

Engineering guidelines for trunked radio systems in the 800 MHz TS band

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Executive brief

In June 2008, the Ministry of Economic Development circulated a technical report entitled Land Mobile Radio Systems operating in the 800 MHz band: engineering and compatibility considerations between APCO, TETRA & Analogue FM trunking networks. The purpose of the report was to fine tune the results of the peer review process initiated by the discussion paper [Digital Land Mobile in the 800 MHz Band: An Engineering Discussion Paper](#).

The technical report proposed engineering recommendations for the licensing of TETRA, APCO and analogue land mobile trunked radio systems in the 800 MHz TS band. It considered coexistence issues, emission characteristics of the systems concerned and the current arrangement of the analogue TS band. Submissions in response to the report supported the Ministry's proposals and provided further suggestions on engineering issues.

1. Purpose

Currently, the 800 MHz TS band is used solely for analogue trunked land mobile services. An initial consultation process identified that digital trunked land mobile services should be accommodated in this band, and that there is demand to assign digital land mobile services in the TS band.

A subsequent report provided recommendations in regards to engineering and technical compatibility criteria to be applied when certifying licenses for digital services in the land mobile TS band (813 - 819 MHz paired with 858 - 864 MHz).

This paper documents submissions in response to the report and identifies the proposed approach to engineering licences for coexistence between TETRA, APCO and Analogue FM land mobile radio in the 800 MHz TS band.

2. Background

The Ministry released in May 2007 an [engineering discussion paper](#) with the purpose of consulting industry on the potential introduction of digital trunk radio technologies in the 800 MHz TS band. This consultation process was put in place to address an expressed interest from band users in deploying new and more efficient technologies. The [outcomes](#) of this consultation were published in December 2007, identifying the following key aspects:

- TETRA and APCO P25 were identified as the preferred digital technologies;
- digital technologies to share the band with analogue systems;
- maintaining existing band plans and including a provision to allow 12.5 kHz channels;
- updating operational policy to permit digital land mobile emissions in the 800 MHz TS band;
- ensuring coexistence between digital standards and incumbent analogue systems.

This last point on technology coexistence became an outstanding engineering issue requiring further analysis. In order to address this point, a technical report was prepared and circulated for consideration by parties that had indicated an interest in the 800 MHz TS band. This technical report built upon, and fine tuned the results obtained in the initial consultation paper. This was required in order to ensure interference mitigation between multiple digital technologies and minimal impact on existing analogue services.

3. Submissions

Peer review of the report Land Mobile Radio Systems operating in the 800 MHz band: Engineering and compatibility considerations between APCO, TETRA & Analogue FM trunking networks, yielded five submissions.

The parties who provided submissions were:

Full name of Submitter
Kordia Ltd
Motorola Inc. Ltd
Team Talk Ltd
TL Parker Ltd
Radiotronics Ltd

A breakdown of the responses to the technical report is provided in [Appendix A](#).

4. Analysis

The technical report posed several recommendations for consideration. This section discusses these recommendations in relation to the comments received.

4.1 Recommendation 1

To efficiently cater for the introduction of APCO P25 phase 1, a channelling plan with a 12.5 kHz raster is implemented in conjunction with the existing 25kHz plan.

The majority of reviewers agree with the proposed recommendation. Further, one reviewer suggested that the majority of services would use 25 kHz channel spacing. 12.5 kHz APCO channels should be introduced depending on popularity.

The initial consultation process identified that there is an interest in APCO P25 (phase 1) systems. The implementation of a channelling plan with a 12.5 kHz raster allows APCO P25 to take place from the outset, providing a more efficient allocation of channels (figure 1). The current 25 kHz channel raster will remain in place, catering for the current analogue service, TETRA and other future 25 kHz applications as required. The current block allocation matrix will also remain in place.

