating to propagation in non-ionised media*".

P.341-4 "*The concept of Transmission Loss for Radio Links*".

P.452-7 "*Prediction Procedure for the Evaluation of Microwave Interference between stations on the Surface of the Earth at frequencies above about 0.7 GHz*".

P.453-5 "*The Radio Refractive Index: its formula and Refractivity Data*".

P.526-4 "*Propagation by diffraction*".

P.530-6 " *Propagation data and Prediction Methods required for the design of Terrestrial Line-of-Sight Systems*".

P.581-2 "*The concept of Worst Month*".

P.676 "*Attenuation by atmospheric gases*".

P.834 "*Effects of tropospheric refraction on radiowave propagation*".

P.837 "*Characteristics of Precipitation for Propagation Modelling*".

P.838 "*Specific Attenuation Model for Rain for use in Prediction Methods*".

P.841 "*Conversion of annual statistics to worst-month statistics*".

ITU-R SF-Series (FS/FSS Frequency Sharing) Recommendations

SF.406 "*Maximum Equivalent Isotropically Radiated Power of Radio-Relay System Transmitters Operating in the Frequency Bands Shared with the Fixed-satellite Service*".

SF.765 "*Intersection of Radio-Relay Antenna beams with orbits used by Space Stations in the Fixed-Satellite Service*".

SF.766 "*Methods for determining the effects of interference on the performance and the availability of terrestrial radio-relay systems and systems in the fixed-satellite service*".

SF.1004 "*Maximum equivalent isotropically radiated power transmitted towards the horizon by earth stations of the fixed satellite service sharing frequency bands with the fixed service*".

SF.1005 "*Sharing between the fixed service and the fixed-satellite service with bidirectional usage in bands above 10 GHz currently unidirectionally allocated*".

SF.1006 "*Determination of the interference potential between earth stations of the fixed-satellite service and stations in the fixed service*".

SF.1193 "*Carrier-to-interference calculations between earth stations in the fixed-satellite service and radio-relay systems*".

Other

"*Spectrum Management Issues Relevant to Telecommunications*", Spectrum Management Agency, August 1996.

"*The Australian Geodetic Datum Technical Manual (National Mapping Council 1986)*".

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"*Frequency Coordination Procedures for Microwave Communication Services*", W. Yates and P. Hilly, August 1990.

Part 101 "*Fixed Microwave Services*" of the FCC Rules, Pike & Fischers Communication Regulations.

"*Catalogue of Software for Radio Spectrum Management*", ITU Radiocommunication Bureau, Geneva 1997.

"Analysing antenna performance in microwave radio interference environment", E.S. Lensson, A. Kerans, G. French, IEEE Asia Pacific Conference (Sydney 3-6 December 2000)

Useful Web Links

http://www.acma.gov.au	Australian Communications and Media Authority.
http://www.ga.gov.au	Geoscience Australia, Department of Industry, Tourism and Resources.
http://www.itu.int	International Telecommunication Union.
http://www.nsma.org	National Spectrum Managers Association (USA).
http://www.fcc.gov	Federal Communications Commission (USA).
http://www.ntia.doc.gov	National Telecommunications and Information Administration (USA).
http://www.ero.dk	European Radiocommunications Office