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Bay of Plenty Radio-Telephony Review and Strategy for the BOPLASS Group

Report

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Bay of Plenty Regional Council		
Opotiki District Council		
Opotiki		

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1 Glossary of technical terms used

APCO P25:	Association of Public Safety Communications (Project 25)
Base Station (BS):	Fixed end equipment that is used to obtain LMR services
BOPLASS	BOPLASS Limited (BOPLASS) is a Council Controlled Organisation established to promote shared services between local authorities in the Bay of Plenty and Gisborne Regions. The company is owned by: Bay of Plenty Regional Council, Tauranga City Council, Gisborne, Kawerau, Opotiki, Rotorua, Taupo, Western Bay of Plenty and Whakatane District Councils. BOPLASS Councils are responsible for delivering services across a large geographic area including the Bay of Plenty, Taupo and Gisborne regions.
Cellular Mobile:	Cellular mobile is the now ubiquitous public mobile telephony service that was introduced into New Zealand in the late 1980s. Cellular mobile networks employ numerous base stations, usually up to around 25 m high, ranging in cell coverage from a few hundred metres to many kilometres, depending on the area to be covered and the anticipated “traffic load” within. The cellular mobile frequency bands in New Zealand are in the UHF range around 900MHz, and also around 2000MHz.
CC:	Coordination Centre. A facility to support a Controller in coordinating a response, or part of it. Coordination centres may be activated to support incident, local, regional, or national level responses. They include Incident Control Points (ICPs), Emergency Operations Centres (EOCs), Emergency Coordination Centres (ECCs), and National Coordination Centres (NCCs).
CDEM:	Civil Defence Emergency Management
CIMS:	Co-ordinated Incident Management System. A proactive incident management framework that systematically manages incidents regardless of size, hazard and complexity. Pronounced ‘sims’.
Coverage:	A diagram that shows the area within which a radio transmitter is broadcasting an effective signal strength in relation to a given standard.
Duplex Communication:	Duplex (or Full duplex) communication means that both ends of the communication can send and receive signals at the same time.

	Half-duplex is also bidirectional communication but signals can only flow in one direction at a time.
Duplex Channel:	Dfferent frequencies are used for each direction of communication which may be either full-duplex or half-duplex.
ECC:	Emergency Coordination Centre. A regional level CC that coordinates the regional response and provides support to local level responses.
EOC:	Emergency Operations Centre. A local level CC that coordinates the local response and provide support to incident level response activities.
e-GIF:	Electronic Government Interoperability Framework
ETSI:	European Telecommunications Standards Institute. A European Standards Organisation that produces standards for Information & Communications Technologies
FDD:	Frequency Division Duplexing is where different frequencies are used for the uplink and downlink.
FDMA:	Frequency Division Multiple Access. The oldest and simplest method for accommodating multiple simultaneous users in a band of radio frequency spectrum by using different frequencies or channels for each user
ICP:	Incident Control Point. Single location where an Incident Controller and members of their IMT coordinate and manage response operations at an incident level response.
ITU:	The ITU (International Telecommunications Union) - a UN (United Nations) organisation that sets international rules and recommendations for telecommunications and radio communications. ITU-R refers to radio communications part of the ITU.
Land Mobile	Land Mobile services provide personal two-way wireless voice communications between portable transceiver terminals routed via a “base station” which is usually situated at a high prominent location to provide wide area coverage. Land Mobile services are often used by taxis, emergency services, couriers, etc. and make use of hand portable and vehicular terminals. The Land Mobile frequency bands in New Zealand are in the VHF range at around 80 and 160MHz, UHF from 400 to 500MHz and 800MHz.

LMR:	Land Mobile Radio (see above)
Mobile Radio:	LMR radio mounted in a vehicle.
PPDR:	Public Protection and Disaster Relief
PMR:	Private or Professional Mobile Radio is another name for LMR
Portable Radio:	Handheld LMR radio
PSRFMG:	Public Safety Radio Frequency Management Group. The group responsible for managing frequency allocations for public safety and emergency services.
Push-to-talk:	PTT, a single button press opens communication on a radio frequency channel.
Radio Service:	Refers to the purpose of the radio link e.g. FM radio, TV, Cellular, Land Mobile.
Repeater:	A repeater station is a fixed radio transceiver that performs automatic retransmission of radio communications that are received mobile/portable radios stations and directed to a mobile/portable.
RSM:	Radio Spectrum Management - the group within the Ministry of Business and Innovation responsible for managing the radio spectrum in New Zealand.
Simplex Communication:	Simplex communication means that communication can only flow in one direction and never flow back the other way.
Simplex Channel:	Only one frequency is used for communication but it can be either duplex or simplex.
TIA:	(Telecommunication Industry Association) The Telecommunications Industry Association (TIA) is accredited by the American National Standards Institute (ANSI) to develop voluntary, consensus-based industry standards for a wide variety of Information and Communication Technologies (ICT) products,
TDD:	Time Division Duplexing is where the same frequency is used for the uplink and downlink but the uplink and downlink use a different time slot.
TDMA:	Time Division Multiple Access. Accommodates multiple users over the same radio by allocated each user a different time slot.
VHF:	Very High Frequency – officially defined as the range 30 MHz to 300 MHz.

UHF:	Ultra High Frequency – officially defined as the range 300 MHz to 3000 MHz and includes part of the region often referred to as "Microwaves".

2 Executive Summary

BOPLASS Limited (BOPLASS) is a Council Controlled Organisation established to promote shared services between local authorities in the Bay of Plenty and Gisborne Regions. The company is owned by: Bay of Plenty Regional Council (BOPRC), Tauranga City Council (TCC), Gisborne (GDC), Kawerau (KDC), Opotiki (ODC), Rotorua (RDC), Taupo (TDC), Western Bay of Plenty (WBOPDC) and Whakatane District Councils (WDC). BOPLASS Councils are responsible for delivering services across a large geographic area including the Bay of Plenty, Taupo and Gisborne regions.

Of the group, the councils participating with this strategy include Opotiki, Rotorua, Tauranga, Western Bay, Whakatane and the BOP Regional Council.

The purpose of this report is to help the participating BOPLASS Councils develop a strategy around the use of radio telephony (RT) or more commonly called Land Mobile Radio (LMR). It consists of two parts:

- A review of current BOP District and Regional Council RT (particularly CD) networks.
- A proposal for a replacement LMR network based on migrating from analogue to digital.

The report concerns the use of LMR for voice services and not for SCADA/Telemetry which use networks separate from those used either for Civil Defence (CD) and 'Business As Usual' (BAU) voice. All the current participating BOPLASS Councils voice LMR equipment is analogue and uses VHF frequencies. Radio repeaters are either owned by the council or leased from a LMR service provider; the mobile/portable radios are all owned by the council's.

The Regional Council and District/City Councils all have their own CD Voice LMR networks but the BOPRC, WBOPDC, and WDC also have separate LMR networks for BAU Voice. For the WBOPDC the BAU network is used for operations primarily within the 'TECT All Terrain Park' which has poor cellular coverage. The WDC BAU network is generally only used as a backup to cellular and the council is considering whether to terminate the leased LMR BAU service and rely solely on either cellular or wireless mesh instead. In general the other councils reply upon cellular as the primary means for BAU but use their CD LMR repeaters as a backup in those areas with poor cellular coverage. However, for the ODC which has in general poor cellular coverage across the district, the CD LMR network is the primary means for BAU communication.

In NZ Radio Spectrum Management (RSM) is part of the Ministry of Business, Innovation and Employment (MBIE) and it is responsible for managing the radio spectrum including policy and licensing. In 2010 they issued a new policy as part of a worldwide process (commonly called narrowbanding) to improve spectral efficiency in the LMR frequency bands. One outcome of this policy is that use of 25kHz VHF channels will cease from the 1st of November 2015. This

affects the BOPRC since their CD (CD16) and BAU repeaters at Putauaki will have to be replaced along with the BAU repeater at Moutohora (Whale) Island.

As part of the review indicative coverage predictions were completed for the current radio repeater sites. Analysis of the results shows that in general CD coverage for each DC is acceptable however the BOPRC coverage is poor in the western, southern and eastern parts of the BOP region. To improve this coverage at least two more repeater sites are required and an existing repeater shifted to another site.

The New Zealand Government has directed that a whole-of-government approach be adopted for Public Protection and Disaster Relief (PPDR) communications. Agencies that are currently recognised as PPDR agencies include Enforcement agencies, First Responder agencies and Support agencies (e.g. CDEM Groups and Territorial Local Authorities). The intent of this approach is gain efficiencies in terms of cost, network assets, and radio spectrum by agencies sharing the same radio network called the Whole of Government Radio Network (WGRN). Currently the WGRN consists of a trunked digital LMR network which is only available in the three metropolitan areas of Auckland, Wellington and Canterbury. There are no plans at present to extend the WGRN to the rest of NZ and hence the Police, who operate and own this network, will continue to use analogue networks in these areas.

Although the WGRN is currently based on LMR, in the long term (5 to 10yrs) for NZ and elsewhere it is expected that Cellular Networks (700MHz LTE) will used as the primary means of communication for PPDR agencies. At present there are number of technological issues to be overcome before Cellular is resilient or reliable enough for PPDR and therefore it would be unwise for any council to rely upon cellular during an emergency. Once these issues are solved it will take time to implement the changes and improve the coverage of the Cellular Network so it is comparable to the current LMR networks particularly in those areas with poor cellular coverage e.g. BOP. Gauging the timescale is difficult as it depends on the time for standards to be developed and approved, radio equipment designed and manufactured, and networks installed. This leaves CD along with other PPDR agencies in the BOP with either extending the life of their current analogue LMR networks (up to 10yrs) until WGRN (Cellular) is available or migrating to digital LMR and realising the benefits of digital sooner rather than later.

For BAU services Cellular is now a viable alternative to LMR if the ‘Push to Talk over Cellular’ (PoC) application is used. This replicates some of the LMR features e.g. push-to-talk individual and group calls with low call setup delay. Its usefulness is still constrained by Cellular coverage and its vagaries and is not considered an option for addressing the BOPRC BAU requirement for regional coverage.

To address the issues of narrrowbanding, coverage and transition to digital, the report proposes a new LMR network for BOPRC carrying both BAU and CD services. It consists of two

data/voice channels at five repeater sites with linking between them and the RC in Tauranga. Initially the repeaters will operate in analogue mode until such time the RC is ready to migrate to digital. Its use can be extended to the DC's if required; with or without additional channels depending upon traffic loading.

In terms of a digital standard for the new network the options are either P25 (WGRN mandate) for DMR (standard most commonly used by NZ commercial radio providers). The other standards e.g. NXDN, dPMR, TETRA are not suitable either because they are not open standards or require a channel spacing incompatible with analogue. The indicative cost for implementing the proposed network is:

P25 $531,630

DMR $229,300

This cost includes linking and the upgrading of solar power supplies at the repeater sites but not the cost for new portable and mobile radios.

Currently radio communication interoperability between PPDR agencies is provided by using analogue on shared radio channels but this is more complicated for digital as the standards are mutually incompatible. However all digital radios are capable of operating in analogue mode and hence interoperability at the local incident level can maintained using analogue simplex channels and between radio networks using gateways. In the control, command, and dispatch operational environment for PPDR it is considered undesirable for radios to roam between the radio networks of different agencies. If staff from one agency is required to use the radio network of another then it is expected that they will be provided with a radio for this purpose. Therefore the issue of interoperability can be considered be a neutral factor when choosing a digital standard.

The proposed new network could be solely council owned, in shared ownership between council and other organisations, or leased from a radio service provider. When looking at synergies between BOP RC DC's and other organisations in terms of shared infrastructure, the possibilities are probably confined to commercial operators since there is no planned rollout of the digital WRGN in the near future for the BOP.

If the BOP RC were to consider sharing a network with a commercial service provider then it would most likely be trunking network and based on DMR. In the BOP there are a number of providers deploying DMR capable repeaters as replacements for old analogue equipment. At present Baywide Communications and Netcom Services Limited have digital (DMR) repeaters that covers the Western Bay of Plenty, ALCOM is presently implementing one that will cover the Rotorua District, and the WRUA have plans for ones in the near future. Hence unless some sort of consortium can be formed between local BOP providers to build a regional digital trunking network then the current analogue "islands" will be become digital "islands" in the future. This

is an area when participating BOPLASS Councils could be involved if there is a benefit economically to the BOP Region.

3 Introduction

3.1 Scope of Work

At the end of 2013, participating BOPLASS Councils was asked to conduct a project for a Bay of Plenty regional strategy around radio telephony (RT). This was in response to an approach from the BOPRC to see if there is an opportunity for the participating BOPLASS Councils to collaborate in a RT strategy for the region and/or the appointment of providers and leases for radio telephone services.

The BOPRC mentioned that there were not necessarily looking for just a procurement strategy, but an overall strategy covering things such as consistency in equipment, channel allocations, programming, coverage, use of new technology, etc. across councils. One of the questions posed was "where do we want to be in 5-10 years?" in relation to Radio Telephony in councils. The BOPRC and the participating BOPLASS Councils see this opportunity as most relevant for civil defence emergency management systems but may also be of value to those councils that are operating or leasing radio telephones for other purposes.

To this end the participating BOPLASS Councils have engaged Rodger Hulston & White who are consulting telecommunication engineers to:

1. Review the current BOP District and Regional Council RT (particularly CD) networks.
2. Propose replacement RT network architectures for the participating BOPLASS Councils including the following considerations:

- Types of Service; Voice, telemetry/SCADA, SMS, GPS. How the distinction between council ‘business as usual’ (BAU) and emergency services can be managed.
- Technology; Analogue vs Digital and how to manage the transition from Analogue to Digital.
- Trunking versus conventional networks.
- Encryption options for radios.
- Service delivery; repeater site and equipment maintenance including lease versus owned networks and service contracts. Also includes Network Performance Objectives including Availability.
- Interoperability across the region with TLA’s and BOPRC, and 3rd-party organisations such as forestry, police, fire, maritime, etc.
- Indicative cost models for proposed RT networks.

The findings regarding the review of the current RT network can be found in Section 3 of this report and proposals regarding replacement RT network in Section 4.

Note that for the remainder of the report LMR (Land Mobile Radio) will be used instead of RT as it is the term commonly understood by the industry and regulator in New Zealand.

3.2 Background

The Territorial Local Authorities (TLA) involved in the review are:

BOPRC	Bay of Plenty Regional Council
WBOPDC	Western Bay of Plenty District Council
KDC	Kawerau District Council
ODC	Opotiki District Council
TCC	Tauranga City Council
RDC	Rotorua District Council
KDC	Kawerau District Council
WDC	Whakatane District Council

And their locations are shown in the map below.

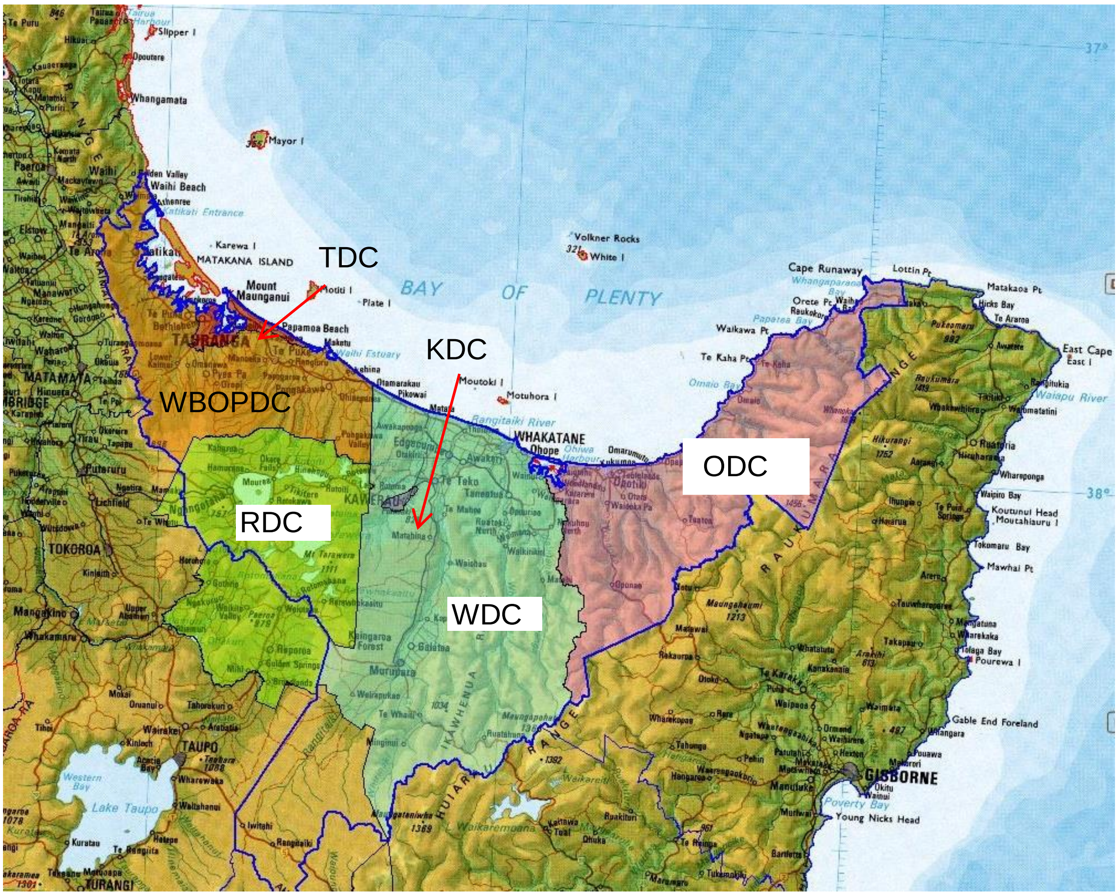


Figure 1: BOP TA Boundaries

The BOPRC is shown as the blue outline on the map and included part of the Taupo District Council and excludes part of the Rotorua District Council.

4 Review of current radio services

4.1 Overview

This section presents the key findings from reviewing the current LMR network. The review consisted of the following activities:

1. Analysis of the RSM Licence Database to determine the Land mobile repeater radio licence holders in the Bay of Plenty (BOP), the frequencies used, and the location of the repeater sites and radio links. This provides an overview of the infrastructure present in the region. Organisations included Police, Fire, Ambulance, DOC, MCDEM, Councils, TeamTalk and other significant regional commercial operators e.g. Forestry.
2. Interviewing key staff at each council (including the regional council) that is responsible or concerned with the use of Land Mobile services either owned or leased by the council. In the case of leased services it will be necessary also to interview the service providers e.g. TeamTalk. The purpose of these interviews was to determine:
    a. What equipment is being used regionally and for what type of services,
    b. What radio communication technology is being used VHF, UHF, Telemetry, Microwave, Digital
    c. What other repeater sites are potentially available in the region
    d. Who is managing the current repeater sites
    e. What cost is there in R&M of the sites and equipment (previous 5 years).
3. Visiting some of the key repeater sites to assess state of radio equipment, antennas, mounting structures, power supplies, and backup generators.
4. Identifying where there are gaps in coverage based on indicative coverage predictions and published coverage maps e.g. TeamTalk.
5. Interviewing Police (WGRN – Whole of Government Radio Network), TeamTalk, and other regional commercial service providers with regard to rollout of digital land mobile networks.