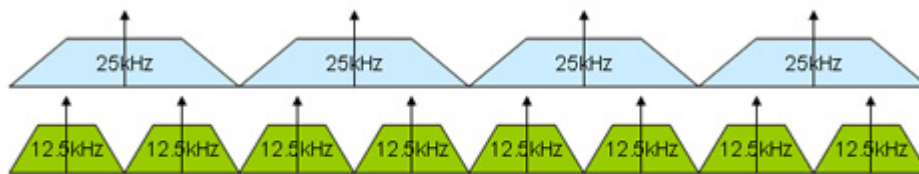


Figure 1. Overlay of 12.5 kHz channels (TSN channels) on current 25 kHz TS band

4.2 Recommendation 2

To promote RF efficiency, a digital trunked dispatch system permitted to operate in the TS-band, must have a minimum number of digital voice channels equivalent to the current minimum number of analogue voice channels. In other words, a single TETRA 25 kHz channel assignment, or three APCO P25 (phase 1) 12.5 kHz channel assignments are considered equivalent to an analogue trunked system (with three RF channel assignments).

The majority of reviewers agree with this recommendation. In regard to this recommendation, one reviewer indicated that trunked systems usually employ one channel for control, affecting spectrum efficiency. In this regard, it suggested considering the implications of the advent of APCO phase 2 channel sizes.

Currently, APCO systems allow either 25 kHz or 12.5 kHz configurations. In order to ensure the orderly and efficient allocation of 12.5 kHz APCO channels, an overlaid 12.5 kHz raster has been identified as appropriate. Future APCO phase 2 platforms may involve TDMA (12.5 kHz channels) or FDMA (6.25 kHz) techniques to allow an increased number of voice channels. However, these techniques are still under development and standards are not available. The Ministry will review the impact of such developments once standards have been finalised.

4.3 Recommendation 3

To adopt an overlay of digital channels on the existing analogue channel raster, and preserve the current block and channel assignment scheme.

All reviewers agreed with this recommendation.

4.4 Recommendation 4

To consider adopting the rule that, in faded conditions, the DAQ 3.4 (BER 2%) coverage area contour (106dBm) of a service should be at least 5 km away from a base station operating in the 1st adjacent channel.

The majority of reviewers agree with the proposed recommendation.

One reviewer proposed applying an additional engineering rule to address ambiguities in regards to fortuitous coverage. It suggests that the determination of the faded -106 dBm coverage contour can be a difficult task considering the New Zealand topography. It was proposed that, in addition to recommendation 4, it would be necessary to implement a rule to exclude fortuitous coverage from interference protection.

Another reviewer suggested that diverse local topography impacts coverage contours and that adjacent channel interference issues should be resolved by Approved Persons based on their experience.

PIB 38 (Sections 3.3 & 3.7) prescribes guidelines to help Approved Persons in making a professional judgement when determining the compatibility of new and existing mobile radiocommunications services. This approach was adequate when a single analogue equipment standard was in use. However, to ensure coexistence between TETRA and APCO/ analogue services, a more precise approach is considered necessary to provide a reasonable expectation for frequency re-use.

5. Summary of outcomes

This section summarises the outcomes obtained from the review. The engineering guidelines obtained as a result will be included in the relevant section of PIB 38.

5.1 General

1. To efficiently cater for the introduction of APCO P25 phase 1, a channelling plan with a 12.5 kHz raster is implemented in conjunction with the existing 25 kHz plan. 12.5 kHz channels will be named “TSN” for “narrow band”. (Figure 1)
2. To preserve the current block and channel assignment scheme ([band plans, TS 800 MHz](#)), digital channels are overlaid on the existing analogue channel raster. The maximum EIRP limit of the band (21.8 dBW) remains unchanged.
3. To promote RF efficiency, a digital trunked dispatch system permitted to operate in the TS-band, must have a minimum number of digital voice channels equivalent to the current minimum number of analogue voice channels. In other words, a single TETRA 25 kHz channel assignment, or three APCO P25 (phase 1) 12.5 kHz channel assignments are considered equivalent to an analogue trunked system (with three RF channel assignments).

