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**Introduction of New Channel Arrangements
For Fixed Services in the 2 GHz Band Based on
Recommendation ITU-R F.1098-1**

- a discussion paper

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1 INTRODUCTION

The 2 GHz Band covers the frequency range 1900 to 2300 MHz. The introduction of spectrum licensing¹ to support third generation (3G) mobile technologies (IMT-2000) and the ACA's decision to make spectrum available for the Mobile Satellite Service (MSS) in this band considerably reduce the amount of spectrum available in this band for point-to-point Fixed Services (FS) under the existing channel arrangements. A significant number of FS incumbents are required to relocate from these affected FS bands.

This paper proposes new channel arrangements in the 2 GHz Band to support FS as a result of changes to existing arrangements. The introduction of the new channel arrangements for FS is not intended to provide a complete solution to the relocation requirements, but it does provide an additional option in the short term for those incumbents able to take advantage of it. Additionally, these new arrangements provide an important additional opportunity for the wider user community.

2 BACKGROUND

The ACA's Radiocommunications Consultative Council (RCC) Working Group on IMT-2000 identified a new FS channel arrangement in the 2 GHz Band², based on ITU-R Recommendation F.1098³ (Rec. F.1098), as potentially helpful to the relocation requirement. The ACA's Microwave Radio Spectrum Trends paper⁴ (the *Trends Paper*) also discussed relocation issues in the 2 GHz Band. The main relocation options focussed on the use of microwave bands above 10 GHz for short path length links and the 6 and 8 GHz bands for longer links. Additionally, the paper proposed the introduction in due course of Rec. F.1098 channel arrangements.

Although the proposed new channel arrangements were not promoted in the *Trends Paper* as necessarily being a major option for the relocation requirement, they do, with suitable channel spacings, offer opportunities for some incumbents to remain in the 2 GHz Band, with associated economic benefits. The ACA summary of comments on the *Trends Paper*⁵ advised that planning for the introduction of the Rec. F.1098 channelling scheme would be included as part of the implementation of spectrum allocations for IMT-2000.

3 CURRENT USAGE

The 2 GHz Band is shared by a number of services including Fixed, Mobile and Spaces Services. The overall spectrum arrangements in the 2 GHz Band are shown in Attachment 1. These include:

¹ Radiocommunications (Spectrum Re-allocation) Declaration No.2 of 2000

² Report of the Radiocommunications Consultative Council Working Group on IMT-2000, December 1999, Sections 10.2 and 10.3.

³ Recommendation ITU-R F.1098-1 "Radio-frequency Channel Arrangements for Radio-relay Systems in the 1 900 - 2 300 MHz Band". These channel arrangements resulted from Australian proposals at WARC-92, in recognition of the need to optimise FS arrangements around the new allocations for IMT-2000 (then FPLMTS).

⁴ "Microwave Radio Spectrum Trends: Accommodating the Demands of Growth, New technologies and Relocation - an ACA Information Paper" - Radiofrequency Planning Group February 2000.

⁵ http://www.aca.gov.au/frequency/mrst_sum.pdf (June 2000)

- Spectrum Licensed spectrum (the IMT-2000 bands) in 1900 to 1980 MHz and 2110 to 2170 MHz on a geographic basis;
- MSS in the 1980 to 2010 MHz and 2170 to 2200 MHz bands;
- FS links operating in the 1893 to 2081.5 MHz and 2106 to 2294.5 MHz bands under the existing ITU-R F.382⁶ (Rec. F.382) channel arrangements;
- Multipoint Distribution Systems in the 2076 to 2111 MHz MDS A band;
- Space Operations and Space Research in the 2025 to 2110 MHz and 2200 to 2290 MHz bands and Space Research (Deep Space) in the 2290 to 2300 MHz band; and
- Airborne mobile telemetry in the 2200 to 2300 MHz band.

3.1 IMT-2000

The IMT-2000 bands 1900 to 1980 MHz and 2110 to 2170 MHz have been re-allocated for spectrum licensing on a geographic basis⁷ as follows:

- 1900 to 1980 MHz and 2110 to 2170 MHz for capital cities other than Canberra;
- 1900 to 1920 MHz, 1935 to 1980 MHz, and 2125 to 2170 MHz in Canberra; and
- 1960 to 1980 MHz and 2150 to 2170 MHz in designated regional areas.

The re-allocation period has been set at 2 years (ending October 2002). All FS links operating in the frequency ranges and geographic areas designated in the re-allocation declaration are required to vacate this spectrum by the end of the re-allocation period.

3.2 MSS

A Frequency Band Plan under Section 32 of the Radiocommunications Act 1992 is currently being prepared to support the use of the 1980 to 2010 MHz and 2170 to 2200 MHz bands by MSS. An Australia wide clearance plan requiring the relocation of FS incumbents from certain channels in the existing Rec. F.382 channel arrangements by 31 December 2002 and an additional relocation from other Rec. F.382 channels with a target date of 31 July 2004 is under way.

3.3 Existing FS Point-to-Point Links

Existing FS links operate under the Rec. F.382 channel arrangements specified in the "2.1 GHz Band" section of RALI FX3⁸. These arrangements provide 6 paired channels of 29 MHz channel width, with Main and Interleaved patterns. The band is typically used for medium capacity data (34 Mbps) and FM video.

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

⁷ Radiocommunications (Spectrum Re-allocation) Declaration No.2 of 2000.

⁸ Radiocommunications Assignment and Licensing Instruction FX3 "Microwave Fixed Services Frequency Coordination".

3.3.1 Current FS Occupancy

There are 1825 one-way assignments associated with FS links in the 2 GHz band; of these, approximately 510 are directly affected by either IMT-2000 or MSS clearance provisions and will require relocation⁹. The incumbent licensees most affected are Telstra (292 spectrum accesses), broadcasters (111 spectrum accesses), and utilities (85 spectrum accesses). Of the affected assignments, 287 (56%) are analogue services and 223 (44%) are digital services. Of the 510 affected assignments:

- 20 operate in a bandwidth of 7 MHz or less;
- 77 operate with a bandwidth greater than 7 MHz but not more than 14 MHz; and
- 413 operate in a bandwidth of greater than 14 MHz, of which:
 - 110 are FM Video (predominantly commercial broadcasters);
 - 157 are multi-channel digital (predominantly Telstra);
 - 96 are multi-channel analogue (predominantly Telstra); and
 - 50 are others types.