4.2 Radio Repeater Sites

From the radio licence information and responses from the district councils, the following repeater sites were identified as being used for BAU or CD voice:

- Papamoa No2
- TECT All Terrain Park
- Rangitoto (Whakapoungakau)
- Moerangi
- Putauaki
- Moutohora (Whale) Island
- Ohiwa Peninsula Hill
- Whanarua Bay

The location of these sites is shown below.

Figure 2: BOP CD/BAU Repeater Locations

4.2.1 Infrastructure

The following table summarises the infrastructure at each of the sites. It was not possible to visit some of the sites within the time allowed because of problems with access.

Site Name	Access	Power	State of Radio Infrastructure	Site Ownership
Rangitoto (Whakapoungakau)	Helicopter or drive and 30 min bush walk	Solar PV	Tidy installation Shelter Sound Wooden pole – old may to be replaced in future	Rotorua Coastguard Site is located within the Lake Okataina Scenic Reserve which is administered on the behalf of the crown by the Lake Okataina Scenic Reserves Board.
Putauaki (WRUA)	Helicopter or drive and 10 min bush walk	Mains with backup generator	Tidy installation Building sound Steel Poles – one for TX and other for RX.	WRUA Mt Putauaki and its surrounds is owned and managed by the Nga Maunga Kaitiaki Trust
Moutohora (Whale) Island	Helicopter or boat	Solar PV	Wooden Pole	WRUA radio site is subject to a concession see below
Ohiwa Peninsula Hill	Drive to site	Solar PV	New Installation	Private Land
Whanarua Bay	Helicopter or walk	Solar PV	Not visited	Private Land
TECT All Terrain Park	Drive to site	Solar PV	New Installation	WBOPRC
Papamoa No2	Drive to site	Solar PV	Shelter sound Antennas and wooden pole sound Indoor installation untidy	WBOPRC

Site Name	Access	Power	State of Radio Infrastructure	Site Ownership
Moerangi	Drive to site	Solar PV with backup generator?	Wooden pole – old may to be replaced in future Shelter Sound	Kaingaroa Timberlands DOC Land

Table 1: Radio Site Information

See Site Photographs for photographs of the sites

Moutohora (Whale) Island

Moutohora Island is managed by Te Tapatoru ā Toi which is a statutory board consisting of the Crown and Ngati Awa to give effect to co-operative conservation management and planning. Currently the board is reviewing the use of the island as a telecommunications site and have extended the concession for the radio site until 2017. It is not known at this stage what will be the outcome of the review but it does raise concerns about the future viability of the radio site.

4.3 Frequencies

To determine what radio licences are held by the BOP Territorial Authorities, licence information was obtained from the Radio Licence Database of the Radio Spectrum Management Group (Ministry of Business Innovation and Employment). This group is responsible for managing radio spectrum in New Zealand.

The list of current radio licences can be found in Appendix 1 and the distribution of radio licences including type is as follows:

TA	Landmobile	Linking	Purpose
BOPRC	√	√	BAU Voice and SCADA Note CD16 service leased from TeamTalk
WBOPDC	√	√	BAU Voice and SCADA
KDC	none	none	
ODC	none	none	Note BAU Voice provided by using CD frequencies
TCC	√	√	BAU SCADA

RDC	√	√	BAU SCADA
WDC	none	none	Note BAU Voice services leased from WRUA
MCDEM	√	√	CD

Table 2: Distribution of Radio Licences

Note BOPRC is referred to as the Environment BOP and the TCC as the Tauranga District Council in the radio licences.

BAU (Business as usual) refers to those licences used for the following applications e.g.

- Voice – used by councils for communicating with staff for day to day operations e.g. animal and weed control, environmental, health and safety etc.
- SCADA/Telemetry – Radio used for provide the communication circuits needed to monitor and control water and waste water reticulation, water level monitoring on rivers and lakes etc.

CD (Civil Defence) refers to those ESB licences held by the MCDEM (Ministry of Civil Defence and Emergency Management) but used by the TLA's for CD and also for BAU voice communication in some TLA's. All the repeater frequencies are being used except the licence at Kopukairua (ES130).

Some TLAs are also leasing radio services where the radio licences are held by the provider e.g. Team Talk (CD16) and Whakatane Radio Users Association (WRUA).

The complete set of licences being used but not necessarily owned by the TAs is given Appendix 1.

The review it is only concerned with voice services for BAU and for CD; the licence information regarding other services has been included for completeness.

For voice services both simplex and duplex frequency channels are used. Simplex channels are used for communications between users within a small geographical area when users communicate directly between each other without using a repeater. Duplex channels are used for communications over wide geographical area where repeaters are needed to overcome terrain obstructions which would otherwise limit communication between users.

The report focusses on the use of repeaters by the councils since this affects the radio coverage within a district and over the BOP region. Also the radio repeaters are the most expensive single component to own, operate and maintain.

4.3.1 BOPRC (Bay of Plenty Regional Council)

BAU Voice

This consists of three repeater sites that are linked together i.e.

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
Rangitoto (Whakapoungakau)	E (VHF)	EN151 (12.5kHz)	BOPRC	Council
Putauaki (WRUA site)	E (VHF)	E197 (25kHz)	WRUA (licence expires Nov 2015)	WRUA
Moutohora (Whale) Island	E (VHF)	E47 (25kHz)	BOPRC	WRUA

Table 3: BOPRC BAU Repeaters

Note that BOPRC leases a Telemetry channel E191 (25kHz expires Nov 2015))

Radio Links	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Linking Equipment
Rangitoto (Whakapoungakau) - Putauaki	J (UHF)	JNB1	Council	Rangitoto (Whakapoungakau) owned by Council Putauaki owned by WRUA
Putauaki – Moutohora (Whale) Island	ESB (VHF)	E197/E47	Council/WRUA ((licence expires Nov 2015)	Back to Back radio repeater owned by WRUA

Table 4: BOPRC BAU Repeater Linking

CD Voice

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
Putauaki (Kordia Site)	CD (VHF)	CD16 (25kHz)	Team Talk (licence expires Nov 2015)	Team Talk

Table 5: BOPRC CD Repeater

4.3.2 WBOPDC(Western Bay of Plenty District Council)

BAU Voice

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
TECT All Terrain Park	E (VHF)	EN158 (12.5kHz)	WBOPDC	Council

Table 6: WBOPDC BAU Voice Repeater

They also lease radio services from Baywide Communications at Kopukairua.

CD Voice

This consists of two repeater sites that are linked together i.e.

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
TECT All Terrain Park	ESB (VHF)	ES135 (12.5kHz)	MCDEM	Council
Papamoa No2	ESB (VHF)	ES4 (12.5kHz)	MCDEM	Council

Table 7: WBOPDC CD Repeaters

Radio Link	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Linking Equipment
Rangitoto (Whakapoungakau) - Putauaki	EE (VHF)	EE19 (12.5kHz)	MCDEM	Council

Table 8: WBOPDC CD Linking

4.3.3 TCC (Tauranga City Council)

BAU Voice

No frequencies owned by the council.

CD Voice

Requirements covered by WBOPDC.

4.3.4 RDC (Rotorua District Council)

BAU Voice

No frequencies owned by the council but CD frequencies used instead.

CD Voice

Sites no linked.

Repeater Sites	**Radio Channel Used**		**Ownership**	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
Rangitoto (Whakapoungakau)	ESB (VHF)	ES1 (12.5kHz)	MCDEM	Council
Moerangi	ESB (VHF)	ES41 (12.5kHz)	MCDEM	CNML

Table 9: RDC CD Repeaters

4.3.5 KDC (Kawerau District Council)

BAU Voice

No frequencies owned by the council.

CD Voice

Requirement covered by WDC

4.3.6 WDC (Whakatane District Council)

BAU Voice

This consists of two repeater sites that are linked together i.e.

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
Putauaki (WRUA site)	ESB (VHF)	ES43 (12.5kHz)	MCDEM	WRUA
Moutohora (Whale) Island	ESB (VHF)	ES131 (12.5kHz)	BOPRC	WRUA

Table 10: WDC BAU Repeaters

Radio Link	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Linking Equipment
Putauaki – Moutohora (Whale) Island	J (UHF)	J45A	WRUA	WRUA

Table 11: WDC BAU Linking

CD Voice

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
Putauaki (WRUA site)	ESB (VHF)	ES132 (12.5kHz)	MCDEM	WRUA

Table 12: WDC CD Repeater

4.3.7 ODC (Opotiki District Council)

BAU Voice

No frequencies owned by the council but CD frequencies used instead.

CD Voice

Repeater Sites	Radio Channel Used		Ownership	
	Frequency Band	Channel No	Frequency Channel	Radio Repeater Equipment
Ohiwa Peninsula Hill	ESB (VHF)	ES7 (12.5kHz)	MCDEM	Council
Whanarua Bay (Simplex Repeater)	ESB (VHF)	ESX50	?	Council

Table 13: ODC CD Repeaters

Notes:

No ESX50 licence found for MCDEM or ODC

Two repeater sites linked using ES7.

4.4 Radio Coverage

(See Appendix B:)

As discussed in section 4.3 simplex frequency channels licences are generally used for local adhoc coverage. Since both ends of the radio link are ‘mobile’ then it is not possible to do coverage predictions for the general case and often portable repeaters are used to supplement or improve local coverage.

The following are the findings or trends in terms of the indicative coverage predicted for each of the repeater sites which are used for district or regional coverage.

4.4.1 Papamoa No2

- Good coverage coastal WBOPDC, Tauranga and NW from Tauranga.
- Poor coverage SW of Tauranga (TECT All Terrain Park direction) and elsewhere.

4.4.2 TECT All Terrain Park

- Good coverage in Park, coastal NE from Tauranga and NW from Tauranga.
- Poor coverage around Tauranga, Mt Maunganui and elsewhere.

4.4.3 Rangitoto (Whakapoungakau)

- Good coverage between NW to NE from site.
- Good coverage of Rotorua district except for region SW of Rotorua.
- Poor coverage of Tauranga and inland region SW of Tauranga.
- Poor coverage elsewhere.

4.4.4 Moerangi

- Good coverage within RDC area.
- Poor coverage elsewhere.

4.4.5 Putauaki

- Good coverage S to Murupara and N to Coast.
- In general good coverage NW to coastal to Katikati.
- Poor coverage between Whakatane and Opotiki.
- Spotty coverage NE coastal to to Waikawa Pt.
- Poor coverage in Rotorua District in general, and SW of Tauranga.

4.4.6 Moutohora (Whale) Island

- Good coverage coastal W to Te Puke and SW coastal/inland through to Kawerau.
- Good coastal coverage S to SE from Whakatane to Opotiki
- Spotty coastal coverage E to Waikawa Pt.
- Poor coverage elsewhere

4.4.7 Ohiwa Peninsula Hill

- Good coverage coastal around site W to Ohope and E to Torere.
- Good coverage inland region behind Opotiki.
- Poor coverage elsewhere.

4.4.8 Whanarua Bay

- Good coverage coastal coverage NE from Waikawa Pt and SW to Omaio.
- Poor coverage elsewhere.

4.4.9 District Coverage for CD service

For the CD services in each council there seems to be adequate coverage over their district given the indicative coverage predictions for the repeaters used.

4.4.10 Regional Coverage

CD Service

The regional council has only one CD repeater site located at Putauaki. While coverage is sufficient to communicate between the ECC at Tauranga and the EOCs at Kawerau, Whakatane and Opotiki it is marginal between the ECC and Rotorua. It is also insufficient to provide good coverage between regional staff across the BOPRC area.

BAU Service

The BAU voice service uses repeaters at Rangitoto (Whakapoungakau), Moutohora (Whale) Island, and Putauaki. The coverage is in general good except for inland SW Tauranga, S of Rotorua, and E of Opotiki.

4.5 Equipment

The review did not include looking at the radio equipment held by the councils however a number of them have provided information about the mobile and handheld radios they hold.

Council	Mobile and Portable Radios			
	Mobile		Handheld	
	Model	Status	Model	Status
ODC	Tait TM8200 TM8100	Current	Motorola GM328	No longer sold or supported
	Tait T2000mk1/2 T2010mk1/2 T2015 T7000	No longer sold or supported		
	ICOM F110	Current		
RDC	Tait TM8115/8110	Current	Hytera TC610	Current
	Tait T2000	No longer sold or supported	Motorola GM300	No longer sold or supported
	Hytera TM610	Current		
WBOPDC	Motorola DM3601	Current model (Analogue and Digital DMR)	Motorola GM300/328	No longer sold or supported
			Entel HT725	Current model
WDC	Tait T2000 (CD & BAU)	No longer sold or supported	Icom ICF50 (CD)	Current
			Icom IC F11 (CD)	Current
			Tait TP8100	Current
Regional CDEM Group	TM8200	Current	TP8100	Current

Table 14: Council Mobile and Portable Radio Models

Council	Portable Repeaters	
	Model	Status
ODC	None	
RDC	Tait model unknown	old
WBOPDC	None	
WDC	Tait T355/356	No longer sold or supported
Regional CDEM Group	GME UHF Crossband VHF	current

Table 15: Council Portable Repeaters

4.6 Other LMR Networks within BOP

In terms of other organisation with LMR networks (more than 2 repeater sites or Trunked systems) in the BOP they can be divided into:

- Private LMR networks for use only by the organisation concerned.
- Public LMR networks which are for public access by subscription.

The organisations are:

Private LMR Networks (Note only those organisation with significant networks are listed i.e. 3 or more repeater sites			
Organisation	**Type of User**	**Ownership**	**Type of Network**
Police and Fire	Emergency Service	Network Owned by Police	Conventional Analogue
Ambulance	Emergency Service	Network leased from Team Talk	Conventional Analogue
Department of Conservation	Government Department	Network Owned by DOC	Conventional Analogue
Tiaki Plantations, Company	Forestry	Tiaki Plantations, Company	Conventional Analogue

Private LMR Networks (Note only those organisation with significant networks are listed i.e. 3 or more repeater sites			
Organisation	**Type of User**	**Ownership**	**Type of Network**
Taumata Plantations Limited Company	Forestry	Taumata Plantations Limited Company	Conventional Analogue
Horizon Energy Distribution Limited	Electricity	Network owned by Horizon Energy	Conventional Analogue
C3 Limited (Cargo handling Company)	Transport	Port of Tauranga	Conventional Analogue
Kiwirail	Transport	Network owned by Kiwi Rail	Conventional Analogue

Table 16: Private LMR Networks

Public LMR Network (commercial providers)		
Company Name	**Type of Network**	**Plans for Digital Network (BOP)**
Alcom	Conventional Analogue Has plans for digital network (DMR)	Yes at Ngongotaha
Baywide Communications Ltd	Conventional Analogue Conventional Digital (DMR)	Already digital at Kopukairua
Kordia NZ Ltd	Trunked Digital (TETRA)	Already digital at Kopukairua

Public LMR Network (commercial providers)		
Company Name	**Type of Network**	**Plans for Digital Network (BOP)**
Netcom Services Ltd	Conventional Analogue Trunked Digital (DMR)	Already digital at Minden, Te Weraiti and Papamoa
Team Talk	Conventional and Trunked Analogue	No plans at the moment.
Whakatane Radio Users Association(WRUA)	Conventional Analogue	Yes plans underway

Table 17: Public LMR Networks

4.6.1 Whole of Government Radio Network (WGRN)

The New Zealand Government has directed that a whole-of-government approach be adopted for Public Protection and Disaster Relief (PPDR) communications. Agencies that are currently recognised as PPDR agencies include Enforcement agencies, First Responder agencies and Support agencies (e.g. CDEM Groups and Territorial Local Authorities). The intent of this approach is gain to efficiencies in terms of cost, network assets, and radio spectrum and has been is encompassed in the WGRN.

Initially the WGRN was envisaged as digital network based on using the NZ Police Replacement Radio Network (RRN) which was designed to replace their aging analogue network but from 2013 it is now an aggregation of both digital and analogue radio networks used by PPDR agencies. For the Police this means that they will operate on their digital radio network in the three metropolitan areas of Auckland, Wellington and Canterbury, while continuing to operate their analogue network in the rest of New Zealand.

In those areas with digital the Police in effect become a service provider to these other agencies. Similar to a Public LMR Network except it is designed to meet higher levels for network reliability and resilience than required for a commercial network. According to a press release (March 2013) it expected that the Fire Service will complete its transition to the Police digital network in the three metro areas by 2014/15. The next agency likely to join is the Ambulance services though no timescale has been given. It is expected other agencies will move to the digital WGRN as it suits their operational and budgetary requirements.

WGRN policy is still evolving but it mainly concerns governance with probably the provision, operation, and maintenance of services being contracted out to third parties as signalled in a recent RFI issued 7 August 2014 (see ref 13). – The purpose of the RFI is to

- "Identify the experience and capability of providers to operate the Whole of Government Radio Network (WGRN) in whole or part;
- Identify if there are providers with an interest in the development and delivery of WGRN services which meet or exceed the requirements of the strategic approach
- Gain providers perspectives on partnering approaches for engagement with Government for the delivery of the WGRN strategic direction; and
- Provide the market with an understanding of the WGRN."

In developing the policy for the WGRN there appears to the writer insufficient consideration of the differences in BAU communications between agencies that comprise the PPDR sector. For Police, Fire, and Ambulance their BAU requirements is emergency communications. Whereas for TLAs (regional and district) their BAU communications are mainly associated with Health and Safety and work flow management. In terms of PPDR, CDEM Groups and TLAs are "support organisations" that provide specialised resources and services in the management of and response to emergencies. Whereas Police, Fire, and Ambulance are "first responders" that provide services in the field as a first response to emergencies

For those areas outside the coverage of the current digital WGRN e.g. BOP there are no plans to roll out a digital network for cost reasons and because in the long term (5 to 10yrs) the communication needs for PPDR is expected to be met using Cellular Networks. This leaves CD along with other PPDR agencies in the BOP with either having to extend the life of their current analogue networks until WGRN (Cellular) is available or migrate to digital.

At present there are number of technological issues to be overcome before Cellular is resilient or reliable enough for PPDR (see Appendix J:). Once these issues are solved it will take time to implement the changes and improve the coverage of the Cellular Network so it is comparable to current LMR networks; particularly in those areas with in general poor cellular coverage e.g. BOP. Although the NZ Government through the Rural Broadband Initiative (RBI see ref 12) has a programme for improving coverage, its primary focus is providing broadband to schools, hospital and medical centres, and libraries. This is unlikely to meet the coverage needs for PPDR unless the Government provides more funding for Spark and Vodafone to extend their cellular coverage.

One possible short to medium term scenario being considered is using radios that support roaming between Cellular LTE and LMR networks. Cellular will be used as the primary means of communication with LMR used as a backup in case of a cellular failure. Should this happened

then given the bandwidth disparity between the two only voice and a limited data service could be carried on LMR.