Later when it becomes available, two APCO P25 (phase 2) 12.5 kHz channel assignments will be considered as equivalent.

5.2 Engineering guidelines (to be included in PIB 38)

a. Coverage area

The coverage area of a base station is the area of service within which the licensee has a reasonable expectation of protection from harmful interference. This is defined by a continuous contour equivalent to a signal level of -106 dBm or a theoretical coverage area with a radius of 58 km*, whichever is the smaller. See Figures 2 and 3.

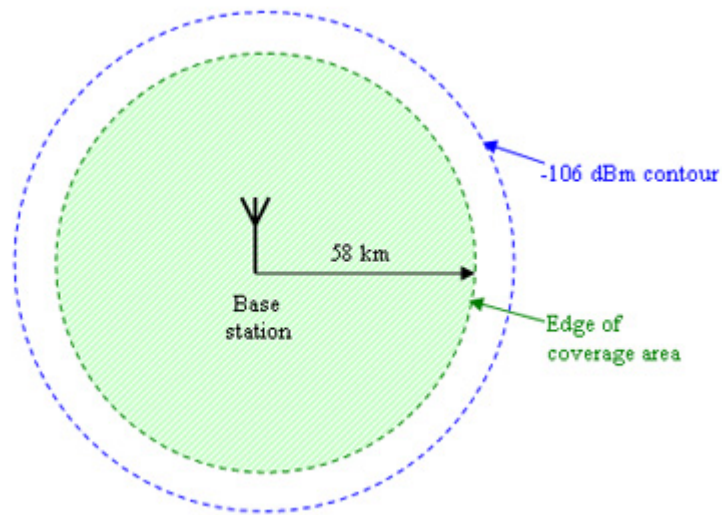


Figure 2 - Without terrain limitation, a 58 km radius applies

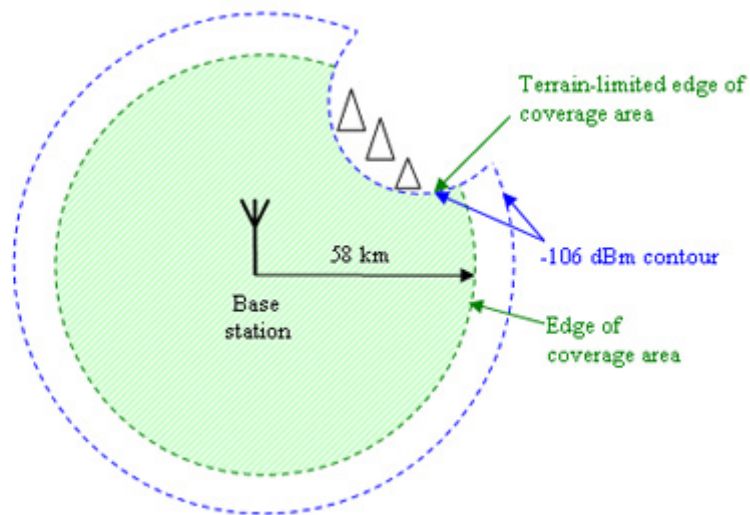


Figure 3 - With terrain limitation, the smaller -106 dBm area applies

b. Co-channel re-use distance

The re-use distance is the distance required to ensure a suitable grade of service between co-channel services. Generally, the re-use distance is constrained by topographic obstructions. See Figure 4.

Figure 4 - Re-use distance to protect existing co-channel services.
Co-channel services isolated by topography

In areas where the local topography may not provide sufficient levels of obstruction loss between co-channel services, the proposed service must protect existing services to a minimum C/I of 18 dB* at the edge of the existing coverage area. See Figure 5.