Additionally, there are other 2 GHz band FS assignments indirectly affected by the clearances, due to the two-frequency pairing arrangements in the existing Rec. F.382 channel arrangements. It is anticipated that some incumbents may also include these links in their relocation considerations. In some geographic areas, the clearance requirements may make operation of some FS networks less viable under the existing Rec. F.382 channel arrangements due to the reduced number of channels remaining available.

3.4 Multipoint Distribution Systems

Multipoint Distribution Systems operate in the 2076 to 2111 MHz "MDS A" band on a geographic basis. The revised *"Multipoint Distribution System Frequency Band Plan 2000"* sets a termination date of 26 July 2002 for MDS operating in this frequency range.

3.5 Space Operations and Space Research

Space operations and space research activities occur in the 2025 to 2110 MHz up link band and the 2200 to 2290 MHz down link band from a number of locations within Australia¹⁰. Space research (deep space) operating in the 2110 to 2120 MHz and 2290 to 2300 MHz bands is undertaken from two locations within Australia¹¹. In addition to operation in these bands by NASA and ESA, the ACA has observed increasing interest in the use of parts of this spectrum for space operations by launch facilities in Australia.

⁹ All estimates based on RADCOM data for October 2000.

¹⁰ Space operations and space research are undertaken from Tidbinbilla ACT and Gngangara WA and will shortly be undertaken at New Norica WA.

¹¹ Space research (deep space) is undertaken at Tidbinbilla ACT and will shortly be undertaken at New Norica WA.

3.6 Airborne Mobile Telemetry

Within the 2200 to 2300 MHz band the Department of Defence operates airborne mobile telemetry in a number of areas within Australia. Airborne mobile telemetry systems operated by BAE Systems also operate at a frequency of 2285 MHz in the Woomera area in support of test flights of experimental aircraft. Additionally, the Bureau of Meteorology has requested spectrum access to these bands for down-link balloon operations. The ACA also receives queries from time to time from other interested parties for these applications.

4 PROPOSED NEW FS CHANNEL ARRANGEMENTS

The introduction of new channel arrangements conforming to Rec. F.1098 is a potentially attractive consideration for current users subject to relocation, as there is good scope to retain much of their existing infrastructure (such as towers, transmitters, receivers, antennas and feeder cables). This applies particularly for links currently occupying a bandwidth of 14 MHz or less (assuming that the new channel arrangements provide for 14 MHz channel widths - see Section 4.1). A total of 97 (19%) current assignments have an emission bandwidth of 14 MHz or less (the maximum channel width available under Rec. F.1098).

For digital links currently occupying a bandwidth of greater than 14 MHz the opportunity is provided to also retain much of the current hardware (towers, antenna, feeders), but with new transmitter and receiver equipment required (this would generally entail a change to higher order digital modulation schemes). For links of reasonably long path length (see Section 4.3.3 for discussion of path lengths), this should still represent a very cost-effective option.

Wide band analogue links (typically FM video) are not likely to be able to adapt to channel widths of less than 14 MHz and would need to be converted to digital to operate under the proposed new Rec. F.1098 channel arrangements.

4.1 Rec. F.1098 Channel Arrangements

The annexes to Rec. F.1098 provide a number of options for channel arrangements, taking account of the spectrum available for FS use in any particular country. Annex 1 to Rec. F.1098 provides two alternative channel arrangements that would suit the spectrum available for FS in the 2 GHz band in Australia. The first option provides up to 6 x 14 MHz channels in a main pattern and 5 x 14 MHz channels in an interleaf pattern. The second provides up to 5 x 14 MHz channels in a main pattern and 5 x 14 MHz channels in an interleaf pattern. Rec. F.1098 also provides for channel widths of 7, 3.5 and 1.75 MHz by subdivision of the 14 MHz channels. Discussion in Sections 4.1.1, 4.1.2 and 4.1.3 of this report refer to 14 MHz channel widths whilst Section 4.1.4 discusses other channel width options.

4.1.1 Rec. F.1098 Annex 1 Option 1

The first option in Annex 1 of Rec. F.1098 maximises the number of available channels in the main pattern providing 6 x 14 MHz channels. [Attachments 1 and 2](#) to this report illustrate this option. To avoid intrusion into MSS spectrum below 2200

MHz¹² or intrusion into IMT-2000 spectrum above 2110 MHz¹³, only 5 channels are available in the interleaf pattern.

4.1.2 Rec. F.1098 Annex 1 Option 2

The second option in Annex 1 of Rec. F.1098 provides one less channel in the main pattern but offers alignment with European arrangements in this band under European Conference of Postal and Telecommunications Administrations (CEPT) Recommendation T/R 13-01¹⁴. The interleaf pattern channel associated with the first main pattern channel in the upper channel pair occurs at 2206.5 MHz and the channel width would need to be restricted to 13 MHz to prevent intrusion into the MSS spectrum below 2200 MHz.

4.1.3 Discussion of Rec. F.1098 Annex 1 Options

The key difference between the two options is that the second directly aligns with European channel arrangements but offers one less channel in the main pattern. Both options use a transmitter-receiver duplex spacing of 175 MHz. The channel centre frequencies associated with the second option are 6.5 MHz above that of the centre frequencies of the first option.

Several equipment suppliers¹⁵ offer products that operate in the 2 GHz FS band. Only one of these suppliers clearly stated support for Rec. F.1098 channel arrangements in its equipment brochure. Some claim conformance with European channel arrangements and others claim support for other ITU-R channel plans. Most of the suppliers claim that their equipment provides agile channel capability¹⁶. Given the kind of channelling capability offered in these products, the ACA believes that vendors can support both channel arrangement options under Rec. F.1098. As the first option (6 x 14 MHz main pattern and 5 x 14 MHz interleaf pattern) provides the most channels, it should be used for the proposed new arrangements.