5 LMR Network Architecture

Given the stated government policy regarding the WGRN then it can be assumed sometime in the future that CDEM in the BOP will be migrated to the digital WGRN. However since that WGRN is unlikely to be deployed across the BOP within the next 5 years then the CDEM in the BOP will have to retain their own networks (both regional and district) in the short to medium term. Probably continuing with the current mix of owned and leased radio infrastructure.

During this time the councils can either decide to:

1. Maintain the status quo of the current network assuming it is meeting the current need of users until such time the WGRN (LMR or Cellular?) is available.
2. Or upgrade the current network to meet the current and future needs of users rather than wait for the WGRN.

When upgrading the current network or building a new one, the following key factors need to be considered since they determine the type and scale of the network (network architecture)

- User Requirements
- Frequency Spectrum
- Radio Coverage
- Type of Network
- Choice of radio technology
- Migration strategy
- Scale of Network (Coverage)
- Reliability, Resilience, and Security
- Implementation and Operating costs.

5.1 User Requirements

This section analyses and describes the user objectives both current and future to be met by any LMR service.

5.1.1 BAU services

Voice

At present the following councils have separate LMR networks for BAU communication:

- WBOP to provide voice communications within the TECT All Terrain Park. They also use a leased repeater service from Baywide Communciations Limited.
- BOPRC for regional voice communications.
- WDC for district voice communications.

For the WBOP (TECT All Terrain Park), BOPRC, and ODC, LMR is the primary means of communication given poor or no cellular coverage in the areas of operation. In the case of the ODC they use their CD LMR network for both BAU and CD services.

For WDC, RDC, and TCC cellular is the primary means of communication with LMR used as a backup for those locations with poor cellular coverage. In the case of the WDC they can use their BAU LMR network whereas RDC and TCC have to use their CD LMR networks.

When compared to CD, most BAU communications can be considered non-critical (i.e. it doesn't matter if communications is delayed) except those associated with health and safety. In this case, like CD, cellular does not provide the same coverage reliability and resilence as LMR particularly for field staff working in remote areas. Therefore in the foreseeable future LMR will still be needed as a backup to cellular.

Scada/Telemetry Networks

The only councils using radio networks for SCADA and Telemetry are WBOPRC, TCC, RDC and BOPRC which are dedicated to this application only. In the past analogue LMR radio in conjunction with modems was used to provide data communications (typically 1200bits/s) for this application. However the trend now is to use digital radios specifically designed for data (serial or Ethernet) particularly with need for higher data rates (>9600bits/s). This is still generally the case when compared with digital LMR which although designed to carry data has data rates less than 9600bits/s.

Apart from providing this overview for completeness, the terms of reference for this report does not include the review of SCADA/Telemetry services.

5.1.2 CD Services

At present LMR is the most common and reliable way of providing communications during a Civil Defence Emergency and for emergency services in general (See Appendix J:). This is why all the district councils need to retain LMR networks despite Cellular being ubiquitous and eroding away some of the reasons why LMR was chosen in the past.

All district and regionals councils have statutory obligations and responsibilities in terms of Civil Defence. The framework for managing emergencies is defined in "The New Zealand Coordinated Incident Management System (CIMS) 2nd edition April 2014" published by the Officials' Committee for Domestic and External Security Coordination which is under the Department of the Prime Minister and Cabinet. It describes the hierarchy of response levels i.e.

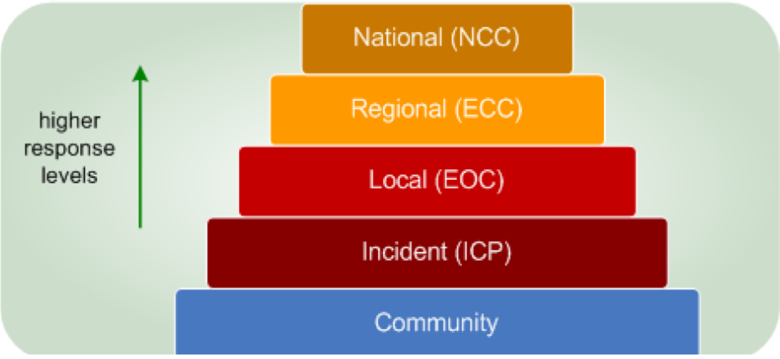


Figure 3: CIMS Response Levels (ref fig 5 of CIMS)

The ICP (Incident Control Point) is a single location where an Incident Controller and members of their IMT (Incident Management Team) coordinate and manage response operations at an incident level response. Agency response carried out by first responders.

District Councils are responsible for EOC (Emergency Operations Centres) which is a local level CC (Coordination Centre) that coordinates the local response and provides support to incident level response activities.

Regional Councils are responsible for ECC (Emergency Coordination Centres) which is a regional level CC that coordinates the regional response and provides support to local level responses.

For the CIMS to work, communication is required between each level for all the agencies/organisations involved in managing the emergency. In terms of communications the TA responsibilities (both DC and RC) are summarised in the following table.

Response Level	Communications Needs	TA responsible	Geographic Area of Communication	Communication Modes (see Appendix F:)
ICP	Between Incident Controller and IMT staff Between IMT staff	District Council	Local coverage (< 1km)	Direct (simplex) Portable Repeater
EOC	Between EOC Controller and one or more Incident Controllers	District Council	District	Fixed Repeater
ECC	Between ECC and one or more EOC controllers	Regional Council	Regional	Number of fixed repeaters

Table 18: CD Comms Requirements

Based on review it appears that district councils are meeting their obligations under this framework in terms local and district wide communications using their current networks.

5.1.3 Interoperability

A key requirement for PPDR agencies is interoperability particular between first responder agencies. Interoperability is broken into following areas: governance, standard operating procedures, training and exercises, usage and technology. This section discusses the technological aspect of interoperability whose purpose is to support an operation, not drive it.

Use of another radio network

This is where a radio from one organisation is used on the radio network of another organisation.

All the digital standards are mutually incompatible whereas for analogue there is essence one standard FM for LMR (AM for LMR has been phased out and is considered obsolete). This means that it is relatively easy for the user of one organisation to use the channel of another organisation for communication, particularly for conventional LMR systems (simplex and repeater modes). Generally all that is required is for the correct channel to be programmed into the radio along with the CTCSS tones and permission from the other organisation. For trunked analogue systems it is little more complicated but still practical.

Liaison Channels

These are agreed common channel/s that can be used for communication between users from different organisations. This type of interoperability is typically needed at an emergency where short range communication is only needed and hence Simplex is used since no network infrastructure is needed making interoperability easier.

As discussed in the previous section this easy to do for analogue but impossible for digital unless the different organisation use the same digital standard.

Radio Gateways

Radio gateways are devices used to connect one radio network to another radio network making it possible for a radio user to use their network, in effect, to talk to a user on another network. When this happens the user appears as another radio Talk Group (TG) on the other network. This is typically done using the following means:

- Direct IP connection between the two networks via gateways
- IP connection to a gateway connected to a radio on the other network.

Telephone interconnects are gateways that are commonly used on analogue networks to connect radio users to the PSTN. It is relatively straightforward to interconnect conventional analogue networks as the same “standard” is being used.

Gateways are also available for interconnecting between analogue and digital networks (any standard) and between digital networks (TETRA, DMR, dPMR, NXDN, P25)

A variation on using a gateway is using a console patching to temporarily connect two incompatible systems together via 4-wire audio or RF links.

Interoperability within PPDR

When considering the hierarchy of management described in the CIMS each agency will use their own networks to communicate with their staff at the ICP, EOC or ECC levels. Hence interoperability is not normally required in the command, control, and dispatch operating environment.

When it may be required at an incident is where the incident controller from one agency may have to communicate directly with first responders from other agency or when a team of first responders is supplemented with others from elsewhere e.g. another area in New Zealand or country as happened in the Christchurch Earthquake. In this case the visitors have to use a local network for communication. If this is not compatible with their radios in the case of digital then either temporary radios would have to be provided or an analogue network used instead. In the Christchurch those international teams with P25 radios e.g. NSW Police were quickly able to use the NZ Police P25 network (now WGRN).

Considerations for participating BOPLASS Councils

Currently within the BOP all the PPDR agencies use analogue LMR and given the indecision regarding WGRN (See Section 4.6.1) are likely to remain so in the short to medium term. Therefore the BOP DC CD voice services should also remain on analogue to maintain interoperability. This is not as important for the BOPRC CD voice service as this is used principally for communicating between the EOCs and ECC. Also the ECC is the logical place for gateways/console to connect to the radio networks of other agencies.

5.1.4 Integrated Network for BAU and CD Services

The Civil Defence communication infrastructure at the local and regional level is funded and provided by the TLAs (regional and district) through rates and hence has to compete with other needs. Also for TLAs the BAU communications infrastructure is generally separate from the CD infrastructure i.e. no integrated radio network. This is in part due to technological limitations associated with analogue LMR but also historical with funding for the two coming out of different budgets. Therefore (like the WGRN) it makes sense for TLAs to move to an integrated radio network for all their LMR services irrespective of the user groups, BAU or CD, to gain efficiencies in network infrastructure costs.

If an integrated radio network is envisaged then it has to meet both the TLAs BAU and CD user requirements. For BAU these will be set by the business/service needs of the TLA whereas for CD they are prescribed by the government PPDR framework which includes the WGRN and CIMS.

5.2 Frequency Spectrum

In NZ radio spectrum is managed by the Radio Spectrum Management (RSM) which is part of the Ministry of Business, Innovation and Employment (MBIE). Their responsibilities include policy, enforcing compliance, and licensing of frequencies for radio communication. For LMR in particular these frequencies/channels are listed in PIB23 "Mobile Service Bands in New Zealand".

5.2.1 Narrowbanding

In 2009 RSM released a discussion paper regarding the introduction of digital land mobile radio (digital LMR) technologies in the VHF and lower UHF bands. This was part of a worldwide process (commonly called narrowbanding) to improve spectral efficiency in the LMR frequency bands which for many countries were becoming congested. In NZ 12.5kHz and 25kHz channels are used for analogue LMR; often referred to as narrow and wideband channels respectively.

One outcome of this policy is that the use of 25kHz analogue channels below 470MHz has to cease this year (1st November 2015). Note that this applies for all licences except those used in ESA band, and for SCADA and Data services in C and D band.

Above 470MHz, 25kHz channels except those for SCADA and Data will be phase out by 31st December 2019.

5.2.2 Implications for BOPRC

For the VHF radio licences used by the BOP District Councils and Regional Council only the following licences will expire because they are for 25kHz channels:

Licence Id	Licence Number	Org Name	Ref Freq	Channel	Tx Loc Name
1498	94956	ENVIRONMENT BOP	151.325	E47	WHALE ISLAND
35587	124929	ENVIRONMENT BOP	150.7625	EX57	ROTORUA CIVIC CENTRE
134397	221417	ENVIRONMENT BOP	153.5813 153.5563	EX89 EX87	BAY OF PLENTY AREA
60477	164331	TEAMTALK LTD	148.3875	CD16	PUTAUAKI
25645	65176	WHAKATANE RTUA	153.2	E197	PUTAUAKI(RTUA)

Table 19: Licences due to expire

- CD16 is used for Regional CD communications and the service is provided by TeamTalk. It is in a legacy band called the CD band which used for CD communications prior to the availability of channels in ESB band.

- E47 and E197 are for Regional Voice communications and the service is provided by WRUA.
- EX57 and EX87 are simplex channels held by the BOPRC their use is unknown.

Voice

As CD16 is critical to CD communications between the district councils and the regional council, a replacement radio service will be required before November 2015. Also a replacement will be needed for E47, E197 and the simplex channels if the services are still required.

SCADA/Telemetry

According to RSM Frequency licence database the TAs within the BOP regional including the BOPRC use the following frequency bands for SCADA/Telemetry:

Mobile Bands	VHF:	E and MS Bands
	UHF:	C, D & F Bands
Fixed Bands	I, TT-D, and J Bands	

For those services using the Mobile Bands only the E band service (E191) used for BOPRC telemetry at Putauaki will need to be replaced because of “narrowbanding”. Note that MS band is excluded from “narrowbanding”. All the other services are either using fixed bands unaffected by “narrowbanding” or covered by the exemption for SCADA and data.

5.2.3 Radio Frequency Management Group (PSRFMG)

In New Zealand, there are specific frequency allocations reserved for public safety and emergency services. The use of these bands is coordinated by the Public Safety Radio Frequency Management Group (PSRFMG), which includes the agencies responsible for public protection and disaster relief services (Police, Ambulance, Fire Service, Defence, Customs, Department of Conservation, Ministry of Fisheries and Ministry of Civil Defence and Emergency Management).

These bands are:

ESA	75 to 80MHz (75.2125 to 79.98125MHz) 12.5 and 25kHz channels
ESB	138 to 144MHz (138.00625 to 143.99375MHz) 12.5kHz channels
ESC	494 to 502MHz (494.0000 to 501.99375MHz) 12.5kHz channels
ESD	812-813/857-858MHz

All bands have both simplex and duplex channels.

The PSRFMG also provides advice to the RSM on frequency allocation and sets rules on how these bands are to be used. Pertinent to this review is the recent clarification in November 2014 regarding the use digital LMR in ES bands. See Appendix D: for copy of the letter. In particular the clarification states:

Only analogue FM or digital APCO P25 - FDMA compliant modulation systems shall be used.

With the rapid development of digital radio and the number of standards now available including DMR, dPMR, NXDN, etc, interoperability is a major concern along with compatibility with the agreed New Zealand PPDR APCO25 standard. Consequently only radio systems complying with the above technical requirements will be licensed to operate on the ES bands. All other digital technologies are required to move to other bands, i.e E or F band.used.

This has profound implications regarding the radio strategy for the BOPRC.

5.3 Radio Coverage

In Section 4.4 of the review the current coverage was analysed based on indicative coverage predictions. While the council owned or lease LMR repeater infrastructure appears to provide good coverage within their districts, the regional council doesn't have good coverage over the region for both BAU and particularly CD voice services.

5.3.1 Regional Coverage

While BAU voice has the benefit of three repeaters at Rangitoto (Whakapoungakau), Moutohora (Whale) Island, and Putauaki, CD voice only has the one at Putauaki. Given the communication needs of the CIMS, the repeater only needs to provide spot coverage at the BOPRC ECC and DC EOCs. This it does with the exception of RDC whose predicted signal is marginal and should be improved if this is so. In general, the predicted coverage from Putauaki doesn't provide good area coverage across the BOP. This could depending on location prevent BOPRC CDEM staff from communicating with each other or the ECC when using the designated regional CD channel.

For BAU voice the repeaters are linked together to extend the range of communication between mobiles to the combined repeater. While this gives good coverage across most of the region it is poor for inland SW Tauranga, S of Rotorua, and E of Opotiki. To improve the coverage in these areas at least two more repeater sites are needed one to the E of Opotoki and another near Tauranga and another one found in the Rotorua District to replace Rangitoto.

Possible candidates are:

- Current WBOPDC repeater site at Papamoa.
- Kaingaroa Timberlands or Alcom site at Moerangi.
- Tiaki Plantation site at Waikawa Point.

The indicative coverage with five sites is shown in Appendix B:11.

Given that regional coverage is required for BAU and desirable for CD users then it makes to adopt an integrated approach to network design. That is one network providing for all regional user services, voice and possibly data in the case of a digital network.

Moutohora (Whale) Island

If the radio site concession for Moutohora should end then its contribution to regional coverage can be replaced by other sites in the Whakatane/Opotoki area. Possibilities include the Chorus site at Pukehoko and GoNet(?) site at Kohi Lookout.

5.3.2 Choice of Repeater Sites

The proposed sites have been suggested because they are known radio sites with good infrastructure in terms of equipment shelter, mast, and power supplies and reasonable access for vehicles. For Papamoa co-location approval is expected to be straightforward since it is council owned. This may not be the case for the other two sites particularly Moerangi where the two site owners are LMR service providers who may require the BOPRC to lease the required service instead. Whether this is an issue will depend on what ownership model is adopted by the BOPRC.

In Rotorua and Tauranga area there are other radio sites that could be used e.g. Kordia, Police, and Chorus. However the co-location rentals at these sites is generally higher since the infrastructure is more expensive to provide and maintain than the dedicated LMR sites

Whatever sites are selected co-location costs will need to be included in any financial analysis of the proposed LMR network.

5.4 Choice of radio technology

5.4.1 Analogue vs Digital

(For more information see Appendix H:)

There are many advantages with migrating to digital LMR from analogue and it is prudent for any new networks to be either digital or analogue but digital capable. Particularly, as analogue is becoming obsolete over time although this is unlikely to happen within the next 5 to 10yrs.

The digital advantages most relevant to the BOPRC network are:

- Better Voice Quality
- Increased Coverage
- Data over LMR
- Encryption

One overlooked disadvantage associated with digital is the need to upgrade the DC power supply for solar powered repeater sites because of its higher standby current drain compared with analogue e.g.

Radio Standard	RX/Standby Current Drain (A)	No of PV panels required (75W)	Battery Capacity (A/H)
Analogue (Tait TB7100)	0.28	2	365
P25(Phase 1) (Tait TB9100)	0.81	3	563
DMR (Tait TB9300)	1.8A	6	1126
Design Assumptions 3.5hrs worse month daily insolation 10 days reserve time 10% TX/RX duty cycle			

Table 20: Analogue Digital Solar Power Comparison

This is significant for the BOPRC as most of its current sites are solar powered.

5.4.2 Digital Standards

(For more information see Appendix I:)

The following digital LMR standards are ones most commonly used throughout the world.

- TETRA:
  This was one of the first digital standards to be launched and now a very mature technology. Originally the letters stood for Trans European Trunked Radio, but as the system is now being used beyond Europe the abbreviation now stands for Terrestrial Trunked Radio. TETRA is widely deployed, especially for the emergency services and other mission-critical applications. The standard was developed by European Telecommunications Standards Institute (ETSI).
- P25:
  P25, Project 25 or APCO-25 is a standardised digital radio communications system that is generally used by federal, state/province and local public safety agencies. It is similar in approach to TETRA.
- DMR (Digital Mobile Radio)
  Digital LMR standard developed by ETSI in particular for commercial applications.
- dPMR (digital Private Mobile Radio):
  Also developed by ETSI but it is a different specification to that of the DMR and utilises different techniques and is therefore not compatible.
- NXDN:
  This is a ‘sister’ technology to dPMR and is also an ‘open proprietary air interface protocol.

It was created by a small group of suppliers, and is made available to members of the NXDN forum. This standard originated within the USA but it is also available in Europe and other countries.

The key differences between standards are:

- All except NXDN are based on standards defined by Standards organisations, ETSI for TETRA, DMR and dPMR and TIA (Telecommunication Industry Association) for P25.
- All except TETRA provide for either conventional or trunked networks.
- P25, DMR and NXDN (12.5kHz version) require a 12.5kHz radio channel and hence conventional repeaters using these standards can operate in an analogue mode or dual analogue/digital mode. dPMR requires a 6.25kHz which is not compatible with analogue. TETRA is digital only.

Given these differences then the choice of digital technology for the BOPRC network is between P25 and DMR since international standards are preferred as they are in general supported by more manufacturers and dual analogue/digital operation is required to manage the transition from analogue to digital.