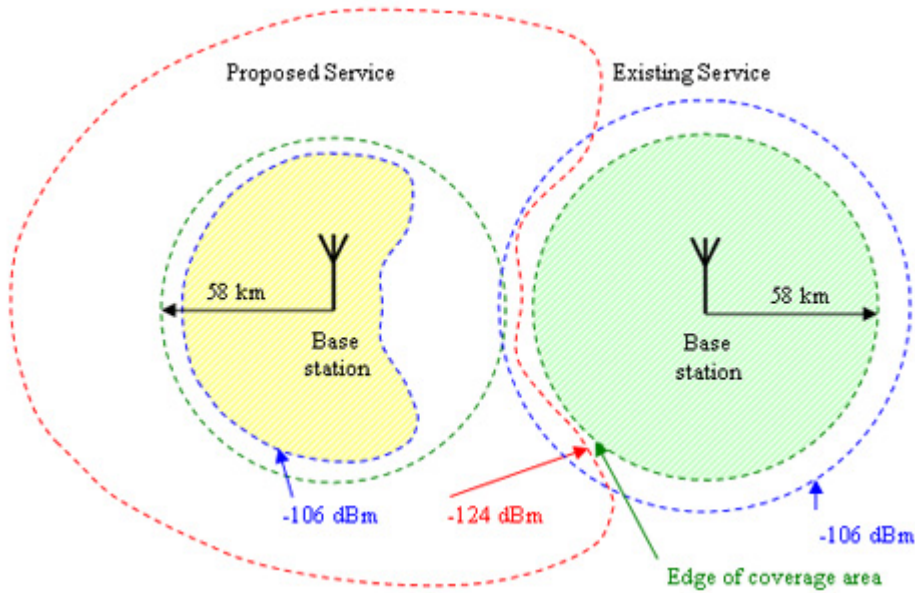


Figure 5 - Re-use distance to protect existing co-channel services.
Insufficient topographic obstruction.

To comply with the minimum C/I of 18 dB at the edge of coverage of existing services, the proposed service must constrain the interfering impact of its transmission by other means. In the example above, a modified horizontal radiation pattern (HRP) is used to achieve the required C/I ratio.

c. Protecting first adjacent channel services

In non co-sited situations – with services sharing a substantial overlapping coverage area – it is recommended that between analogue FM, APCO and TETRA base stations, the new base station be spaced at least 5 km away from the edge of the coverage area of the existing service. In situations where the local terrain and clutter provide sufficient obstruction loss, this measure can be relaxed provided that an equivalent co-channel C/I of 18 dB is maintained by the proposed service at the edge of the coverage area of existing services. Where the new service is TETRA, and has an adjacent channel leakage ratio of -55 dB, the C/I for the first and second adjacent channel is -37 dB, and where the proposed service is APCO P25, with an ACLR of -60 dB, the first and second adjacent channel C/I is -42 dB. See Figure 6.

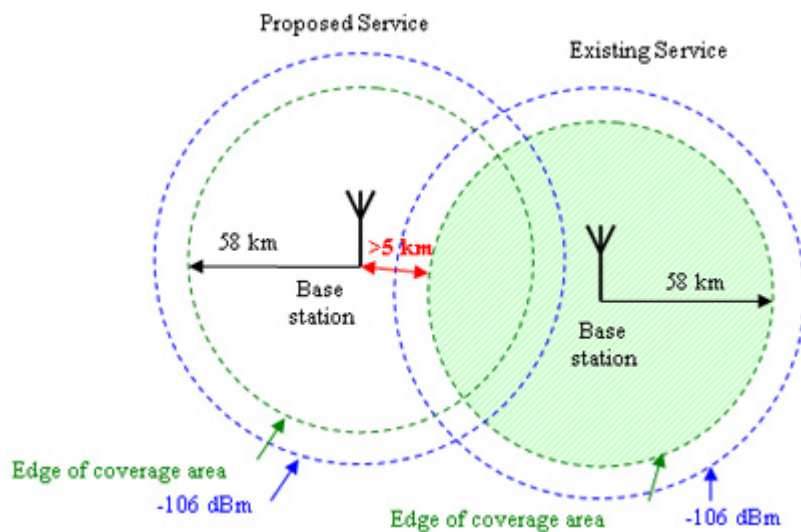


Figure 6 - Protecting existing first adjacent channel (± 25 kHz) services.