4.1.4 Channel Width Options

The maximum channel width under the provisions of Rec. F.1098 is 14 MHz. As noted in Section 3.3.1, 97 (19%) assignments subject to relocation have a bandwidth of 14 MHz or less. In the *Trends Paper* and other industry discussions regarding Rec. F.1098 (such as the RCC Working Group on Spectrum Demands for New Telecommunications Services), the ACA has consistently indicated a new channel arrangement based on channel widths of 14 MHz. Whilst the ACA is not aware of any particular concerns with this approach, no detailed discussions have taken place

¹² If an interleaf pattern channel in the upper channel of a pair were permitted which had a centre frequency of 2200.5 MHz, any practical channel width associated with it would cause emissions below 2200 MHz and intrude into the MSS spectrum.

¹³ If an interleaf pattern channel in the lower channel of a pair were permitted which had a centre frequency of 2109.5 MHz, any practical channel width associated with it would cause emissions above 2110 MHz and intrude into the IMT-2000 spectrum.

¹⁴ CEPT Recommendation T/R 13-01 "*Preferred Channel Arrangements for Fixed Services in the Range 1-3 GHz*"

¹⁵ Alcatel, Continental Microwave, Harris Corporation, Italiana Ponti Radio, Itelco, NEC and Nera.

¹⁶ Most modern microwave equipment uses programmable synthesisers to set operating frequency. Manufacturers offer either pre-programmed channel plans or the ability to directly set operating frequencies from the front panel. In either case, provided the diplexer in the equipment can support such operation, any frequency and duplex offset can be selected in the band. For the purpose of this report, the term Agile Channel Capability is used to describe this ability.

with industry on the appropriateness of this channel width at this stage. Rec. F.1098 also supports lower channel width options of 1.75, 3.5 and 7 MHz. This report assumes that support for 34 Mbps medium capacity data links using the proposed new Rec. F.1098 channel arrangements is a continuing requirement. Whilst the Rec. F.1098 plan does not support the wider 29 MHz spacing in the current Rec. F.382 arrangements, the following discussion includes relevant consideration of this spacing.

4.1.4.1 14 MHz Channel Width

As noted earlier, existing systems of less than 14 MHz bandwidth could in principle directly relocate to the new channels, and users of higher capacity digital systems could consider the procurement of new transmitters / receivers suited to this channel width. If channel widths of 7 MHz or less were to be implemented then very few existing systems (20 assignments or 4%) would be able to directly relocate into the new channel arrangements.

4.1.4.2 7 MHz or Less Channel Width

Some potential users of the proposed new Rec. F.1098 channel arrangements might prefer a channel width of 7 MHz or less. This might be on the basis that they do not require a system that supports bit rates as high as 34 Mbps or that they intend to use modulation schemes that are more spectrally efficient than current schemes operating in the 2 GHz band. Whilst less than 14 MHz channel widths might be interpreted as encouraging more efficient use of the spectrum, there are some undesirable limitations associated with implementing such channel widths.

Firstly, for a system that has a requirement to support a 34 Mbps digital stream in a bandwidth¹⁷ of 14 MHz or less, a higher order modulation scheme than the typical current 4-PSK scheme¹⁸ operated in the 2 GHz band would be required. 16-QAM can deliver the same bit rate signal within a bandwidth of half that required for a 4-PSK system and therefore would be a suitable modulation scheme to transmit a 34 Mbps digital stream in 14 MHz or less bandwidth. To transmit a 34 Mbps digital stream in a bandwidth of 7 MHz or less would require a higher order modulation scheme of at least 256-states. The systems currently offered by suppliers (see [Attachment 3](#)) have higher order modulation scheme capabilities such as 16-QAM, 64-QAM, 32-TCM, 128-TCM but none offer 256-state schemes. It is concluded that if the channel width under the proposed new Rec. F.1098 channel arrangements were to be lowered to 7 MHz that it would significantly reduce, if not deny, scope for 34 Mbps systems.

Secondly, segregation of the available spectrum to accommodate some 14 MHz channel width channels and some 7 MHz channel width channels might be considered a possible solution. However, to do so would mean reducing the number of 14 MHz channels available on trunk routes and would severely limit the opportunities for more than one licensee to operate within the same trunk route. A similar limitation could also arise if 7 MHz channels overlaid all or even some of the 14 MHz channels. As noted in 4.1.4.3, at least 2 and sometimes 3 channel pairs are required to support

¹⁷ A upper bound to the bandwidth requirement can be estimated using the equation:

$BW = BR * (1 + \alpha) / \text{Log}_2(M)$ where BW is the required bandwidth, BR is the signal bit rate, α is the roll-off factor of the transmitter raised-cosine filter (typical value is 0.5) and M is the number of modulation states.

¹⁸ A typical 34 Mbps digital stream using 4-PSK would occupy a bandwidth of about 25.5 MHz.

frequency reuse on trunk routes. It is desirable that the channel pairs selected are not first adjacent channels to each other so that the protection ratio requirement for successive hops is eased considerably. Under such arrangements the channel pairs would need to be either 1, 3 and 5 or 2, 4 and 6. That is, all six channels need to be available if support for 34 Mbps digital data streams in a trunk route by more than one licensee is required. Subdividing any of these 14 MHz channels to provide 2 x 7 MHz channels would once again reduce the number of 14 MHz channels available.

4.1.4.3 29 MHz Channel Width

Given that the number of incumbents with bandwidth of less than 14 MHz is only 19 % of the total, it could be argued that a wider channel width would more readily accommodate a greater number of incumbents. Indeed, consideration could even be given to "ad-hoc" (non-channel specific) use of the available FS spectrum by relocated links, in the interests of possible expedient relocation. Such an approach was supported in the 1.8 GHz band, during the recent re-allocation program in that band.