Standards and the Market for Mobile Radio Communications

When deciding on what standard to choose it is useful to see how manufacturers of the equipment see the market. The following table below has been provided by Tait Communications (see ref 10)

Mobile radio communications networks can be divided into the following types, each reflecting the different needs of the organisations that use them:

- Public Safety or Mission Critical (fully featured and highly available networks for police, fire, first responders).
- Critical Infrastructure (wide area networks that are essential for business, for utilities, transport, and for public access mobile radio).
- Professional or Business and Industrial (smaller “campus” networks for a variety of organisation types).
- Commercial (peer-to-peer communications that don’t require any infrastructure).

Mission Critical (Public Safety, Defense, Security)	Critical Infrastructure (Utilities, Transportation, PAMR/SMR)	Professional, Business and Industry (Education, Mining, Agriculture, Hospitality)	Commercial (Contruction, Retail, Family (FRS), Sports)
P25 trunked and conv			
Tetra trunked			
MPT trunked			
DMR trunked			
	DMR licensed		
	pDMR licensed		
			DMR unlicensed
			pDMR unlicensed

Table 21: Digital Standards vs Market Sector

Digital LMR networks deployed in NZ

The following are digital LMR networks being used in NZ based on the author's knowledge of the industry:

P25	Standard used for the WGRN both conventional and trunked.
DMR	Used by number of LMR supply and service companies e.g. TL Parker, Ashburton Electricity, CDHB (Canterbury District Health Board) both conventional and trunked.
NXDN	Some single conventional repeater systems. CD for the Christchurch City Council and Canterbury Regional Council are presently implementing a trunked system (12.5kHz)

5.4.3 P25 or DMR

P25

At the time when the Police were deciding what digital standard to use for the WGRN the only international standards available were TETRA and P25 with the latter being chosen for the following reasons (see reference 11):

1. Equipment is available from a range of suppliers.
2. Allows communication with legacy conventional FM analogue systems.
3. Supports an orderly migration from existing systems.
4. Is compatible with NZ's current VHF and UHF frequency plans.
5. Offers security in accordance with Government Communication Security Bureau (GCSB) requirements.

6. Allows interoperability between PPDR agencies.
7. Allows interoperability with some regional partner PPDR networks operating in similar frequency bands.

Points 1 to 4 also apply to the newer digital standards e.g. DMR and NXDN (12.5kHz).

Point 5 is largely concerned with encryption which the newer standards do not currently meet but will do so in the near future.

Points 7 & 8 are not reasons but consequences of WGRN policy. Interoperability here is understood as being able to use your radio on another agencies radio network. This is true for any digital network if the same standard is being used for both the mobile/portable and repeater/base station radios.

DMR

Phase 1 P25 uses FDMA when multiplexing channels together and since 2 channels are required for the BOPRC network then two radio channels and repeaters will be required for each site. DMR on the other hand uses TDMA to provide two timeslots (virtual channels) within one 12.5kHz radio channel. This makes DMR the preferred choice in terms of frequency and equipment efficiency. However this advantage is lost when compared to Phase 2 P25 since it also uses TDMA.

If DMR was chosen then new frequencies in another band e.g. E or EE would have to be used since the PSRFMG only allows P25 (Phase 1) to be used within ES bands. This change is not a problem in itself but it may be perceived that these other bands are not as ‘secure’ because they have not been exclusive reserved for PPDR agencies like the ES bands.

Migration

When considering the migration from Analogue to Digital on an existing network, the main steps in the process are:

1. Upgrading the radio repeaters so they dual modes i.e. digital/analogue.
2. Replacing the mobile/portables with dual modes.
3. Switching the LMR network from analogue to digital operation.

This approach is only available for those digital standards that operate with the same channel bandwidth as analogue i.e. 12.5kHz. Since migration will be required for the new LMR network then only P25 or DMR are suitable given NXDN is not an international standard.

For P25 this approach can applied channel by channel when migrating from analogue to Phase 1 P25 because it uses FDMA. However it is complicated for DMR when migrating since two analogue RF channels are condensed to one RF channel because of TDMA.

Consider how this would affect migration for the BOPRC network. As an urgent priority to maintain the status quo, the BOPRC has to replace the wideband (25kHz) CD16 repeater

service at Putauaki and BAU voice service at Putauaki and White Island with a narrowband (12.5kHz) service this year. This will also require the reprogramming the existing mobile/portable radios held by BOPRC and other third parties who currently use these channels. If BOPRC decides to begin the process of upgrading their network from analogue to digital then dual mode repeaters would be installed instead of analogue only ones. For P25 two repeaters would be installed at Putauaki and the two services, BAU and CD, can be migrated to digital independent of each other. However for DMR two repeaters would be required initially until both voice services were migrated to digital. This in the short term would mean that the channel efficiency of DMR would be lost.

Other Areas of Comparison

Area of Comparison	P25	DMR
WGRN Interoperability	Radios will operate on the digital WGRN Network or other P25 networks	Radios will not operate on the WGRN
Cost	Handsets and Mobile generally more expensive than DMR For two channel operation the repeater costs are significantly higher since two radio repeaters are required instead of one for DMR. Also combining equipment costs are higher.	
Synergies with other organisation networks	Within the BOP at present no P25 networks are being planned.	Opportunities to share or use public digital LMR networks since DMR seems to be preferred standard for commercial providers based on the current and planned networks in NZ. In BOP at least one commercial operator is planning a DMR Network
Frequency Planning	ESB, E or EE bands can be used. 10 frequencies required. ESB is the preferred band for PPDR but new frequencies (≤ 10) would have to found.	Only E or EE band can be used. frequencies required. Currently BOPRC have two E band licences and hence only three more are needed.

Table 22: P25 vs DMR comparison

Future Mobile/Portable radio purchases

Whether or not the network is analogue or digital this report recommends any new mobile/portable radio purchased should be at least P25 capable for those times where CDEM staff may have to work elsewhere in NZ on the WGRN. If P25 is chosen then only dual mode radios (Analogue/P25) are needed. If DMR is chosen then a number of triple mode (Analogue/P25/DMR) radios will be required in particular for CDEM staff. At present these are not readily available across the suppliers except for Tait which has just recently released a portable one. For the majority of Regional staff only dual modes are needed (Analogue/DMR).

5.5 Type of Radio Network

5.5.1 Cellular

(See Appendix J: for more detail)

While the need for RT strategy presupposes that there is an ongoing need for LMR services it is important to consider whether the alternative radio technology, Cellular, is more suitable.

Push to Talk over Cellular (PoC)

Although around since GSM it is only with the availability of ¾G cellular networks that it is a serious replacement for the traditional LMR push to talk (PTT) services. Despite the advantages its' use is limited to those areas with cellular coverage and there are issues regarding network Quality of Service (QOS), reliability and resilience particularly during natural disasters and other emergencies. These issues are real and significant as shown during recent emergencies and disasters across the world including the Christchurch Earthquakes. Work is underway to address these issues (See Appendix J: 2) but it will be sometime before PPDR agencies will be confident enough to use Cellular as the primary means of communication.

Using PoC instead of LMR is useful option to consider for those Councils wanting PTT like services but over Cellular for their BAU needs but it is not suitable for CD communications. It is also not option for the BOPRC BAU requirements because of limited rural coverage particularly in the Eastern BOP.

5.5.2 LMR

Given the considerations in the above sections (Section 5.1 to 5.3) then the following factors are significant in determining architecture of any new LMR network:

- The network should be designed to cover the BOP region and to meet the voice (BAU and CD) and future data requirements of the BOPRC principally.
- The Regional BAU & CD Voice repeater services at Putauaki and Whale Island will need to be replaced before the radio licences expiry on 1st of November 2015 due to "narrowbanding".

- Based on the review findings to date, it appears that LMR needs of the district councils are being meet and there is no imperative to upgrade their infrastructure (for CD only with the exceptions noted Section 5.1). However at some stage within the next 10yrs it is likely that current analogue LMR CD networks within each council will have to be replaced with a digital one. This replacement is likely to be the WGRN (LMR or Cellular).

5.5.3 Capacity

Given the small number of user groups (BAU and CD) then the use of Trunked Network (see Appendix G:) cannot be justified and therefore a Conventional Network is appropriate (see Appendix F:).

With the introduction of digital LMR the communication channel is transparent; it doesn't matter what application being used e.g. data or voice. Hence for digital LMR it is much easier for share a channel between different applications than for analogue. As consequence, the industry trend is for an upsurge in data services over radio when analogue voice systems are migrated to digital. Users discover the advantages of data applications that were not previously contemplated e.g.

- GPS tracking/Automatic Vehicle Location (AVL).
- Electronic Workflow Management, database access and updates.
- Interactive data messaging (status & text messages).
- Small scale or itinerant Telemetry or SCADA applications.

LMR Digital systems data rates range from 4k8 to 9k6 bits depending on the standard and have the same capabilities to carry data as found in Internet Protocol provided this is done within the bandwidth and protocol constraints of the system.

Therefore to meet the current requirements for voice and future requirements for data at least two radio channels are required e.g.

Channel A: Voice (BAU and CD)

Channel B: Data (BAU and CD?)

For most of the time Channel A would be only used for BAU voice but during a CD event CD voice would be given pre-emptive rights to Channel A. Channel B would be dedicated to data services (see above).

To differentiate between BAU and CD voice users different talk groups would be assigned to each. Talk Groups (TG) are a way for groups of users to share the same radio channel without distracting and disrupting other users of the channel. For analogue this is done using CTCSS (Continuous Tone-Coded Squelch System).

The same result can be achieved using all the digital standards but it is easier, more effective and has greater flexibility. Like analogue for digital only one TG can use the channel at a time and can only hear or access the traffic for those TGs programmed in the radio.

An alternative channel arrangement could also be used i.e.

Channel A: CD (Voice and Data)

Channel B: BAU (Voice and Data)

5.5.4 Proposed Integrated BOPRC LMR network

Given the considerations and conclusions from previous sections the following is the proposed for the BOPRC LMR Network:

- Five Repeater Sites at Papamoa, Moerangi, Putauaki, Moutohora (Whale) Island, and Waikawa Pt.
- Linking will be required between all sites to give regional voice coverage and a backbone network for data to and from application servers e.g. Tauranga. Digital UHF linking will be required given the distances involved with data from 80 to 120kbit/s typical in a 25kHz channel.
- Two channels at each radio site carrying either digital voice or data for CD and BAU services. Initially the channels will only carry analogue voice.
- Conventional Repeaters will be used as there is insufficient traffic to justify trunked repeaters. Dual mode analogue/digital repeaters to be used for transition from analogue to digital.

Figure 4: Proposed LMR Network

5.6 LMR Network Ownership Options

Currently the BOPRC and DC LMR radio services are mix of leased repeaters or TLA owned repeaters. For the BOPRC leased repeaters are used at Putauaki and Whale Island, and council owned at Rangitoto (Whakapoungakau.

When upgrading or replacing the current BOPRC LMR network either leased or council owned network should be considered in preference to mix of both given this tends to bring out the 'worse in the both'.

For both options it generally assumed that the BOPRC will own the CPE (client/customer premise equipment) e.g. mobile and portable radios. However in recent years it seems more organisations are considering the lease of LMR radios like they do for Cellphone handsets.

5.6.1 Leased

The following companies provide Public LMR services within the BOP along with the sites they use based on a search of radio licences.

Company Name	Radio Repeaters Sites within BOP
Alcom	MOERANGI

Company Name	Radio Repeaters Sites within BOP
	TAWA ROAD WAIPA MILL
Baywide Communications Ltd	KOPUKAIRUA
Kordia	KOPUKAIRUA
Netcom Services Ltd	PAPAMOA HILLS TE WERAITI (NETCOM) MT MINDEN
Team Talk	KOPUKAIRUA MANAWAHE POLICE MANAWAHE TELECOM MATANGIA MOANUI(GS) MT NGONGOTAHA PUKEHOKO RAINBOW MT TE WERAITI(TELECOM SOUTH) PUTAUAKI
Whakatane Radio Users Association(WRUA)	MARAETOTARA 1 PUTAUAKI PUTAUAKI(RTUA) WHALE ISLAND

Table 23: BOP Providers for Leased Radio Repeaters

The BOPRC requires region wide coverage for LMR and with the exception of Team Talk which has sites distributed across the BOP the rest only have sites only within a district. See Appendix D: for TeamTalk coverage of the BOP.

If BOPRC were to consider a lease service across the region then the options are either Team Talk or number of companies which would be can harder to manage.

5.6.2 BOPRC Owned

For this option, the BOPRC would own the radio infrastructure i.e. dc supplies, radio, antennas, feeders, and combiners etc. and contract out the operation and maintenance of the network. BOPRC would have to negotiate co-location agreements with the site owners for installing the

equipment. This may be an issue if the site owner prefers to own the equipment and offer leased services instead.

Indicative cost model for proposed RT network

The following table gives the indicative costs for building the proposed LMR Network given in Section 5.5.4 based on either DMR or P25.

Repeater Cost	DMR	P25
Materials		
Solar Power Supply (4 Sites)	$48,600	$48,600
AC Power Supply (1 Site)	$2,000	$2,000
Radio Repeater (5 off)	$53,420	$355,750
Radio Linking (between sites and to Tauranga)	$39,200	$39,200
Installation	$86,080	$86,080
Total	$229,300	$531,630

Mobile and Portable Radio Cost	DMR	P25
Portable(each)	$1,783	$2,298
Mobile (each)	$1,650	$2,338

Table 24: Indicative RT Network Costs

Assumptions and Constraints

- New solar power systems installed uses four 145W panels and 1200AH of battery capacity and is based on the following design constraints.

  3.5hrs worse month daily insolation

  10 days reserve time

  10% TX/RX duty cycle

- Tait Radio Repeaters, mobile, and portable radios i.e.

  DMR; TB9315, TP9360, TM9355

  P25; TB9115, TP9460, TM9455

- One off list prices used for radio equipment
- Sufficient space on mast/pole/tower for new antenna if required

- Sufficient space in equipment shelter for new radio equipment and batteries
- New mounting frame required for new solar panels

Exclusions

- Radio discounts for quantity or any government supply contract price for P25 radios.
- Resource and Building Consents
- Project Management
- Freight
- Structural design and strengthening if required for any aspect of proposal
- Solar Design
- Radio Design
- Radio supplier programming fees
- Operating Costs e.g. Operation and Maintenance, Radio Licence Fees, site Rentals

As shown in the above table the cost of implementing a P25 network is at least twice that of DMR and another reason why DMR is preferable to P25.

5.6.3 Shared Ownership

An alternative to the BOPRC owning the entire radio network infrastructure, is sharing the cost with other organisations. This could realise synergies through efficiencies in scale in the area of capacity, coverage, and operating and capital costs. As discussed earlier the proposed network represents the first level of rationalisation by merging the Regional CD and BAU networks into one. This section discusses the options for the next level which is sharing the network infrastructure across organisations.

BOP RC and DC's

Sharing the cost of network infrastructure

Because the DC's are not using LMR for BAU services there is no advantage currently with moving from analogue to digital just for CD services. For them it probably makes sense to wait until the WGRN is available.

If this were to change then the additional traffic (district wide) could be accommodated on Regional CD service as other talk groups possibly without increasing radio capacity.

Integrated Management of LMR networks across the BOP

Within each council the same task of managing their radio infrastructure is being repeated. Efficiencies could be realised if this task was done regionally particularly in the areas of maintenance, managing service contracts, radio licences etc.

Portable and Mobile Radio Equipment supply and maintenance

Both WBOPRC/TCC and RDC have modern analogue mobile and portable radios whereas ODC and WDC based on the information supplied will need to be replaced in the near future. It would make sense financially to have a regional supply contract for radios to take advantage of volume pricing since it appears at the moment purchasing is done independently by each council. The same also appears to apply for after sales support.

BOP RC DC's and other PPDR agencies

As discussed in the section on the WGRN there is no planned rollout for a digital network in the BOP within the next 5yrs at least. This means that Police (and Fire) will remain on the current Police analogue network. Within this time frame for other PPDR agencies in the BOP i.e. Ambulance and DOC there are no plans to upgrade their LMR networks to digital. This is mostly because cost outweighs the benefits.

DOC are considering when buying new radios to choose dual mode analogue/P25 ones so they can be used when deployed in a WGRN region. This is probably driven by their rural fire obligations as at least one council (Waimakariri) in the Canterbury region is also considering P25 radios for their rural fire vehicles.

To summarise there is no obvious synergies with sharing the cost of network infrastructure between the BOPRC and other PPDR agencies in the short to medium term unless one of the other agencies decides to pre-empt the WGRN. If this were to happen then this could probably be meet using conventional repeaters based on P25 assuming that agency was on the WGRN elsewhere in the country. This shared network would have a limited life as it would be superseded by the WGRN when it is rolled out in the BOP.

BOP RC DC's and commercial LMR service providers

If the BOP RC were to consider sharing a LMR network with a commercial service provider then it would most likely have to be trunking network because there will be more user groups to be managed as a consequence of being a Public as opposed to a Private LMR network (see Section 4.6). This LMR network would most likely to be based on DMR as this is becoming the de-facto standard in NZ for commercial providers.

Within the BOP at present the only commercial digital LMR repeaters in operation are those provided by Netcom Services Limited and Baywide Communications Limited however ALCOM Communications Services Limited is presently in the process of installing one, and WRUA have plans for one in the near future. Both Netcom and Baywide have coverage only over the Western Bay of Plenty, ALCOM will have coverage only over the Rotorua District, and presumably WRUA will have coverage over principally the Whakatane District. As discussed in Section 5.5.4 a barrier to achieving synergies is the fragmentation of coverage between suppliers except for

TeamTalk and the choice of frequency bands; Netcom Services is using 800MHz, Baywide 450MHz, and ALCOM 160MHz as well as probably WRUA.

Hence unless some sort of consortium can be formed between local BOP providers to build a regional digital trunking network then the current analogue “islands” will be become digital “islands” in the future. This is an area where the participating BOPLASS Councils could be involved if there is a benefit economically to the BOP Region.

5.7 Reliability, Resilience, and Security

5.7.1 Reliability and Resilience

At present all the existing radio repeater sites used by the BOPRC and DC’s have no redundancy and therefore are vulnerable to single failures. Without information regarding fault history it not possible to assess how reliable the service has been. The key factor determining the network reliability in this case is the Mean time to repair (MTTR). For rural sites a 6 -10hrs MTTR would be considered typical and acceptable for the BAU services but not for CD if a fault were to happen during an emergency. Also during an emergency it may be difficult to access the faulty repeater site. Although hot/standby repeater systems (radio and antennas) can be installed to improve network resilience this is not as effective as site diversity which is more expensive to implement. A more practical alternative is having another means of communication as a backup e.g. satellite phone or another LMR service provider e.g. TeamTalk. However the latter may not be as effective as satellite since many of the LMR providers in the BOP share the same repeater sites e.g. Putauaki, Whale Island, Moerangi.

For CD portable repeaters there should be at least one spare available.

5.7.2 Security

Although P25 is inherently more secure than DMR currently, the main security risk is not the air interface but rather the IP network that connects the repeaters together in a digital LMR network. For DMR trunked networks registration and authentication is used to validate individual mobile/portable radios. This is not available for conventional networks.