Co-channel, first and second adjacent channels, etc, in this document refer to the 25 kHz raster, not the 12.5 kHz sub-channels.

d. Protected C/I

In some instances, the above guidelines may not be optimal when considering specific characteristics of the local topography, especially in large and flat terrains. In such cases, the above distances can be adapted, provided that the proposed service complies with the minimum C/I of 18 dB at the edge of the coverage area of the existing service.

Explanatory notes:

* The C/I level of 18 dB has been obtained considering dynamic conditions (fading) for analogue, APCO and TETRA systems. This figure takes into account the C/I requirements to maintain a Delivered Audio Quality (DAQ) grade of 3.4 (as specified in TSB88.1, table A-1). This value is also used in ITU-R SM.337-4 (table 1), where a calculation example is given for determining frequency and distance separation between land mobile services in the UHF band.

Detail of C/I specifications (extract from TSB88, table A-1):

Modulation type(channel spacing)	Static ref / $\frac{C}{N}$	DAQ 3.4 BER% / C (I+N)
Analogue FM \pm 5kHz (25kHz)	12 dB SINAD / 4 dB	20 dB
Analogue FM \pm 4kHz (25kHz)	12 dB SINAD / 5 dB	22 dB
C4FM (IMBE) (12.5kHz)	5% / 7.6 dB	2% / 17.7 dB
CQPSK (IMBE) (12.5kHz)	5% / 7.6 dB	2% / 17.7 dB
CQPSK (IMBE) (6.25kHz)	5% / 7.6 dB	2% / 17.7 dB
TETRA (25kHz)	5% / 8 dB	2% / 16 dB

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6. Conclusions

The Ministry will implement the recommendations outlined in Section 5 to provide a reasonable balance between the protection of existing services and allowing the deployment of digital land mobile technology in the 800 MHz TS band. For this effect, the engineering guidelines provided in section 5.2 will be included in the Land Mobile - Trunk dispatch section of PIB 38.

The current channel block allocation matrix used for analogue land mobile will be maintained ([band plans, TS 800 MHz](#)). In addition, an overlaid raster with 12.5 kHz channels (TSN channels) will be introduced to allow efficient allocation of APCO P25 – phase 1 channels.

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Appendix A

Summary of reviewers comments

Submitter	Recommendation 1	Recommendation 2	Recommendation 3	Recommendation 4

Kordia	Agrees	Agrees. Further proposes that future licences include minimal technical performance specifications to ensure spectrum efficiency.	Agrees	Suggests that fortuitous coverage needs addressing. It recommends that, in addition to rule of -106 dBm protected contour, a maximum radius of protection to exclude fortuitous coverage must be specified.
Motorola	Agrees	Agrees	Agrees	Agrees
Team Talk	Suggests that the majority of services will use 25 kHz channel spacing. 12.5 kHz APCO channels should be introduced depending on popularity.	Notes that trunked systems usually employ one channel for control, affecting spectrum efficiency. In this regard, it suggests considering the implications of the advent of APCO phase 2 channel sizes.	Agrees	Suggests that protecting a -106dBm coverage contour would be difficult taking into account the variety of real life propagation scenarios. Adjacent channel issues should be resolved by AREs/ARCs based on their experience and licence information available.
TL Parker Ltd	Agrees	Agrees	Agrees. Emphasises the need for maintaining the analogue channel allocation due to site infrastructure already in place.	Agrees
Radiotronics Ltd	Agrees	Agrees	Agrees	Agrees