However, there are a number of reasons why wider than 14 MHz or unstructured channelling should not be used in the 2 GHz Band:

- Ad-hoc use of "unsold" 1.8 GHz spectrum was feasible on a strict temporary basis, as the affected spectrum was not viable for an ongoing structured FS arrangement. In fact, in city areas, the spectrum used for this purpose has subsequently also been re-allocated and sold.
- Rec. F.1098 is an internationally recognised "standard" for channel arrangements, using spectrum that deliberately avoids IMT-2000 bands and as such has the potential for long term FS applications. It should be of interest to a wide range of FS users, not just to incumbents subject to relocation. As such, its adoption in Australia would be consistent with good planning and with the ACA's long standing practice of implementing FS plans that accord with international standards.
- Rec. F.1098 has a range of channel width options up to 14 MHz. The 14 MHz option allows for 6 main channels to be implemented in the available spectrum, with interleaving. A minimum of 2, and under more difficult frequency reuse circumstances, 3 channel pairs are necessary to effectively support multi-hop trunk route FS systems¹⁹. The 14 MHz channel width options provides for more than one trunk route system to be able to operate along the same general route.
- The retention of the current 29 MHz channel width would support only 2 full width channels in the available spectrum; a reduction to 28 MHz would allow for

¹⁹ 2 channel pairs can be used where terrain shielding or antenna directivity or cross polar discrimination (or a combination of these factors) offers sufficient path loss between the transmitting antenna of the first hop and the receiving antenna of the third hop (the first reuse of the channel frequency) to maintain the required protection ratio. When antenna directivity and cross polar discrimination do not offer sufficient path loss between the transmitting antenna of the first hop and the receiving antenna of the first reuse of a channel then a third channel pair needs to be used. Under these circumstance the distance between these 2 antennas will be around 200km and additional path loss associated with earth bulge obstruction will usually assist in the reuse of the channel.

three full width channels, with some interleaving. This small number of channels would only provide for a single system on a particular trunk route and would only be of use to some incumbents on an opportunity basis, for isolated single hop links.

Given these observations, the ACA believes the introduction of a non-standard channel width of greater than 14 MHz cannot be justified. The adoption of a 14 MHz channel width would be appropriate if significant weight is to be given to supporting the incumbent relocation.

4.1.4.4 Preference for 14 MHz Channel Width

The ACA is of the view that, on balance, a 14 MHz channel width represents a reasonable compromise between meeting the needs of incumbents in relation to relocation and providing opportunities for the wider FS community.

Proposals:

- 1. That a 14 MHz channel width be utilised for the new channel arrangements.*
- 2. That the first option in Annex 1 to Rec. F.1098 (ie. 6 x 14 MHz channels in the main pattern - see Attachments 1 and 2) be implemented as it provides for the maximum number of channels to be used in the remaining available spectrum.*

Industry comment is invited on these proposals.

4.2 Coordination With Other Services in the Band

RALI FX3 details the existing coordination requirements between FS systems and gives guidance on coordination between FS systems and other services operating in the 2 GHz band. RALI FX3 will be updated to incorporate the proposed new Rec. F.1098 channel arrangements and related coordination requirements. There are a number of sharing issues to be considered with the introduction of these new arrangements.

4.2.1 Sharing With IMT-2000

The IMT-2000 spectrum in the 1900 to 1980 MHz and 2110 to 2170 MHz bands is subject to spectrum licensing on a geographic basis. FS operating under the new Rec. F.1098 channel arrangements operate in spectrum adjacent²⁰ to IMT-2000 and coordination will be required between these services at the relevant frequency and geographic boundaries. Advice is provided to spectrum licensees in this regard by way of Advisory Guidelines²¹ and the ACA is preparing advice to FS apparatus licensees on these coordination requirements, for inclusion in Appendix 7²² to RALI FX3.

²⁰ A 14 MHz wide FS link operating in channel 6M of Rec. F.1098 would have an upper frequency bound of 2109.5 MHz and be only 500 KHz away from IMT-2000 spectrum (see Attachment 1).

²¹ Radiocommunications Advisory Guidelines (Protection of Apparatus-licensed and Class-licensed Receivers - 2 GHz band) 2000; and: Radiocommunications Advisory Guidelines (Managing Interference from Apparatus-licensed and Class-licensed Transmitters - 2 GHz band) 2000.

²² The current title of Appendix 7 is "*Coordination of Apparatus Licences with Spectrum Licences: 1.8 GHz Band Fixed Services*". The title and contents will be amended to include 2.1 GHz Band fixed services.

4.2.2 Sharing With Fixed Services

FS channels under the existing Rec. F.382 arrangements unaffected by IMT-2000 or MSS clearance requirements, but in overlapping spectrum to be used for the proposed new Rec. F.1098 channel arrangements, have been "grand-fathered" (see next section for details). The assignment process for Rec. F.1098 channels will need to include frequency coordination with existing assignments in these overlapping channels. Consequently, in some (perhaps many) areas the new channels will not be readily available in the short term because of interference considerations. Rec. F.382 FS channels unaffected by IMT-2000 or MSS clearance requirements and not in overlapping spectrum to be used for the proposed new Rec. F.1098 channels, continue to be available for use by existing and new assignments.

4.2.2.1 "Grand-fathering" of Existing Links in Rec. F.1098 Spectrum

The proposed new Rec. F.1098 channel arrangements overlap some channels (5I-6M, 4I'-6M') of the existing Rec. F. 382 channel arrangements not directly affected by clearance requirements (see Attachment 2).

To optimise access to the proposed new Rec. F.1098 channel arrangements for incumbents in the short term and in general for the longer term, the overlapping channels in the existing Rec. F.382 channel arrangements have been embargoed from further new assignments, under ACA Embargo 23²³. The embargo notice provides for exceptions to be made on a case-by-case basis for retuning into the embargoed spectrum by incumbent links subject to relocation from IMT-2000 or MSS spectrum, but only for links in remote localities. Existing licences can be renewed. That is, the Rec. F.382 channels have been "grand-fathered" in favour of the new Rec. F.1098 channels.

This planning strategy provides for the most efficient overall use of the available FS spectrum in the long term. The approach gives priority of future use of this spectrum to the proposed new Rec. F.1098 channel arrangements over the existing Rec. F.382 channel arrangement, which is in effect unusable in many parts of the country. Additional IMT-2000 allocations in country areas in the future would render Rec. F.382 channel arrangements virtually obsolete.

Summary: The current Rec. F.382 channels overlapping the Rec. F.1098 channels have been embargoed from new assignments except for retuning in remote areas as a result of relocation. Renewal of existing licences is unaffected.

4.2.3 Sharing With MDS

The MDS A band overlaps a significant proportion of the proposed new Rec. F.1098 channel arrangements (see Attachment 1). Operation of FS on the affected channels in MDS A areas cannot commence until after the cessation of MDS in July 2002. However, this does not prevent the application for and frequency coordination of licences for FS prior to that date. Licences may be issued with the condition that transmissions must not occur before a specified date. This approach will afford FS users the ability to forward plan in this part of the band.