6 Appendices

Appendix A: Current Radio Licences used by BOP TAs

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
117560	Land Repeater >5W; BW <=12.5kHz	ENVIRONMENT BOP	152.625	10K0F3EJN	EN151	WHAKAPOUNGAKAU	MOBILE	BOPRC BAU Voice
1498	Land Repeater >5W; BW >12.5kHz	ENVIRONMENT BOP	151.325	16K0F3EJN	E47	WHALE ISLAND	MOBILE	BOPRC BAU Voice
3793	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ENVIRONMENT BOP	450.0375	16K0F3DXT	J55C	CABLEWAY	WAIOEKA	BOPRC Linking
6949	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ENVIRONMENT BOP	453.7375	16K0F2DXN		RANGER STATION	TAWHAI RIDGE	BOPRC Linking
15901	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ENVIRONMENT BOP	453.7375	16K0F2DXN		TAWHAI RIDGE	RANGER STATION	BOPRC Linking
20460	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ENVIRONMENT BOP	450.1375	16K0F3EJN	J59C	PAKIHI	BLUE MOUNTAINS	BOPRC Linking
29045	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ENVIRONMENT BOP	450.0375	16K0F3DXT	J55C	WAIOEKA	CABLEWAY	BOPRC Linking
30400	Maritime Private Coast Station	ENVIRONMENT BOP	156.8	16K0F3EJN	MM16	WHAKATANE HEADS	WHAKATANE MM AREA	BOPRC Maritime Voice
30400	Maritime Private Coast Station	ENVIRONMENT BOP	156.575	16K0F3EJN	MM71	WHAKATANE HEADS	WHAKATANE MM AREA	BOPRC Maritime Voice
30400	Maritime Private Coast Station	ENVIRONMENT BOP	156.725	16K0F3EJN	MM74	WHAKATANE HEADS	WHAKATANE MM AREA	BOPRC Maritime Voice
35587	Land Simplex	ENVIRONMENT BOP	150.7625	16K0F3EJN	EX57	ROTORUA CIVIC CENTRE	MOBILE	BOPRC Simplex Voice

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
103143	Fixed Bi-directional Point-to-Multipoint	ENVIRONMENT BOP	453.7375	16K0F2DXN		OPOTIKI	GORGE MOUTH	BOPRC SCADA/Telemetry
103143	Fixed Bi-directional Point-to-Multipoint	ENVIRONMENT BOP	453.7375	16K0F2DXN		OPOTIKI	BROWNS BRIDGE	BOPRC SCADA/Telemetry
103173	Fixed Bi-directional Point-to-Multipoint	ENVIRONMENT BOP	453.7375	16K0F2DXN		GORGE MOUTH	OPOTIKI	BOPRC SCADA/Telemetry
103174	Fixed Bi-directional Point-to-Multipoint	ENVIRONMENT BOP	453.7375	16K0F2DXN		BROWNS BRIDGE	OPOTIKI	BOPRC SCADA/Telemetry
117562	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	ENVIRONMENT BOP	453.63125	10K0F3EJN	JNB1	WHAKAPOUNGAKAU	PUTAUAKI(RTUA)	BOPRC Linking for BAU Voice
117566	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	ENVIRONMENT BOP	458.66875	10K0F3EJN	JNB1#	PUTAUAKI(RTUA)	WHAKAPOUNGAKAU	BOPRC Linking for BAU Voice
37457	Land Mobile - Mobile Transmit	ENVIRONMENT BOP	155.50625	16K0F3EJN	E47#	MOBILE	WHALE ISLAND	
117578	Land Mobile - Mobile Transmit	ENVIRONMENT BOP	154.40625	10K0F3EJN	EN151#	MOBILE	WHAKAPOUNGAKAU	
134397	Land Simplex	ENVIRONMENT BOP	153.58125	16K0F3EJN	EX89	BAY OF PLENTY AREA	MOBILE	Available for CD Simplex in BOP
134397	Land Simplex	ENVIRONMENT BOP	153.55625	16K0F3EJN	EX87	BAY OF PLENTY AREA	MOBILE	Available for CD Simplex in BOP
105098	Land Repeater >5W; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.1125	10K0F3EJN	ES9	PORTABLE REPEATER ALL NEW ZEALAND	MOBILE	Available for CD Portable Repeaters across NZ
105391	Land Repeater >5W; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.8125	10K0F3EJN	ES65	PORTABLE REPEATER ALL NEW ZEALAND	MOBILE	Available for CD Portable Repeaters across NZ
105392	Land Repeater >5W; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.85	10K0F3EJN	ES68	PORTABLE REPEATER ALL NEW ZEALAND	MOBILE	Available for CD Portable Repeaters across NZ

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
105393	Land Repeater >5W; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.9375	10K0F3EJN	ES75	PORTABLE REPEATER ALL NEW ZEALAND	MOBILE	Available for CD Portable Repeaters across NZ
169774	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.5125	10K0F3EJN	ES41	MOERANGI	MOBILE	RDC CD Voice
169257	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.5375	10K0F3EJN	ES43	PUTAUAKI(RTUA)	MOBILE	WDC BAU Voice
166615	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.05	10K0F3EJN	ES4	PAPAMOA NO2	MOBILE	WBOPDC CD Voice
166616	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	142.625	10K0F3EJN	ES130	KOPUKAIRUA	MOBILE	
169695	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	142.65	10K0F3EJN	ES132	PUTAUAKI(RTUA)	MOBILE	WDC CD Voice
166662	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.0125	10K0F3EJN	ES1	WHAKAPOUNGAKAU	MOBILE	RDC CD Voice
169381	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	142.6875	10K0F3EJN	ES135	TECT ALL TERRAIN PARK	MOBILE	WBOPDC CD Voice
169527	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	142.8875	10K0F3EJN	ES151	BAY OF PLENTY REGION	MOBILE	Available for CD Portable Repeaters with BOP
169376	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	142.6375	10K0F3EJN	ES131	WHALE ISLAND	MOBILE	WDC BAU Voice

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
171895	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	141.0875	10K0F3EJN	ES7	OHIWA PENINSULAR HILL	MOBILE	ODC CD Voice
19398	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.725	10K0F3EJN	ESX18	KAWERAU AREA	MOBILE	Available for CD Simplex in Kawerau DC
19398	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	143.575	10K0F3EJN	ESX46	KAWERAU AREA	MOBILE	Available for CD Simplex in Kawerau DC
19398	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.9875	10K0F3EJN	ESX39	KAWERAU AREA	MOBILE	Available for CD Simplex in Kawerau DC
171538	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	162.4375	10K0F2DXN	EE19	PAPAMOA NO2	TECT ALL TERRAIN PARK	WBOPDC CD Voice linking
171539	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	167.0375	10K0F2DXN	EE19#	TECT ALL TERRAIN PARK	PAPAMOA NO2	WBOPDC CD Voice linking
173227	Land Repeater NZ Wide; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	142.8875	10K0F3EJN	ES151	BAY OF PLENTY REGION	MOBILE	Available for CD Portable Repeaters with BOP
10593	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.825	10K0F3EJN	ESX26	WHAKATANE & WHAKATANE BOARD MILL AREAS	MOBILE	Available for CD Simplex in Whakatane
10593	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	143.5625	10K0F3EJN	ESX45	WHAKATANE & WHAKATANE BOARD MILL AREAS	MOBILE	Available for CD Simplex in Whakatane
10593	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.9875	10K0F3EJN	ESX39	WHAKATANE & WHAKATANE BOARD MILL AREAS	MOBILE	Available for CD Simplex in Whakatane

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
27760	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.7125	10K0F3EJN	ESX17	BAY OF PLENTY AREA	MOBILE	Available for CD Simplex in BOP
27760	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.7625	10K0F3EJN	ESX21	BAY OF PLENTY AREA	MOBILE	Available for CD Simplex in BOP
27760	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.9875	10K0F3EJN	ESX39	BAY OF PLENTY AREA	MOBILE	Available for CD Simplex in BOP
105099	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.9375	10K0F3EJN	ESX35	ALL NEW ZEALAND	MOBILE	Available for CD Simplex across NZ
105099	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.95	10K0F3EJN	ESX36	ALL NEW ZEALAND	MOBILE	Available for CD Simplex across NZ
140954	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	140.6875	10K0F3EJN	ESX15	ROTORUA & ROTORUA DISTRICT AREAS	MOBILE	Available for CD Simplex in RDC
140954	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	143.55	10K0F3EJN	ESX44	ROTORUA & ROTORUA DISTRICT AREAS	MOBILE	Available for CD Simplex in RDC
140954	Land Simplex; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	150.225	10K0F3EJN	ENX14	ROTORUA & ROTORUA DISTRICT AREAS	MOBILE	Available for CD Simplex in RDC
166275	Land Simplex Govt. use only; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	143.65	10K0F3EJN	ESX52	ALL NEW ZEALAND	MOBILE	Available for CD Simplex across NZ
166276	Land Simplex Govt. use only; BW <=12.5kHz	MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT	143.9625	10K0F3EJN	ESX77	ALL NEW ZEALAND	MOBILE	Available for CD Simplex across NZ

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
2306	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0G9WWX	I552#	KAHAROA PUMP STATION	KAHAROA RESERVOIR	RDC SCADA/Telemetry
12378	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	ROTOITI PUMP STATION	KAHAROA RESERVOIR	RDC SCADA/Telemetry
13966	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	422.4125	16K0F2DXN	I597	UTUHINA HEADWORKS	MATIPO RESERVOIR	RDC SCADA/Telemetry
16231	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	EASTERN RESERVOIR	KAHAROA RESERVOIR	RDC SCADA/Telemetry
29498	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	ROTOITI RESERVOIR	KAHAROA RESERVOIR	RDC SCADA/Telemetry
29501	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	ROTOMA STATION	KAHAROA RESERVOIR	RDC SCADA/Telemetry
29665	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ROTORUA DISTRICT COUNCIL	450.0625	16K0F2DXN	J56C	LAKE ROTOMA	LAKE ROTOMA RESERVOIR	RDC SCADA/Telemetry
29666	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	ROTORUA DISTRICT COUNCIL	450.0625	16K0F2DXN	J56C	LAKE ROTOMA RESERVOIR	LAKE ROTOMA	RDC SCADA/Telemetry
35206	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	ROTORUA DISTRICT COUNCIL	420.1875	16K0F2DXN	I508	KAHAROA RESERVOIR	WAIOTAPU	RDC SCADA/Telemetry
35207	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	ROTORUA DISTRICT COUNCIL	425.2	16K0F2DXN	I508#	WAIOTAPU	KAHAROA RESERVOIR	RDC SCADA/Telemetry
81758	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	427.425	16K0F2DXN	I597#	MATIPO RESERVOIR	UTUHINA HEADWORKS	RDC SCADA/Telemetry
140180	Land Mobile - Mobile Transmit	ROTORUA DISTRICT COUNCIL	450.60625	10K0F3EJN	CN27#	MOBILE	TIHIOTONGA	
115842	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	ROTOMA STATION	KAHAROA RESERVOIR	RDC SCADA/Telemetry
142482	Land Mobile - Mobile Transmit	ROTORUA DISTRICT COUNCIL	451.05625	10K0F3EJN	CN63#	MOBILE	KAHAROA RESERVOIR	

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
115845	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	ROTOITI PUMP STATION	KAHAROA RESERVOIR	RDC SCADA/Telemetry
115857	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	EASTERN RESERVOIR	KAHAROA RESERVOIR	RDC SCADA/Telemetry
142937	Land Mobile - Mobile Transmit	ROTORUA DISTRICT COUNCIL	452.64375	10K0F3EJN	CN190#	MOBILE	WAIOTAPU	
115862	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	ROTOITI RESERVOIR	KAHAROA RESERVOIR	RDC SCADA/Telemetry
115869	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	426.3	16K0F2DXN	I552#	KAHAROA PUMP STATION	KAHAROA RESERVOIR	RDC SCADA/Telemetry
140179	Land Repeater >5W; BW <=12.5kHz	ROTORUA DISTRICT COUNCIL	455.64375	10K0F2DXN	CN27	TIHIOTONGA	MOBILE	RDC SCADA/Telemetry
142477	Land Repeater >5W; BW <=12.5kHz	ROTORUA DISTRICT COUNCIL	456.09375	10K0F3EJN	CN63	KAHAROA RESERVOIR	MOBILE	RDC SCADA/Telemetry
155283	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	421.2875	16K0F2DXN	I552	KAHAROA RESERVOIR	ROTOMA STATION	RDC SCADA/Telemetry
155283	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	421.2875	16K0F2DXN	I552	KAHAROA RESERVOIR	ROTOITI RESERVOIR	RDC SCADA/Telemetry
155283	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	421.2875	16K0F2DXN	I552	KAHAROA RESERVOIR	EASTERN RESERVOIR	RDC SCADA/Telemetry
155283	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	421.2875	16K0F2DXN	I552	KAHAROA RESERVOIR	KAHAROA PUMP STATION	RDC SCADA/Telemetry
155283	Fixed Bi-directional Point-to-Multipoint	ROTORUA DISTRICT COUNCIL	421.2875	16K0F2DXN	I552	KAHAROA RESERVOIR	ROTOITI PUMP STATION	RDC SCADA/Telemetry
142477	Land Repeater >5W; BW <=12.5kHz	ROTORUA DISTRICT COUNCIL	456.09375	10K0F2DXN	CN63	KAHAROA RESERVOIR	MOBILE	RDC SCADA/Telemetry
142936	Land Repeater >5W; BW <=12.5kHz	ROTORUA DISTRICT COUNCIL	457.68125	10K0F2DXN	CN190	WAIOTAPU	MOBILE	RDC SCADA/Telemetry
142936	Land Repeater >5W; BW <=12.5kHz	ROTORUA DISTRICT COUNCIL	457.68125	10K0F3EJN	CN190	WAIOTAPU	MOBILE	RDC SCADA/Telemetry

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
80427	Land Mobile - Mobile Transmit	TAURANGA DISTRICT COUNCIL	469.5625	16K0F3EJN	D103#	MOBILE	MT MAUNGANUI RESERVOIR	
83543	Land Mobile - Mobile Transmit	TAURANGA DISTRICT COUNCIL	450.5125	16K0F3EJN	C10#	MOBILE	CAMBRIDGE ROAD RESERVOIR	
110367	Land Mobile - Mobile Transmit	TAURANGA DISTRICT COUNCIL	469.7625	16K0F3EJN	D111#	MOBILE	MT MAUNGANUI RESERVOIR	
110405	Land Mobile - Mobile Transmit	TAURANGA DISTRICT COUNCIL	451.6875	16K0F3EJN	C57#	MOBILE	MAKETU RESERVOIR	
156065	Land Mobile - Mobile Transmit	TAURANGA DISTRICT COUNCIL	469.9375	16K0F3EJN	D118#	MOBILE	MT MAUNGANUI RESERVOIR	
926	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	TAURANGA DISTRICT COUNCIL	450.0125	16K0F2DXN	J54C	JOYCE ROAD	OROPI GORGE PUMPS	TCC SCADA/Telemetry linking?
927	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Uni-directional)	TAURANGA DISTRICT COUNCIL	450.0125	16K0F2DXN	J54C	OROPI GORGE PUMPS	JOYCE ROAD	TCC SCADA/Telemetry linking?
12740	Telemetry/Telecommand (Uni-directional)	TAURANGA DISTRICT COUNCIL	158.6	16K0F2DXN	MS22	MT MAUNGANUI	OROPI	TCC SCADA/Telemetry linking?
13356	Telemetry/Telecommand (Uni-directional)	TAURANGA DISTRICT COUNCIL	158.6	16K0F2DXN	MS22	OROPI	MT MAUNGANUI	TCC SCADA/Telemetry linking?
110413	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	TAURANGA DISTRICT COUNCIL	449.53125	10K0F2DXN	JBX13	WAIKITE ROAD RESERVOIR	WAIKITE ROAD HIGH LEVEL RESERVOIR	TCC SCADA/Telemetry linking?
110418	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	TAURANGA DISTRICT COUNCIL	449.53125	10K0F3EJN	JBX13	WAIKITE ROAD HIGH LEVEL RESERVOIR	WAIKITE ROAD RESERVOIR	TCC SCADA/Telemetry linking?

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
83542	Land Repeater >5W; BW >12.5kHz	TAURANGA DISTRICT COUNCIL	455.55	16K0F2DXN	C10	CAMBRIDGE ROAD RESERVOIR	MOBILE	TCC SCADA/Telemetry linking?
110403	Land Repeater >5W; BW >12.5kHz	TAURANGA DISTRICT COUNCIL	456.725	16K0F2DXN	C57	MAKETU RESERVOIR	MOBILE	TCC SCADA/Telemetry linking?
80426	Land Repeater >5W; BW >12.5kHz	TAURANGA DISTRICT COUNCIL	464.375	16K0F2DXN	D103	MT MAUNGANUI RESERVOIR	MOBILE	TCC SCADA/Telemetry linking?
110365	Land Repeater >5W; BW >12.5kHz	TAURANGA DISTRICT COUNCIL	464.575	16K0F2DXN	D111	MT MAUNGANUI RESERVOIR	MOBILE	TCC SCADA/Telemetry linking?
156062	Land Repeater >5W; BW >12.5kHz	TAURANGA DISTRICT COUNCIL	464.75	16K0F2DXN	D118	MT MAUNGANUI RESERVOIR	MOBILE	TCC SCADA/Telemetry linking?
60478	Land Mobile - Mobile Transmit	TEAMTALK LTD	149.775	16K0F3EJN	CD16#	MOBILE	PUTAUAKI	
60477	Land Repeater >5W; BW >12.5kHz	TEAMTALK LTD	148.3875	16K0F3EJN	CD16	PUTAUAKI	MOBILE	BOPRC CD Voice
105844	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	450.3375	16K0F3EJN	C3#	MOBILE	CORNER CRAWFORD & PORIPORI ROAD	
107528	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	472.3125	16K0F3EJN	F13#	MOBILE	OMOKOROA MPS	
108974	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	469.8875	16K0F3EJN	D116#	MOBILE	WAIHI WATER	
109024	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	469.8875	16K0F3EJN	D116#	MOBILE	WAIHI WATER	
121369	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	452.4375	16K0F3EJN	C87#	MOBILE	MAKETU RESERVOIR	

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
121373	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	452.8875	16K0F3EJN	C105#	MOBILE	MUTTONS WATER TREATMENT	
121377	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	452.9125	16K0F3EJN	C106#	MOBILE	TAHAWAI WATER TREATMENT PLANT	
124369	Land Simplex; BW <=12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	150.625	10K0F3EJN	ENX46	WESTERN BAY OF PLENTY DISTRICT TLA	MOBILE	Available for CD Simplex in WBOPDC
126429	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	154.49375	10K0F3EJN	EN158#	MOBILE	TECT ALL TERRAIN PARK	
151822	Land Mobile - Mobile Transmit	WESTERN BAY OF PLENTY DISTRICT COUNCIL	472.59375	10K0F3EJN	FN48#	MOBILE	MAKETU WASTE WATER	
100107	Telemetry/Telecommand (Uni-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	471.325	16K0F2DXN	TT15D	WAIHI WATER	WAIHI	WBOPDC SCADA/Telemetry
100157	Telemetry/Telecommand (Uni-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	471.325	16K0F2DXN	TT15D	WAIHI	WAIHI WATER	WBOPDC SCADA/Telemetry
103434	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	450.1375	16K0F3EJN	J59C	MANIATUTU ROAD PUMP	MANIATUTU ROAD TANK	WBOPDC SCADA/Telemetry
103814	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	450.1375	16K0F3EJN	J59C	MANIATUTU ROAD TANK	MANIATUTU ROAD PUMP	WBOPDC SCADA/Telemetry
108091	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	454.3	16K0F3EJN	J27B	NO 3 ROAD RESERVOIR	NO 3 ROAD PUMP	WBOPDC SCADA/Telemetry

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
108093	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	459.3375	16K0F3EJN	J27B#	NO 3 ROAD PUMP	NO 3 ROAD RESERVOIR	WBOPDC SCADA/Telemetry
121504	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	454.46875	10K0F2DXN	JNB68	WRIGHT ROAD TANKS	WRIGHT ROAD PUMP	WBOPDC SCADA/Telemetry
121505	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	453.83125	10K0F2DXN	JNB17	OMOKOROA RESERVOIR	YOUNGSON ROAD CSZ1 BOREPUMP	WBOPDC SCADA/Telemetry
121508	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	458.86875	10K0F2DXN	JNB17#	YOUNGSON ROAD CSZ1 BOREPUMP	OMOKOROA RESERVOIR	WBOPDC SCADA/Telemetry
121511	Fixed < 1GHz; BW <=12.5kHz (Bi-directional)	WESTERN BAY OF PLENTY DISTRICT COUNCIL	459.50625	10K0F2DXN	JNB68#	WRIGHT ROAD PUMP	WRIGHT ROAD TANKS	WBOPDC SCADA/Telemetry
126405	Land Repeater >5W; BW <=12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	152.7125	10K0F3EJN	EN158	TECT ALL TERRAIN PARK	MOBILE	TECT All Terrain Park BAU Voice
105840	Land Repeater <=5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	455.375	16K0F3EJN	C3	CORNER CRAWFORD & PORIPORI ROAD	MOBILE	WBOPDC SCADA/Telemetry
121364	Land Repeater >5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	457.475	16K0F2DXN	C87	MAKETU RESERVOIR	MOBILE	WBOPDC SCADA/Telemetry
121370	Land Repeater >5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	457.925	16K0F2DXN	C105	MUTTONS WATER TREATMENT	MOBILE	WBOPDC SCADA/Telemetry
121374	Land Repeater >5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	457.95	16K0F2DXN	C106	TAHAWAI WATER TREATMENT PLANT	MOBILE	WBOPDC SCADA/Telemetry

Licence Id	Working Description	Org Name	Ref Freq	Emission	Channel	Tx Loc Name	Rx Loc Name	Application
108971	Land Repeater >5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	464.7	16K0F3EJN	D116	WAIHI WATER	MOBILE	WBOPDC SCADA/Telemetry
109022	Land Repeater >5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	464.7	16K0F2DXN	D116	WAIHI WATER	MOBILE	WBOPDC SCADA/Telemetry
107478	Land Repeater >5W; BW >12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	478.3	16K0F2DXN	F13	OMOKOROA MPS	MOBILE	WBOPDC SCADA/Telemetry
151817	Land Repeater >5W; BW <=12.5kHz	WESTERN BAY OF PLENTY DISTRICT COUNCIL	478.58125	10K0F1DXN	FN48	MAKETU WASTE WATER	MOBILE	WBOPDC SCADA/Telemetry
25644	Land Repeater >5W; BW >12.5kHz	WHAKATANE RTUA	153.125	6K00A3EJN	E191	PUTAUAKI(RTUA)	MOBILE	BOPRC SCADA/Telemetry
32574	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	WHAKATANE RTUA	454.7625	16K0F3EJN	J45A	WHALE ISLAND	PUTAUAKI(RTUA)	WDC BUA Voice linking between Putauaki and Whale Island
33646	Fixed < 1GHz; BW >12.5kHz & <=50kHz (Bi-directional)	WHAKATANE RTUA	459.775	16K0F3EJN	J45A#	PUTAUAKI(RTUA)	WHALE ISLAND	WDC BUA Voice linking between Putauaki and Whale Island
39961	Land Mobile - Mobile Transmit	WHAKATANE RTUA	154.90625	6K00A3EJN	E191#	MOBILE	PUTAUAKI(RTUA)	
25645	Land Repeater >5W; BW >12.5kHz	WHAKATANE RTUA	153.2	16K0F3EJN	E197	PUTAUAKI(RTUA)	MOBILE	
39962	Land Mobile - Mobile Transmit	WHAKATANE RTUA	154.98125	16K0F3EJN	E197#	MOBILE	PUTAUAKI(RTUA)	

Appendix B: Indicative Radio Coverage

1. Coverage Parameters

Program: Pathloss 5 area coverage module

Digital Terrain Data: 25m horizontal grid ± 10m vertical accuracy

Terrain Obstruction Model: Pathloss diffraction algorithm which is a combination of the Longley Rice Model and Multiple Edges model.

Earth Radius Factor (k): 1.333

Climate: Maritime Temperate Overland

Diffraction Time Variability: 50%

Frequency: 156MHz (average frequency between ESB and EE band)

Receive Sensitivity: -118dBm for 12dB SINAD
-120dBm for 5% BER (equiv to 12db SINAD)
-109dBm for 20dB SINAD
-110dBm for 2% BER (equiv to 20dB SINAD)

Transmitter Power: Repeater 50W (17dBW)
Mobile 25W (14dBW)

Antenna: Omnidirectional

Antenna Gain Repeater 0dBD
Mobile 0dBD

Feeder losses: Repeater 2dB
Mobile 1dB

Duplexer Losses: Repeater 1dB

Ambient Manmade Noise: F_{am} =7dB (ref Recommendation ITU-R P372-11, Rural location at 150MHz)

Target Coverage Availability: 95%

Dynamic Path Loss: 14dB for combined Shadowing and Multipath Fading.

Coverage Map Area Legend

The coverage map uses the following colours to denote signal quality and reliability at a location.

Colour	Receive Signal	Signal Quality and Reliability
	Receive Signal ≥ -88dBm	good signal quality which is reliable
	-102dBm ≤ Receive Signal < -88dBm	good signal quality but not reliable
	-112dBm ≤ Receive Signal < -102dBm	poor signal quality and not reliable
	Receive Signal < -112dBm	unusable

Table 25: Coverage Map Legend

2. Papamoa No2

3. TECT All Terrain Park

4. Rangitoto (Whakapoungakau)

5. Moerangi

6. Putauaki

7. Moutohora (Whale) Island

8. Ohiwa Peninsula Hill

9. Whanarua Bay

10. BOPRC BAU Voice Coverage

11. Regional Coverage with five sites

Appendix C: Site Photographs

1. Rangitoto (Whakapoungakau) (now called Rangitoto)

Figure 5: Cabling Inside Equipment Shelter

Figure 6: Radio Equipment Rack 1

Figure 7: Radio Equipment Rack 2 top and bottom

Figure 8: Antenna Pole and Building

2. Putauaki (WRUA)

Figure 9: WRUA Equipment Room

Figure 10: WRUA Antenna Poles

3. Moutohora (Whale) Island

Photos provided by A1 Electronics (Whakatane)

Figure 11: Antenna Pole and Building

4. Ohiwa Peninsula Hill

Figure 12: Antenna Pole and Equipment Enclosure

5. Whanarua Bay

No photos unable to access site during review however site looks very similar to Ohiwa Peninsula.

6. TECT All Terrain Park

No photos unable to access site during review.

7. Papamoa No2

Figure 13: Antenna Pole and Shelter

Figure 14: Inside Shelter Batteries

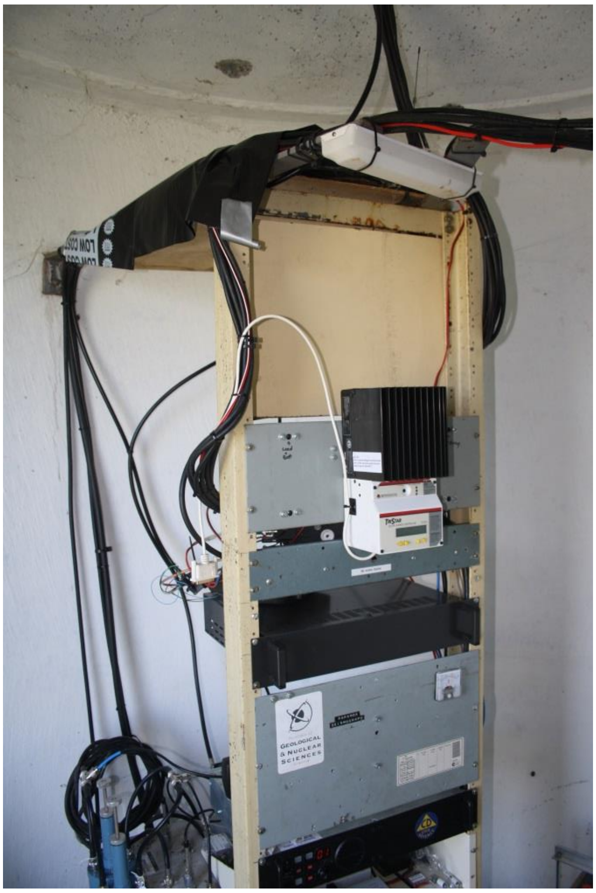


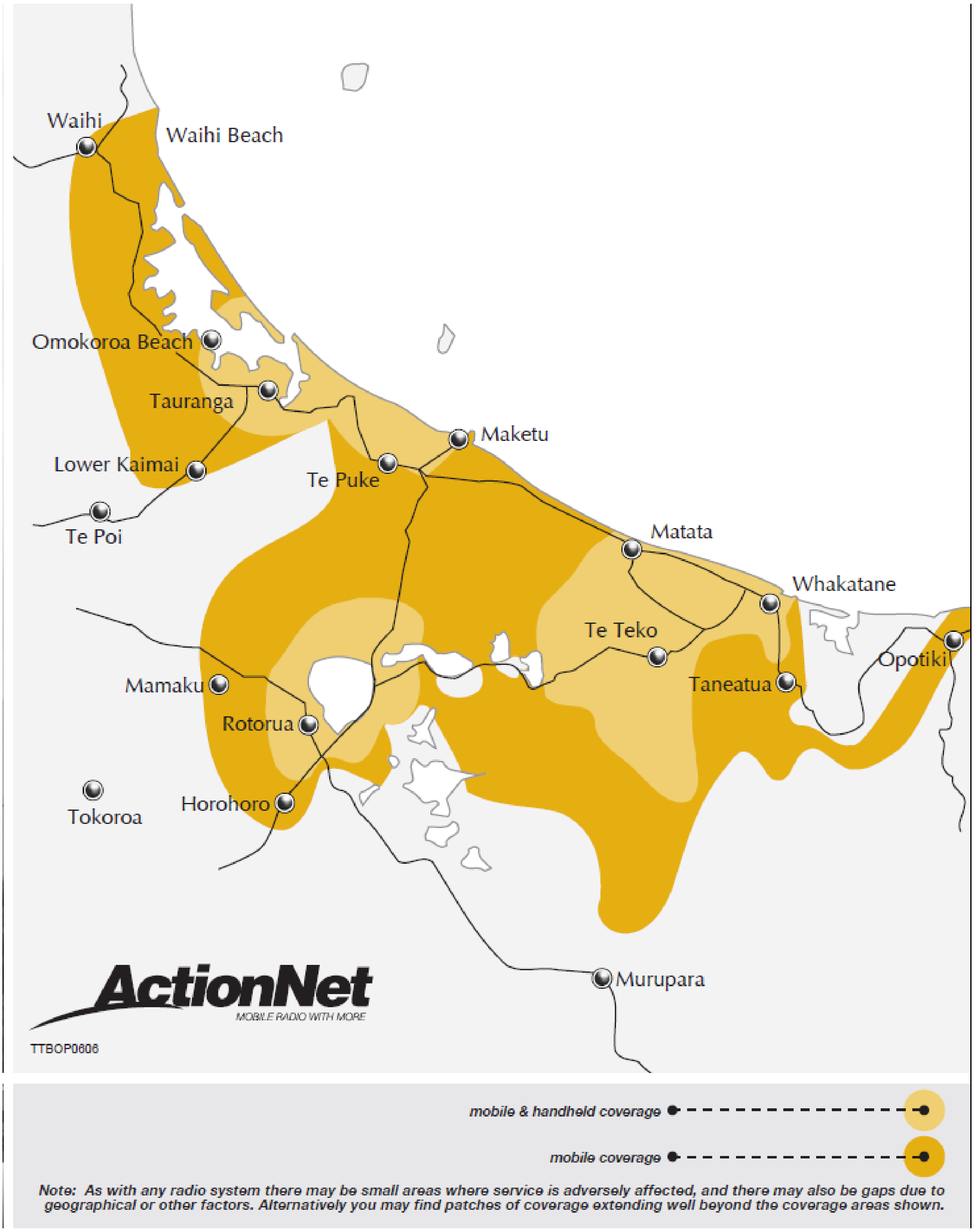
Figure 15: Radio Equipment Rack top and bottom

8. Moerangi

(Note did not have permission to view inside equipment shelter)

Figure 16: Antenna Pole, Equipment Shelter and PV Array

Appendix D: Team Talk Coverage for BOP



Appendix E: PSRFMG rules regarding ES bands

PUBLIC SAFETY RADIO FREQUENCY MANAGEMENT GROUP
To Secure and Manage Specific Radio Frequency Bands for the Purpose of Public Safety And Security

15 November 2014

PSRFMG Members

Clarification of Rules to operate within ES Band

In 1989 the Public Safety Radio Frequency Management Group (PSRFMG) was established to secure and manage frequencies for the purpose of Public Safety. Radio Spectrum Management (RSM) set the direction for operating within the established bands of 138 – 144MHz (ESB) and 494 – 502MHZ (ESC).

PIB 58 provides the Policy Rules for any licence to operate within these bands and Section 3.12.3 relates to the conditions for any emergency services licences. They state:-
"Approved persons are required to use the following conditions on all license applications for the ES band. – *"The licence permits radio communications solely for non-commercial public safety and security operations relating to the protection of life and property"* Where the Ministry of Civil Defence & Emergency Management is the licensee there is an additional condition that *"Primary use is for Civil Defence and Emergency Management purposes"*.

The PSRFMG Rules of Operation (Section 5) provides guidance on the technical requirements to operate within these bands in order to ensure interoperability between the agencies involved. These rules agreed by the Ministry of Business, Innovation and Enterprise (MBIE) are:-

1. Only analogue FM or digital APCO P25 – FDMA compliant modulation systems shall be used
2. Equipment must comply with the applicable land mobile standards specified in the MBIE Radio Communications standards notices (ASNZ4295 for analogue and TIA-102 family of standards with particular reference to ANSI/TIA-102.CAAB-C for APCO 25 Phase 1 digital voice and data.
3. Equipment must comply with MBIE ES channelling plans specified in PIB23.

With the rapid development of digital radio and the number of standards now available including DMR, dPMR, NXDN, etc, interoperability is a major concern along with compatibility with the agreed New Zealand PPDR APCO25 standard. Consequently only radio systems complying with the above technical requirements will be licensed to operate on the ES bands. All other digital technologies are required to move to other bands, ie E or F band.

When considering any communications upgrade to digital please ensure that the above requirements are complied with.

Please promulgate this information to all involved in this area of radio communications.

Regards

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Appendix F: Introduction to LMR

(see references 6,7, and 8)

Land Mobile Radio (LMR) - sometimes called Professional Mobile Radio or Private Mobile Radio (PMR) was developed for business users who need to keep in contact over relatively short distances with a central base station / dispatcher - a typical example is a taxi company. LMR is also widely used by emergency services. LMR networks consist of one or more base stations and a number of mobile terminals.

Often a LMR system owned and operated by the same organisation as its users however may also be developed to allow public access (by subscription), and they are then known as Public Access Mobile Radio (PAMR). The users of PAMR systems are usually not the same as the system's owner and operator

1. Requirements for LMR Services

The requirements for LMR can be summed in terms of providing a reliable communication service. Key requirements are:

- Reliability. Many LMR services are used in safely critical systems and so in general LMR users prefer to control their own network. Along with ensuring the service is reliable and secure it also helps to control costs.
- Speech and data transmission capability. Mobile data services are increasingly being used for tracking, Telemetry or information updating services.
- Centralised and decentralised operation. In many organisations, LMR is used to organise users and a central dispatch point/control centre is therefore required. However, it may also be important that users are able to contact each other in the absence of a central control point or even any infrastructure at all.
- Point to point, group calls and broadcast calls. For LMR a flexible group call structure is essential so that users can share information directly rather than having to relay via others. Therefore, group calls, calls involving a number of defined users, and broadcast calls, where the call includes all terminals, are required in addition to point-to-point (single terminal to single terminal) calls.
- Fast call set-tip. Rather than dialling a number to set up a call, with the called party answering a phone LMR systems use "push-to-talk" to activate a call to the dispatcher or user group. With the receiving terminal annunciating the message without an answering procedure. Calls may therefore consist of a sentence or two, and users expect to be connected to the called terminal without delay. This is particularly important in the emergency services where the radio may be used to give urgent commands and the

dropping of the first few words of the message due to delaying in setting up the call might have serious consequences.

- Good coverage. LMR mobile radio users usually have less choice as to where to make a call than a cellular user. The call location is often stipulated by the location of the work the user is undertaking. In the case of a utility this may mean having good coverage over a wide area and for public safety users constraints can be even more severe. LMR use VHF or UHF frequency bands ranging from 70 to 900MHz.
- Long battery life. User maintenance costs money in terms of lost work time in LMR systems, and reliability of service is also important. This compares with public cellular systems where the users are responsible for battery charging

Other requirements that may not be needed in all cases are:

- Security this includes encryption and authentication of radios.
- Call priorities so operators can differentiate between users in terms of different call priorities or qualities of service. For example an emergency call may be able to pre-empt other call types to gain access to the network.
- Communication between networks. Many large companies operate over large areas or with several sites. They may not want to provide the complete network themselves, or they may use different networks on different sites due to equipment replacement cycles or regulators restrictions. Their LMR networks may therefore have to communicate with each other. Also in many circumstances communication with general telephone or data networks is a useful feature.
- Ease or licensing. This issue involves not just the bureaucratic process of obtaining permission to use a radio channel but also the issues of the availability of channels and any coordination which may be required with other users in the same area. The problem of licensing hundreds of different users operating in numerous different areas is much more complex than that of organising a small number of national cellular operators. It is only possible if the LMR radio channels are as self-contained as possible with regard to interference between users.
- Capacity or efficient use of the radio resource. In general for LMR users this not an issue due to the length of the call, and since licences have been relative cheap in most countries.

2. LMR Configurations

Radio Channel Arrangement

Radio communications circuits can be either half duplex where users can either listen or talk but not both simultaneously or full duplex where they can where they can talk and listen simultaneously e.g. cellular.