²³ Radiocommunications Assignment and Licensing Instruction MS3 "Spectrum Embargoes" Embargo Number 23 February 2001.

Summary: Licensing of Rec. F.1098 channels will be permitted in advance of MDS A cessation, subject to restrictions on use until after that event.

4.2.4 Sharing With Space Operations and Space Research

The bands proposed for Rec. F.1098 FS channels are also allocated to the Space Operations, Space Research and Earth Exploration Satellite services. Any licensed operations of these services in Australia will need to be taken into account in the assignment of frequencies to the new FS.

RALI FX3, Appendix 5²⁴, provides guidance on sharing with data relay satellites (DRS) operating in the space operations service. It is based on ITU-R Recommendation F.1247²⁵ and sets a limit of +8 dBW/MHz on the EIRP spectral density radiated from an individual FS station in the direction of a DRS. Appendix 5 of RALI FX3 also sets a minimum angular separation of 2 degrees between the direction of the main beam of an FS station and the direction of a DRS for FS stations that operate above the EIRP spectral density limit.

Sensitive Earth stations of space services operate in the Canberra region (at Tidbinbilla), in WA (at New Norcia and Gngarra) and in Tasmania. The need to protect and avoid interference from these stations will limit the availability of spectrum for new FS in these licensed areas. ACA RALI MS26²⁶ provides guidance on coordination with earth stations of space services including space operations and space research. It refers to Recommendations ITU-R IS.847²⁷ and IS.849²⁸ for protection criteria both to and from FS stations. Other ITU recommendations provide additional information, including ITU-R SA.363-5²⁹ and ITU-R SA.1157³⁰. The RALI FX 3 arrangements for the Rec. F.1098 channels will include guidance on sharing with these services.

The ACA has recently been approached by a number of companies seeking access to spectrum in these bands under the space operations service to support space launch facilities. Prospective operators of this kind of use are being encouraged to plan their systems for operation in the 2285-2290 MHz band, outside the proposed new Rec. F.1098 channel arrangements.

4.2.5 Sharing With Airborne Mobile Telemetry

Airborne mobile telemetry systems operation in the 2200-2290 MHz band can be characterised as intermittent operations over specific geographic locations. This band

²⁴ The title of Appendix 5 is "Geostationary Satellite Orbital Avoidance"

²⁵ ITU-R Recommendation F.1247-1 "Technical and Operational Characteristics of Systems in the Fixed Service to Facilitate Sharing with the Space Research, Space Operation and Earth Exploration-Satellite Service Operating in the Bands 2025-2110 MHz and 2200-2290 MHz"

²⁶ Radiocommunications Assignment and Licensing Instruction MS26 "Coordination of Microwave Fixed Services with Earth Stations"

²⁷ ITU-R Recommendation IS.847-1 "Determination of the Coordination Area of an Earth Station Operating with Geostationary Space Station and Using the Same Frequency Band as a System in a Terrestrial Service"

²⁸ ITU-R Recommendation IS.849-1 "Determination of the Coordination Area for Earth Stations Operating with Non-Geostationary Spacecraft in Bands Shared with Terrestrial Services."

²⁹ ITU-R Recommendation SA.363-5 "Space Operations systems frequencies, bandwidths and protection criteria."

³⁰ ITU-R Recommendation SA.1157 "Protection criteria for deep-space research."

is shared with FS, space operations and space research. There are two main but separate operational scenarios for airborne mobile telemetry systems in Australia.

The first of these is airborne telemetry operated by BAE Systems in the Woomera SA area on a relatively infrequent basis of 3 or 4 times per year. The transmitter operates at altitudes up to 60,000 feet of duration 20 to 30 minutes at a frequency of 2285 MHz. In this scenario the relative remoteness of the location and the current absence of FS operating at that frequency make for very favourable sharing with FS. In support of this favourable sharing scenario, the ACA is considering restricting the use of channel 6M' of both the existing Rec. F.382 and the proposed new Rec. F.1098 channel arrangements in the Woomera area. The restriction might be either to embargo the channel from assignment in that area or to impose a "no interference and no protection" licence condition on its use by FS. This issue is still being studied; the detail of any restrictions will be included in RALI FX3.

The second scenario concerns airborne transmitters used by the Department of Defence, with an operating duration of approximately 30 to 40 minutes at the rate of one operation per 20 to 30 days. On some occasions, the operating rate may increase to 2 or 3 operations at the one time. These operations currently occur on a single frequency chosen per operation from a limited number of spot frequencies in the 2200-2300 MHz frequency range with a maximum EIRP of 25W (but to date has typically been between 2 and 5W). Operations occur at three locations in Australia. The first of these is on the eastern seaboard near Nowra NSW, including an aircraft transit corridor between Newcastle and Nowra. Within the operational area, transmissions can occur at any altitude from sea level up to 31,000 feet. Whilst in the transit corridor, operation is at 31,000 feet (except for take-off and climb). The second area where these transmitters operate is in Woomera SA and within a transit corridor between Adelaide and Woomera. The third area is over the ocean west of Rockingham WA. Operation in the Woomera SA (1 or 2 times per year) and Rockingham WA (5 to 7 times per year) areas is less frequent than the eastern seaboard (every 20 to 30 days).

This scenario is far less favourable for sharing with FS. This is because operation is proposed to be at a number of spot frequencies in the 2200 to 2300 MHz range and the most used operating area is the eastern seaboard, where the highest density of FS in the 2 GHz Band exists and is expected to grow. Defence has recently indicated a need for increased access to this band (ie. more spot frequencies), raising issues of compatibility with existing and the proposed new FS services. Preliminary analysis of the potential for interference to FS from airborne mobile telemetry operating on the eastern seaboard indicates the likelihood of interference to some existing FS receivers, under conditions of adverse multipath propagation between the link ends. Similarly, the amount of spectrum requested for this service have implications for the viability of the proposed new FS arrangements in high demand FS areas. The ACA and Defence are working together on developing suitable options to resolve these issues, taking into account the need for reasonably equitable access to spectrum by both services. It is likely that restrictions may need to be placed on the assignment of or the level of protection afforded to some of the Rec. F. 1098 channels in the affected areas. The final arrangements for the sharing of these bands by these two services will be provided in RALI FX 3.

The Bureau of Meteorology (BOM) has also requested spectrum access to these bands for down-link balloon operations across Australia. The ACA has recommended that the BOM confine spectrum use to the 2285-2900 MHz band for these services, to minimise any coordination requirements with the FS.

4.3 Assignment Policies for Rec. F.1098 Arrangements

The assignment policies and coordination requirements for FS are detailed in RALI FX 3. In addition to specifying the channelling arrangements and any sharing restrictions, the key elements of these requirements include link minimum path length, notional antenna characteristics and interference protection ratios. These requirements are discussed in following sections.

4.3.1 Review of Support for Analogue Services

The implementation of the proposed new Rec. F.1098 channel arrangements presents an opportunity to review the level of support that should be given to analogue services in the band, such as FM video and multi-channel analogue. Analysis of data on assignments of 14 MHz or less subject to relocation shows only 11 assignments are purely analogue services, with a further 39 comprised of both analogue and digital components. Additionally, there are 232 assignments (less than 13%) for these types of services in the entire 2 GHz Band that operate within a 14 MHz bandwidth. It may be timely to limit the support for analogue services under the proposed new Rec. F.1098 channel arrangements to those required to relocate and that can meet the channel width limit.

Proposal: No assignments under the new Rec. F.1098 channel arrangements should be made for analogue services in the 2 GHz Band except for those that are required to relocate out of IMT-2000 or MSS spectrum. Industry is invited to comment on this proposal.

4.3.2 Preferential Access by 2 GHz Incumbents Subject to Relocation

As noted, the *Trends Paper* advocated the introduction of the new channel plan in due course, taking account of the current MDS usage of the band. However, a case is now made for the earlier introduction of the new plan, primarily to support the relocation obligations of the incumbents, particularly in the light of the very short clearance period of 2 years and consistent with the views of the RCC WG on IMT-2000. Accordingly, it is intended that assignments will be restricted to applications resulting directly from IMT-2000 or 2 GHz MSS relocation requirements, for a period of 12 months from the introduction of Rec. F.1098 channel arrangements. (This restriction would not apply to ongoing assignments for channels under the Rec. F.382 channel arrangements).

Proposal: For a period of 12 months from the introduction of Rec. F.1098 channel arrangements, assignments to be restricted to applications resulting directly from IMT-2000 or 2 GHz MSS relocation requirements. Industry is invited to comment on this proposal.

4.3.3 Minimum Path Length Requirements

Remaining in the 2 GHz Band is expected to be an attractive consideration for users of FS links of relatively long path length, assuming capacity requirements can be accommodated in the Rec. F.1098 channels. Relocation of such links to higher bands could involve the inclusion of a new intermediate station (repeater), at considerable expense and additional planning effort in terms of site acquisition and environmental and local planning permits.

The achievable path length for an FS link decreases with increasing operating frequency. As the achievable path length gets shorter, more repeaters are required for a radio relay system³¹ to reach its final destination. This equates to higher infrastructure costs and it is therefore economically desirable to use as long a path length as possible for each hop in a radio relay system. This is particularly important in cost sensitive applications such as the provision of services in regional and remote areas. The continuing pressure on the availability of spectrum in the lower microwave bands (including this band) for FS links strengthens the need to maintain an appropriate minimum path length in the 2 GHz FS band.

Analysis of the path lengths of all existing FS in the 2 GHz Band shows that 87% of all links located outside the capital cities operate over path lengths of 20 km or more. Within capital city areas, 68% of links operate over a path length of 20 km or more. The statistics are very similar for links that are required to relocate.

Current arrangements for the 2 GHz FS band in RALI FX-3 specify a minimum path length of 20 km. The ACA believes that the maintenance of a minimum path length requirement of 20 km in the 2 GHz Band is warranted for new assignments made either under the existing or new channel arrangements. This would preclude 90 assignments subject to relocation (18% of the total) from remaining in the 2 GHz Band. However, it can be argued that these links belong more appropriately in higher bands.

Summary: A minimum path length of 20 km for new assignments will apply in the Rec.F.1098 FS Band.

4.3.4 Notional Antenna Requirements

The ACA does not propose to apply a more stringent requirement for the notional antenna for this band than currently exists in RALI FX3 (ie. based on a 3.0m grid parabolic dish). However, a review is under way on the use of notional antenna requirements in high spectrum demand areas³² and there may be a change in the requirement as a result of the review. The review is unlikely to be completed before the implementation of the proposed new Rec. F.1098 channel arrangements.

³¹ A radio relay system is a series of FS links connected end-to-end to traverse a path that is not achievable by a single point-to-point link alone.

³² High spectrum demand areas (HSDA) are defined in RALI FX3 as geographic boundaries within which the overall link density is high and where demand mandates a tightly managed assignment strategy. These geographic boundaries typically encompasses population centres. Although trunk routes between such centres are not specifically defined as HSDA they are managed as such.

4.3.5 Protection Ratios

Protection ratios³³ provide the mechanism by which proposed new assignments are assessed for compatibility with existing assignments. Currently, RALI FX3 sets the protection ratio requirement for co-channel operation at 60dB, with correction factors to account for path length, channel offset, emission bandwidth and refractive gradient variations.

For the introduction of the proposed new Rec. F.1098 channel arrangements it is proposed that the protection ratios currently stated in RALI FX 3 remain. They will be supplemented by appropriate frequency offset and channel width entries in the protection ratios tables to account for the overlaying of the existing Rec. F.382 and the proposed new Rec. F.1098 channel arrangements.

5 SUMMARY

This report proposes the introduction of new channel arrangements in the 2 GHz Band to support the future operation of point-to-point fixed services. The key proposals are:

- adoption of ITU-R Rec. F.1098 channel arrangements using 14 MHz channel widths in a 6 x main pattern and 5 x interleaf pattern configuration;
- restricting, for a period of 12 months from the introduction of the new arrangements, the assignment of Rec. F.1098 channels to eligible links subject to IMT-2000 or MSS relocation requirements; and
- limiting support under the Rec. F1098 channel arrangements to digital services.