Full duplex communication is possible using either Frequency or Time Division Duplexing (FDD or TDD). As show in diagram below, FDD uses two different frequencies (duplex frequency pair) simultaneously for each direction of communication.

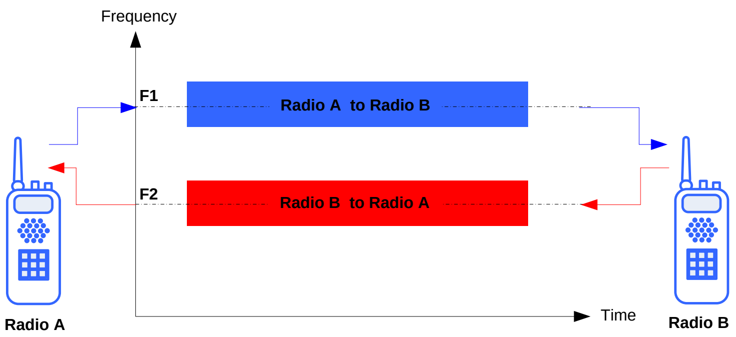

Figure 17: Frequency Division Duplexing (FDD)

Whereas for TDD the same frequency is used for each direction of communication but the frequency is shared in time between each direction e.g.

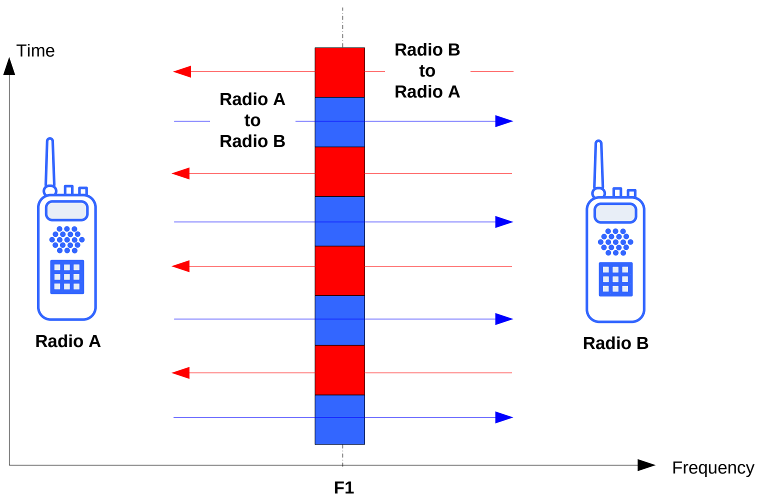

Figure 18: Time Division Duplexing (TDD)

For LMR networks in general communication is half duplex and the radio frequency channel arrangement is either simplex or duplex. In simplex channels the same frequency is used for both transmit and receive whereas for duplex channels two different frequencies are used, one for transmit and the other for receive.

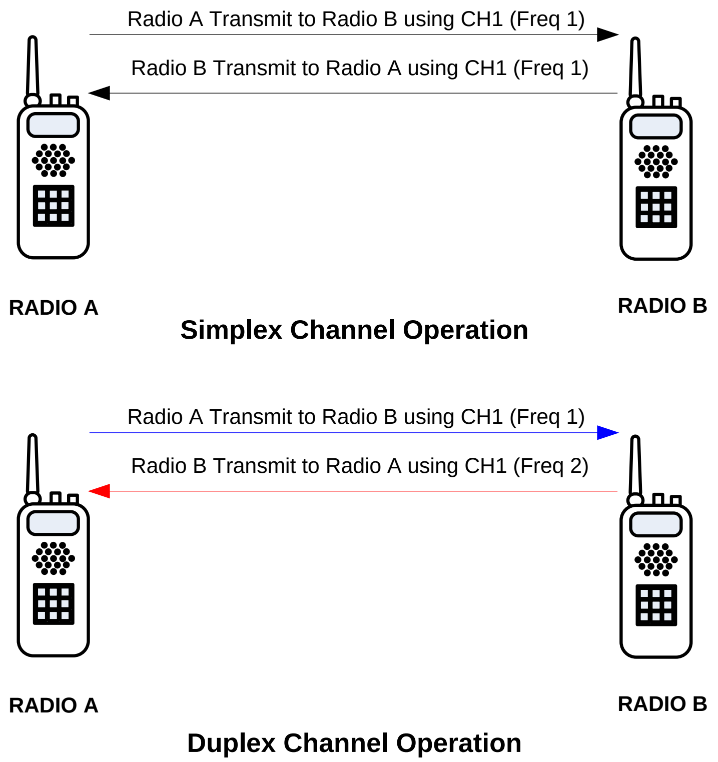

Figure 19: Simplex vs Duplex Channels

With the new digital LMR standards using TDMA full duplex communication is possible using TDD.

Frequency Planning

A LMR network can be can be termed either conventional or trunked depending upon frequency utilisation.

Conventional system is the most basic radio communications system and refers to a "traditional" method of frequency utilisation. Each radio operates on fixed channels with each user group permanently assigned a fixed frequency or a set of frequencies (Channel = Frequency). The radio operates on one channel at a time with correct channel selected by the user. Users can only talk when their channel is clear of traffic otherwise they must wait in "queue" before being able to transmit. The advantages of conventional radio are:

- Simple and cost-effective for sites with a small number of channels.
- Fast call set-up.

The system is limited by the number of frequencies available for a given system. In multi-channel systems, channels are used for to separate purposes. A channel may be reserved for a specific function or for a geographic area. In a functional channel system, one channel may be used for communication between road repair crews and a second channel for communicating between road repair crews and the office. In a geographic system, a taxi company may use one channel to communicate in the northern area and a second channel when taxis are in southern area.

For users who belong to multiple groups using different channels, it is difficult for them to monitor each channel. Therefore automatic scanning is used to scan every assigned channel when the user is not transmitting. The scan will stop when it detects a channel is used and hence the user will be able to automatically follow conversation in different group. Of course, this user can only participate in one group at any one time.

With a conventional system there is a practical limit to number of channels that can be created by adding frequencies and splitting activities geographically. The limiting factors are:

- Availability of spectrum
- Cost of multi-channel operation in terms of radios, antennas and combining equipment this includes running costs e.g. maintenance and power.
- User group radio management and administration.
- Unreliable channel scanning. Scanning and detecting the presence of signals within a channel takes time and it is possible to miss messages if too many channels are scan. For this reason, scan features are either not used or scan lists are intentionally kept short in emergency applications.

For networks where a conventional system isn't a viable option because there are too many users wanting to use the system; a trunking system is used. Trunked radio is discussed in detail in Appendix G:

Modes of Operation

In Conventional networks the following configurations or modes of communication are used:

- Direct Mode
- Dispatch
- Conventional Repeater

In Trunked networks only the repeater configuration is used.

Direct Mode

The direct mode of operation is where one mobile station talks directly to another mobile, or group of mobiles, without going through a fixed base station or repeater. It is also called simplex

since the same frequency is used for both transmit and receive. Either a single common frequency is used or different frequencies can be used for different call groups.

Communication is only possible between radios when they are in range of each other and given the power limitations on battery operated portable radios this may be a significant restriction.

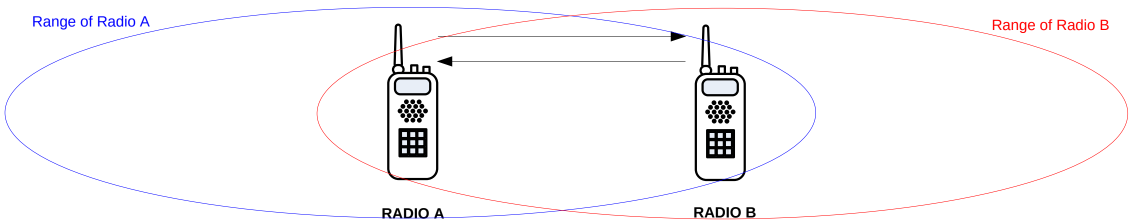

Figure 20: Simple direct mode LMR

Simplex is used typically by organisations requiring temporary communications over relatively small areas e.g. emergency personnel working at a scene of an incident marshals for sporting and other public. Simplex channels are often used for liaison between different public safety agencies.

Dispatch and Repeater Modes

These are the simplest LMR modes that uses fixed infrastructure. It requires a pair of two frequencies, one for uplink communications between the mobile/portable radios and the base station and one for the downlink to the mobile/portable radios. In this operation all mobile/portable radios in the system can hear the base station transmission but mobile/portable cannot hear each other since different frequencies are used for transmit and receive. Only the base station can hear all mobile/portable radios.

In Dispatch mode the base station is connected to the control station where the dispatcher is located. All calls include dispatcher who controls communication and communication between mobile/portable radios is not possible. Links with the public switched telephone or data networks are possible via the dispatcher.

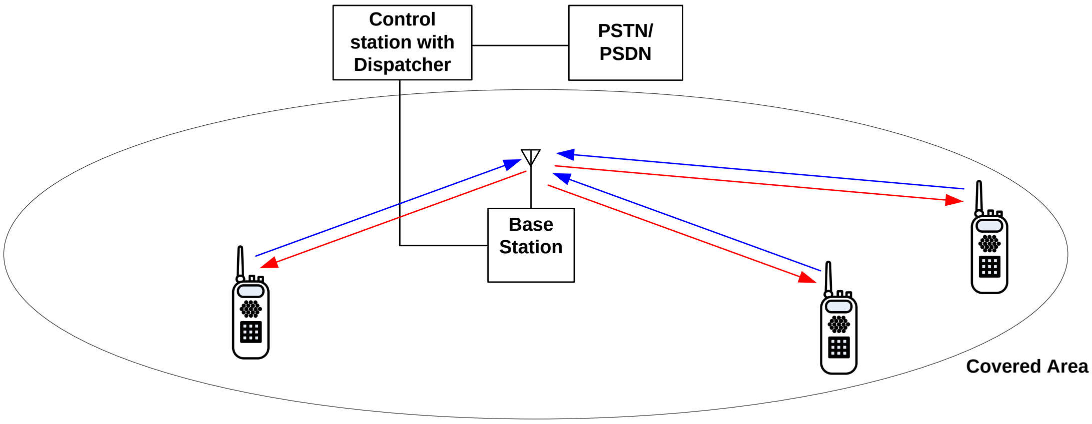

Figure 21: Dispatch mode LMR

In repeater operation ("talkthrough") any uplink messages received by the base station are retransmitted (repeated) on the downlink effectively extending the range of mobile/portable radios. Repeaters are typically sited on a local high point e.g. mountain top, towers, and tall buildings to provide maximum coverage.

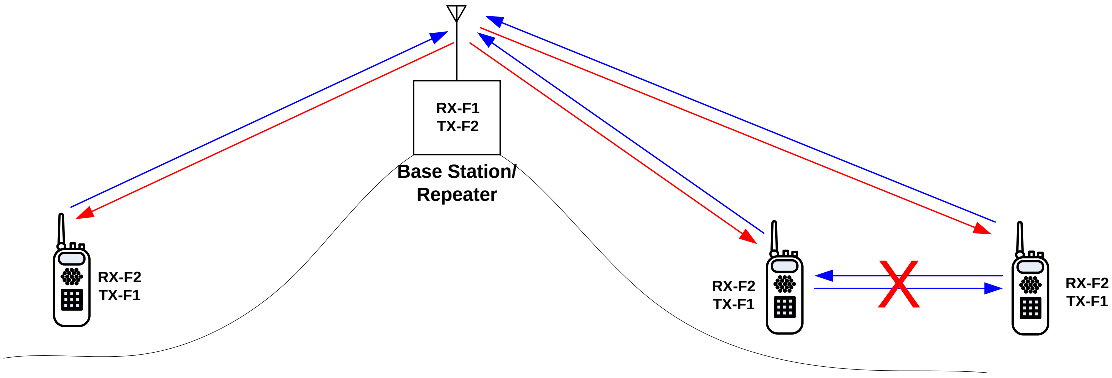

Figure 22: Repeater LMR Mode

Different organisations can share repeaters so-called “community base stations" or "community repeaters" if the different users have signalling to identify their message. The signalling is retransmitted by the base station so that mobiles in other groups are muted and privacy maintained. Since users in groups do not hear all the messages it is necessary to keep usage low to ensure access. Such systems therefore include time outs to ensure that users do not ‘hog’ a channel.

In general most radios include both simplex and duplex channels for direct and repeater operation respectively. They will often include a simplex channel that uses the same frequency as the uplink frequency for a duplex channel so they bypass the repeater and talk directly to mobiles. This is called “talkaround” and is essentially the same as direct mode operation.

3. Coverage

LMR radio operates in the VHF and UHF bands and hence is limited to line-of-sight propagation which implies that you must be able to see the radio your wish to communicate with. However in practice communication beyond this range is often possible due to the diffraction, reflection or refraction of the radio waves.

An engineered LMR radio system will include calculating the coverage for any given base station/repeater which is an estimate of the useful range of communication between it and mobile/portable radios. This range depends on radio propagation conditions, which are a function of frequency, antenna height and characteristics, atmospheric noise, reflection and refraction within the atmosphere, attenuation of the radio signal by obstructions (such as terrain, vegetation or buildings), transmitter power and receiver sensitivity, and required signal-to-noise ratio for the chosen modulation method.

VHF versus UHF

If radio communication is required mostly outdoors then VHF is probably the best choice as it is attenuated less by buildings and terrain. However if radios are used in in a heavily wooded area then often UHF is better than VHF.

If the radios are used mainly inside buildings, then UHF (or even 800 or 900 MHz) is likely the best solution since its shorter wavelength travels through the buildings better. Since there are more available channels with UHF it is more likely that a free channel (less interference) will be found in more populated areas. Also since the range of UHF is also not as far as VHF under most conditions, there is less chance of distant radios interfering with the signal.

Range

In direct mode communication the range is limited to the line of sight path between the two mobile/portable radios.

If a repeater is used then communication is limited to the line of sight path between the repeater and any mobile/portable radio.

When the distance becomes too long, or the coverage provided is too restricted for a single repeater, more repeaters are added. By establishing a series of repeater sites, a chain can be linked together to provide radio coverage over a large area. Unfortunately for analogue linking, every time a signal is “repeated”, some of the quality is lost, thus the number of repeaters that can be linked together in any one line is limited. This is not the case for digital linking.

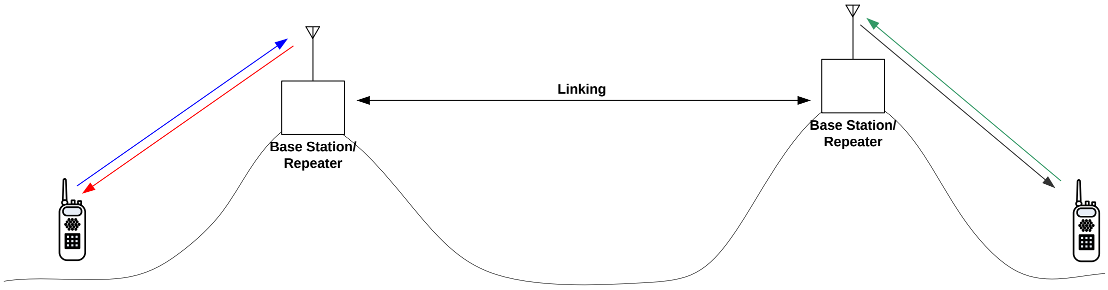

Figure 23: Linked Repeater Sites

The range will also depend on whether a portable or mobile radio is used. Since the transmit power for handheld portable radios (<5W) is less than mobile radios (<25W) mounted in vehicles (due to battery and safety restrictions) then range for portable radios is less than for mobile radios.

4. LMR Design Process

There are many steps to designing a radio system, even a simple repeater system which include:

- Choosing the frequency band and channels to be used.
- Determining the required coverage area and hence where repeater site(s) need to be located. This usually involves a number of trade-offs.
- Selecting the equipment (repeater, duplexer, antenna, batteries, etc.) to be installed.

Appendix G: Trunked LMR

1. Trunking Overview

In Trunking systems is where several channels are shared dynamically between users making it more likely a free channel will available. It is however more complex than conventional systems.

In a trunked radio system, the system logic automatically picks the physical radio frequency channel. There is a protocol that defines a relationship between the radios and the radio backbone which supports them. The protocol allows channel assignments to happen automatically.

Instead of channels, radios are related by groups which may are commonly called talk groups. These can be thought of as virtual channels which appear and disappear as conversations occur as opposed to a conventional system which dedicates a radio frequency to each group.

Digital trunked systems may carry simultaneous conversations on one physical channel. In the case of a digital trunked radio system, the system also manages time slots on a single physical channel (frequency). This is called multiplexing.

A radio may have several talk-groups programmed into it, and the user selects the one he or she wants to use at any particular time.

2. Operation

Radio frequency channels in a trunked system can be divided into two types: traffic and control.

- Traffic channels are what the controller assigns to a user when they wish to speak.,
- Control channels carry instruction and status messages between radios and the controller.

A site typically has one radio frequency set aside as a control channel while the rest are used to carry traffic. Because control channels are transmitted continuously from repeater sites, many systems change the control channel frequency from day to day in order to more evenly distribute the wear and tear on the repeater equipment.

All radios are tuned to the repeater output frequency that carries the control channel. This is called the idle state.

When a group member wishes to speak with the other members of their talk-group, the following steps take place when the user presses the push-to-talk button on their radio:

1. The radio transmits a request along with the radio's current talk-group identifier to the repeater where it is received and forwarded to the controller.
2. The controller checks if there is a traffic channel not currently in use. If there is a traffic channel available, the controller assigns it to the talk-group and marks it

as "in use."
If all of the traffic channels are in use, the controller sends a "busy" message back to the user's radio to inform the user to try again later.

3. The controller sends a message out to all radios, telling them that the talk-group is active on the assigned traffic channel. Radios that receive the message and are programmed with that talk-group tune to the assigned traffic channel.
4. The requesting user's radio receives the message and emits a "go ahead" beep to the user and the user begins speaking.

Steps 1 through 4 happen very quickly, usually in less than one second. Eventually the user stops talking and releases the push-to-talk button and the following steps take place.

5. The user's radio transmits a "finished" message to the repeater where it is received and forwarded to the controller.
6. The controller receives the message and in turn sends a message out to all radios indicating that the talkgroup is no longer active on the assigned traffic channel.
7. Radios that were tuned to the assigned traffic channel retune to the control channel.
8. The controller releases the active channel and marks it as "not in use."

Logic Trunked Radio (LTR)

LTR systems do not have a separate control channel but use a distributed method of access where service may be requested on any channel, and every channel may be used for voice communications. In a five-channel LTR system, all five channels can be used for voice traffic, making more efficient use of the assigned radio frequencies. It also removes the bottleneck that delays messages during periods of heavy use if all access requests are being handled in sequential order by the control channel.

Without a dedicated control channel LTR lacks the centralised control functions required by some users and hence LTR systems are not common in public safety but are often used for industrial and business applications.

LTR systems can have problem with ‘Late Entry” where a user joins a call already in progress after powering on or entering system coverage.