In addition, this report identifies other policies aimed at supporting the introduction of the proposed new Rec. F.1098 channel arrangements:

- the "grand-fathering" of channels of the existing Rec. F.382 channel arrangements which overlap the proposed new Rec. F.1098 channel arrangements (in accordance with ACA RALI MS 3, Embargo 23);
- licensing of Rec. F.1098 channels will be permitted in advance of MDS A cessation, subject to restrictions on use until after that event; and
- a minimum path length of 20km will apply to all assignments under the proposed new Rec. F.1098 channel arrangements, consistent with current 2 GHz policy.

6 INVITATION TO COMMENT

The ACA had previously forecast the introduction of new channel arrangements based on Rec. F.1098 in the *Trends Paper* and in other documents. This report presents details of the proposed implementation of new channel arrangements for FS in the 2 GHz Band. Industry is invited to comment on the proposals and the related

³³ The Protection Ratio sets an upper limit to the amount of interference that a new assignment is permitted to impose on an existing assignment. It takes account of requirements for the existing assignment such as the minimum carrier-to-interference plus noise ratio required to maintain the desired signal quality and the effect of multipath fading.

assignment policies. After taking into account all comments received, the ACA intends to implement the new arrangements by inclusion in ACA RALI FX-3 at the earliest opportunity.

Comments should be submitted in writing and addressed to:

Mr Geoff Hutchins
Manager Spectrum Planning
Radiofrequency Planning Group
Australian Communications Authority
PO Box 78
BELCONNEN ACT 2616

Fax: (02) 6219 5256.

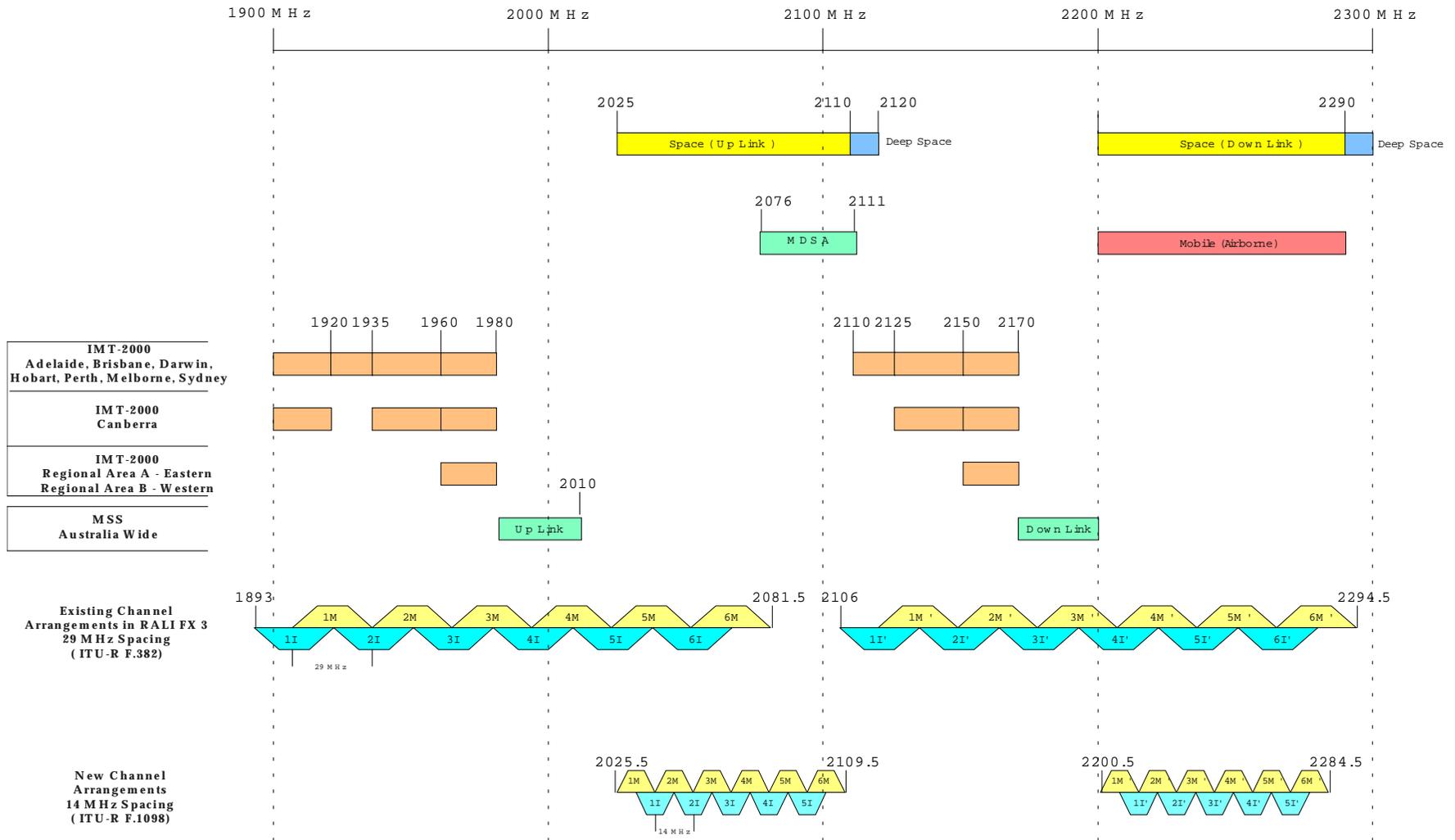
Alternatively, submissions may be forwarded by email to freqplan@aca.gov.au. Submissions should reach the ACA by 18 May 2001.

Queries regarding the content of this report should be directed to Mr. Ed Jaskolski on telephone 02 6219 5241.

Attachments:

1. Overall Arrangements for the 2 GHz Band
2. Existing and Proposed New Channel Arrangements for FS in the 2 GHz Band
3. Summary of Equipment Available for Operation Under the New Arrangements

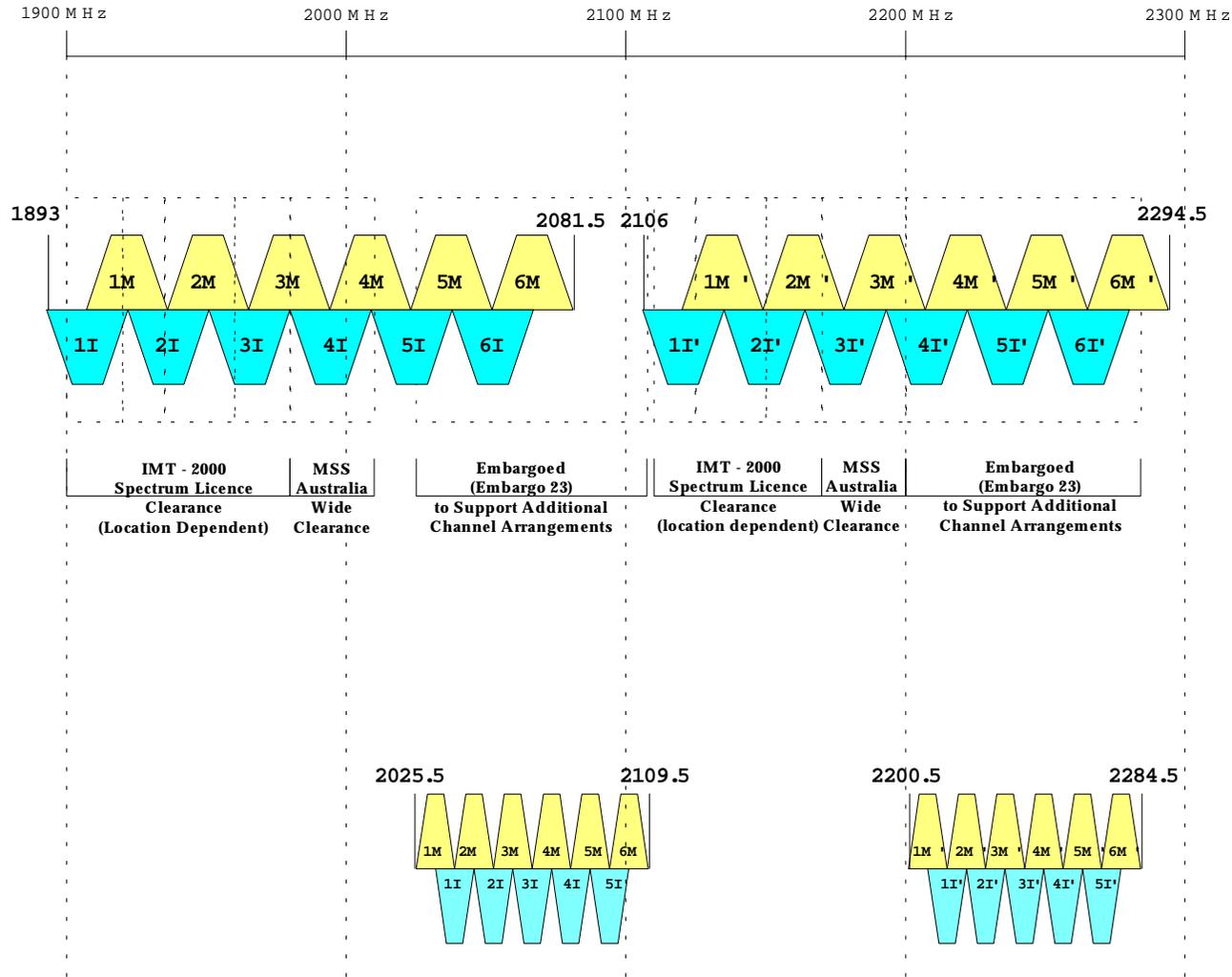
ATTACHMENT 1



Overall Arrangements for the 2.1 GHz Band

ATTACHMENT 2

**Existing Channel Arrangements
29 MHz Spacing
(ITU-R F.382)**



**New Channel Arrangements
14 MHz Spacing
(ITU-R F.1098)**

Existing and Proposed New Channel Arrangements for FS in the 2.1 GHz Band

Attachment 3

Summary of Equipment Available for Operation Under the New Arrangements

Manufacturer	Model	Frequency Range (GHz)	Channelling	Capacity (Mbps)	Modulation Scheme	Occupied Bandwidth (MHz)
Alcatel	9420 LX	1.7 - 2.7	ITU-R F.283-5 ITU-R F.382-7 ITU-R F.746 ITU-R F.1098-1	2x2	4 QAM	3.5
				4x2 or 8		7
				8x2 or 2x8		14
				16x2 or 4x8 or 34 or 3x8 + 4x2		28
	MDR-6502-X Range	1.7 - 2.7	Not Stated	2x1.544	32 TCM	1.25
				4x1.544		2.5
				8x1.544		3.75
				12x1.544		5.25
				16x1.544		7
	MDR-6702-X Range	1.7 - 2.7	Note Stated	2x1.544	128 TCM	0.8
				4x1.544		1.25
				8x1.544		2.5
				12x1.544		3.75
				16x1.544		5
	NEC	TRP-2/7/8/13G17/34MB-2500	1.7 - 2.3	ITU-R F.283-5	8x2	4 PSK
16x2					Not Stated - 28 MHz assumed	
Continental Microwave	VFL2-20 series	1.7 - 2.3	Not Stated Agile Tuning Capability	1.5	Not stated	Not stated
				2	Not stated	Not stated
				8	Not stated	Not stated
				34	16 QAM	9.4 MHz (-3dB) 12.7 MHz (-35dB)
				45	16 QAM	12.2 MHz (-3dB) 16.5 MHz (-35dB)

Itelco	DRTX2	1.7 - 2.3	Not Stated	8	QPSK	Not stated
				34	QPSK	Not stated
				45	16 QAM	Not stated
					64 QAM	
Harris Corporation	Quadralink 2 GHz CEPT Digital Hierarchy	1.7 - 2.3	ITU-R F.283 ITU-R F.382 Others Available	2	OQPSK	Not stated
				2x2		Not stated
				1x8 or 4x2		Not stated
				2x8 or 8x2		Not stated
				34		Not stated
Italiana Ponti Radio	DML Series	1.5 - 2.4	Unspecified ITU-R	2	DQPSK	Not stated
				8		Not stated
				34		Not stated
				45		Not stated
Nera	NL243	1.9 - 2.3	ITU-R F.382 ITU-R F.746	16x2	4 PSK	Not Stated
	NL182	1.7 - 2.3	ITU-R F.283	4x2	4 PSK	Not Stated