3. Advantages of trunked radio

- More efficient use of frequencies due to the dynamic channel allocation at the call setup.
- Greater control with authenticated user access to the network and its services.
- Channel (Talk Group) capabilities
- Various user features, including Emergency Alarm, PTT ID, Channel Regrouping, Call Alert, and Radio Inhibit

- Suitable for calls involving more than one site, as the trunking controller only includes sites which have participants in the call.
- Sophisticated handling of failure scenarios. For example, the loss of one traffic channel only reduces the capacity of the network by one call; no users lose service. Most vendors offer systems which degrade gracefully if equipment or links fail.
- Consistency in radio coverage

Appendix H: Analogue versus Digital

(see reference 9)

1. Coverage and Voice Quality

Digital has greater voice clarity at low received signal levels near the edge of coverage than analogue which can result in a 20% increase in coverage for digital when compared with analogue.

Signal strength falls off exponentially as the distance from the transmitter increases, following the inverse square law. At the same time, the background RF "noise" level remains constant, so the signal-to noise ratio (SNR) declines by a factor of four with each doubling of the distance between transmitter and receiver. For analogue this decreasing SNR translates into a declining voice quality as FM reception becomes increasingly noisier and intermittent in fringe areas. Whereas digital incorporates built-in error-correction which reconstitutes the voice at nearly its original fidelity throughout most of the RF coverage area. This is shown in the graph below where

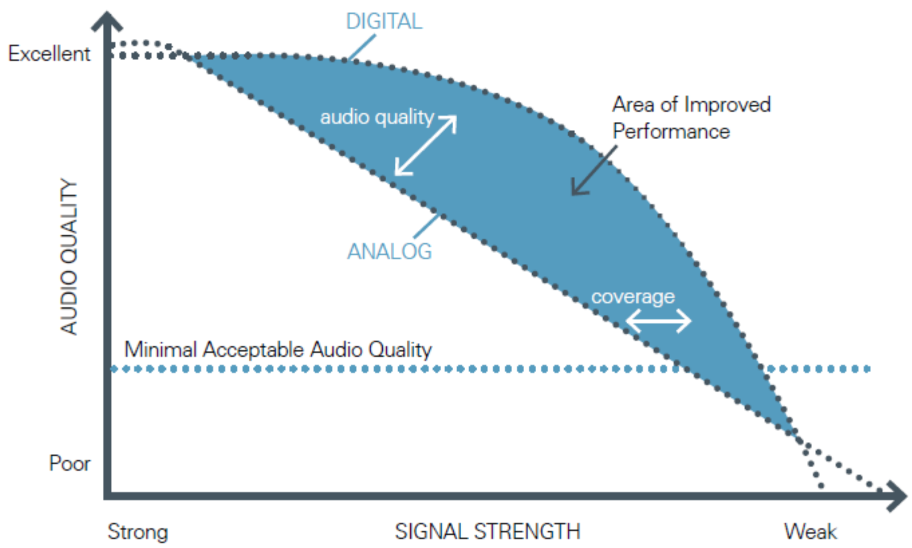

Figure 24: Coverage Performance between Analogue and Digital

One caveat applying to the general statement that digital voice is superior to analogue relates to the use of wide band channels (25kHz) where analogue might be superior in environments with high noise levels. This is background noise can cause distortions in the vocoder (used in digital radios to compress human speech) output. This was the conclusion of 'The Phoenix Fire

Department' after its own testing where it decided to use analogue simplex communications at the fire scene. (ref http://www.ci.phoenix.az.us/FIRE/radioreport.pdf.)

2. Static and noise rejection

Along with the decreasing SNR increasing the static in analogue signals, there are other sources of static which can degrade voice quality in difficult environments. By contrast, digital receivers simply reject anything they interpret as an error resulting in either a brief dropout or bursts of sound which is generally more acceptable than persistent static. Moreover, some digital systems incorporate background noise suppression at the transmitter so background crowd or traffic noise is never transmitted and therefore never heard at the receiver.

3. Encryption

Digital encryption has no effect on voice quality; Analogue scrambling or encryption techniques can degrade it which becomes more noticeable at the edge of coverage.

4. Battery Life

Depending on the device design, digital systems can also improve field operations through longer battery life and additional features. For example, TDMA based systems that provide 6.25 kHz equivalency in a 12.5 kHz channel use only half their transmit time to carry a single half-duplex conversation. Since transmitting RF signals is very power-intensive, this means digital systems place less drain on the battery than their analogue counterparts. TDMA-based digital radios function about 40 percent longer on a battery charge than analogue systems.

5. Spectral Efficiency

For digital LMR systems using either FDMA or TDMA, the same bandwidth (12.5 kHz) that is used to carry one analogue channel can be used to carry instead two digital channels. The two-for-one channel advantage can be used to carry a second conversation, to provide dispatch data in parallel with verbal instructions, to enable enhanced call-control and emergency pre-emption, and for a variety of other existing and future applications.

6. Data over LMR

Both Analogue and digital radio can transfer either voice or data however data is generally not defined in analogue standards leading to proprietary implementations.

Digital systems typically use data rates from 1k2-19k2 bits per second and have the same capabilities to carry data as found in Internet Protocol provided this is done within the bandwidth and protocol constraints of the system. Because of the limited bandwidth available IP data may

have to be compressed and applications designed to minimise the amount of data they need to send

Although LMR networks have primarily provided voice call services, the importance of data is likely to increase. Networks can have dedicated data channels or dual-purpose channels that can handle voice and data, generally giving voice the priority. They are well-suited to provide low-bandwidth data services and to integrate them with voice. Data services can be used by applications such as the following:

- Vehicle location and tracking
- Real time passenger information
- Work force management database access and updates (form based data terminal usage)
- Interactive data messaging (status and text messages).
- Vehicle telematics
- Some simple forms of SCADA (supervisory control and data acquisition)
- Fixed sign updates

The raw data rate of many LMR/LMR standards is 9k6 bit/s, which, after providing forward error correction, slot formatting, headers, and framing, leaves approximately 2k – 6k bit/s for the data application. Unlike voice, data cannot have any errors and may have to be re-sent, reducing the throughput. Hence the coverage for data applications is likely to be less than for voice.

Appendix I: Digital LMR Technologies

(see reference 10)

1. TETRA

Full European Telecommunication Standard status was obtained in 1995. TETRA provides a full set of standards for air and line interfaces. It is established as the default standard for public safety networks in the UK and in Europe. Two years ago the intellectual property hurdles were removed for the United States and TETRA is now aiming to enter the market.

ETSI envisaged networks provided by national organizations, with nationwide coverage, operating usually in urban environments. Consequently, TETRA is more like a cellular telephone system than other professional or land mobile radio standards, and is suited to areas with high volumes of radio traffic. It relies on high user numbers to share the infrastructure cost. Most of TETRA's differences in features from other standards arise from this different purpose.

TETRA does not define an analogue mode of operation. There is no migration path from legacy analogue networks. Operation is trunked; there is also no conventional mode. Initially, TETRA had no direct mode but this has since been rectified, with a number of direct mode options.

TETRA equipment is generally comprehensively tested for interoperability.

2. APCO Project 25 (P25)

APCO Project 25 is an open standard initiated by the USA Association of Public Safety Communications Officials (APCO) and developed by the Telecommunications Industry Association (TIA). It has had strong end user input and although it is United States-based and primarily oriented towards public safety requirements, many countries outside the United States and commercial organisations use it.

Non-proprietary open standard since one of the important aims in developing the standard was to ensure interoperability between different agencies at an emergency scene, as proprietary systems had prevented this in the past.

Very secure end-to-end encryption complies with the USA Homeland Security requirements.

Conventional, trunked, and simulcast options. Combinations of these options can be optimised to reflect customer requirements i.e. trunked in high-density urban areas and conventional in rural areas and supports simplex mode for direct communications outside network coverage.

The standard initially only defined the air interface, but has evolved to cover dispatch interfaces and other interfaces between trunking subsystems, allowing networks from different vendors to be interconnected.

Designed for gradual, phased migration from analogue LMR(FM). Equipment can operate in analogue LMR mode, digital P25 mode, or in dual mode but trunked P25 networks cannot offer analogue LMR services

P25 mandates two 'phases', in the migration.

- Phase 1 uses 12.5kHz for a single digital channel which it means it is compatible with existing narrowband FM systems.
- Phase 2 uses 2-slotTDMA to fit two voice channels into a 12.5kHz radio channel to achieve 6.25kHz channel equivalence

P25 Phase 2 radio standard will be backwards compatible with P25 Phase 1.

3. DMR

There are several levels of the DMR standard (TS 102 361). DMR is divided into three tiers.

- Tier I: Unlicensed – DMR equipment having an integral antenna and working in direct mode (communication without infrastructure).
- Tier II: Licensed, conventional – DMR systems operating under individual spectrum licences working in direct mode or using a base station (BS) as a repeater.
- Tier III: Licensed, trunked – DMR trunking systems under individual spectrum licences operating with a controller function that automatically regulates the communications.

All DMR tiers have a channel bandwidth of 12.5kHz, and two-slot time-division multiple access (TDMA) is used. This means the DMR standard meets the requirement of a 6.25kHz equivalent spectrum usage, which is the narrowband requirement for digital in many countries including NZ.

The standard has been published by ETSI since 2005, and is a mature standard.

DMR already supports direct mode, but it is not as spectrum efficient as it could be. Proposals to enhance direct mode are now being discussed in ETSI TG DMR. At the moment security implementations are proprietary, but proposals on making one proprietary solution available for general use have been agreed.

4. dPMR

The characteristics of dPMR are very similar to DMR, but with some important differences. The modulation is different, and modes replace tiers. The modes are:

- Unlicensed peer-to-peer, Conventional, Low power (500mW) radios with integral antenna.
- Mode 1 Licensed peer-to peer, Conventional Peer-to-peer (direct mode) operation without BSs or infrastructure

- Mode 2: Licensed, Conventional Repeater dPMR systems incorporating one or more BSs for repeating or providing system gateways
- Mode 3: Licensed, Trunking, dPMR systems operating under a managed access mode in systems incorporating one or more BSs.

All modes have a channel bandwidth of 6.25kHz, and uses FDMA to fit two channels within a 12.5kHz channel and hence meets the requirement for narrowband digital in many countries including NZ.

The dPMR standard is newer than DMR and was only published by ETSI in 2009.

5. NXDN

NXDN is an ‘open proprietary’ air interface protocol drafted by Icom and Kenwood and available to members of the NXDN Forum. It uses the same modulation, same channel bandwidth and same codec as dPMR, but is not interoperable with dPMR.

NXDN supports peer-to-peer operation and conventional repeater, as well as two trunking protocols:

- Original ‘Type C’ based on dedicated control channel logic architecture
- New alternative ‘Type D’ protocol based on a distributed control channel architecture.

It is likely that suppliers will support one protocol or the other, not both.

6. 12.5kHz TDMA or 6.25kHz FDMA?

There are two candidate technologies for increasing the capacity of existing 12.5 kHz channels: two-slot 12.5 kHz Time-Division Multiple Access (12.5kHz TDMA) or 6.25kHz Frequency-Division Multiple Access (6.25kHz FDMA). Both methods meet the requirements for greater spectral efficiency compared with analogue i.e. fitting two voice channels into a 12.5kHz channel instead of one with analogue.

- FDMA divides the available bandwidth into separate RF frequency channels, as shown below and one user occupies one frequency (1 voice path per channel).
- TDMA divides a RF frequency channel into number of repeating time slots as shown below and one user occupies one timeslot. A timeslot is in effect a virtual channel. As TDMA frequency channel can only provide two channels, FDMA has to be used to provide additional radio channels.

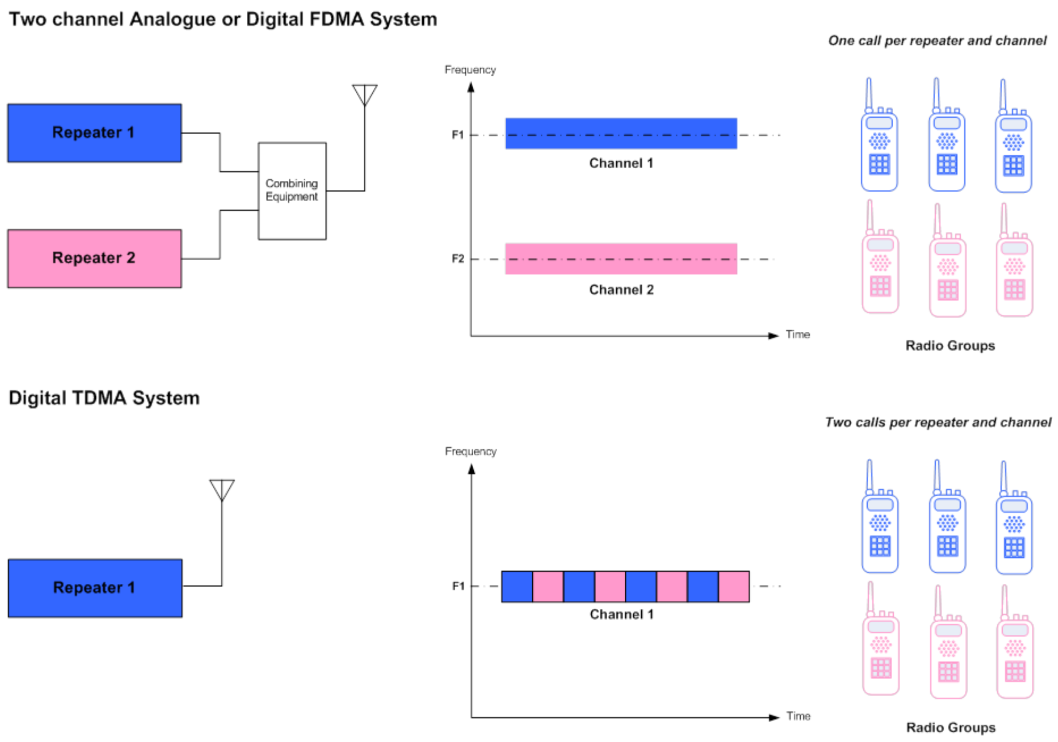

Figure 25: FDMA and TDMA

The choice between FDMA and TDMA has been controversial, prompting debates within standards bodies particularly between DMR (TDMA) and dPMR (FDMA). TDMA is well established, having been used in GSM and TETRA installations for many years, while FDMA for 6.25 kHz is new. Fears that using FDMA with this narrow bandwidth would be technically too difficult have not been substantiated.

Advantage of TDMA over FDMA

- Ease of migration as existing analogue 12.5kHz channel can be retained along with existing combining equipment. For FDMA two new radio channels will be required along with new combining equipment increasing cost.
- For TDMA the wider channel bandwidth compared with FDMA results in a more relaxed specification for transmitter adjacent noise performance and frequency accuracy more akin to analogue LMR. It is also less sensitive to carrier frequencies caused by Doppler Shift when users are travelling at speed.
- Compared with an analogue LMR a 2-slot TDMA radio using one timeslot is only transmitting for half the time. For portable radios, this dramatically reduces battery power consumption, as transmitting is a very power-intensive activity. In a standard operating pattern, (5% transmitting, 5% receiving, and 90% standby), power consumption is reduced by around 40%, greatly extending the battery charge duration and increasing talk time.

When compared with FDMA this less of an advantage since the transmit power of a FDMA radio can be reduced (reducing power consumption) and still obtain the same signal to-noise ratio as the equivalent DMR radio because the modulation bandwidth is less than TDMA. The difference in transmit power is less than the 3dB expected given a FDMA channel is half the width of TDMA because FDMA cannot compress the voice signal as efficiently into the narrower bandwidth.

- Opportunity for reverse channel signalling on the same channel (different timeslot) i.e. from receiving equipment to the sending equipment when it is transmitting. Reverse channel signalling can for example can tell a transmitting radio to stop because an emergency call is waiting, or to inform it of its signal strength so that it can turn its transmit power down or up accordingly.

Disadvantages of TDMA compared with FDMA

- Multipath interference may affect call quality. For the same basic receiver design, TDMA cannot handle as much multipath as FDMA where there is more than one ‘propagation’ path between the transmitter and receiver. This can cause the received signal to be artificially strengthened or weakened.
- Direct mode (simplex) is not as spectrum-efficient. In some cases, radios may use both timeslots.

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7. Summary of Digital LMR Standards

(see reference 10)

	Standard	Business Targeted[1]	Network Size	Analogue or Digital?	C or T[2]?	Modulation	TDMA/FDMA	Vocoder	Vendor: System Name[3]
Conventional Analogue	Yes		Local, Regional	Analogue	C	FM			All
NXDN	No	C	Local, Regional	Digital	C	4FSK	FDMA	AMBE + 2	Icom: IDAS, Kenwood: Nexedge
DMR Tier II	Yes, ETSI	C	Local, Regional	Digital	C	4FSK	TDMA 2 slots	AMBE + 2	Motorola: Mototrbo, Selex: ECOS, Radio Activity
DMR Tier III	Yes, ETSI	B, C	Local, Regional	Digital	T	4FSK	TDMA 2 slots	AMBE + 2	Tait: TaitNet
MPT 1327	Yes (British)	B, C	Nationwide	Digital signalling, Analogue voice	T	FM			Tait, Fylde, Motorola, Simoco
OpenSky	No	A, B	Regional, Nationwide	Digital		4-GFSK	TDMA 4 slots	AMBE	Harris (formerly M/A-COM, Tyco
P25 Conventional Phase 1	Yes, TIA	A	Regional	Digital	C	C4FM	FDMA 12.5 kHz	IMBE or AMBE + 2	Motorola: Smartzone P25, Tait: TaitNet, Harris, Simoco, EF Johnson, Daniels Electronics, Raytheon
P25 Trunking Phase 1	Yes, TIA	A, B	Regional, Nationwide (ISSI)	Digital	T	C4FM	FDMA 12.5 kHz	IMBE or AMBE + 2	Motorola, Tait, Harris, Spectra Engineering, Simoco, Daniels Electronics, EF Johnson, Raytheon, EADS, Teltronic
P25 Phase 2	Yes, TIA	A, B	Regional, Nationwide (ISSI)	Digital	C or T	CQPSK	FDMA 12.5 kHz (backward compatible) and TDMA 2 slots		We expect that Phase 1 providers will develop Phase 2 product.
TETRA	Yes, ETSI	A, B	Nationwide	Digital	T	π/4-QDPSK	TDMA 4 slots	ACELP	Motorola, EADS, Teltronic, Rohill, Rhode & Schwarz and more
TETRAPOL	No	A	Nationwide	Digital	T	GMSK	FDMA 12.5 kHz	CELP	EADS

Notes:

1. A = Public Safety or Mission Critical
   B = Critical Infrastructure
   C = Professional or Business
2. C = Conventional, T = Trunking
3. Examples only: list not exhaustive

Standard	Conventional	Trunked
DMR	Yes (Tier 2)	Yes (Tier 3)
dPMR	Yes (Mode 2)	Yes (Mode 3)
APCO P25 Phase 1	Yes	Yes
AP CO P25 Phase 2	No (will be developed)	Yes
TETRA	No	Yes
NXDN	Yes	Yes

Appendix J: LMR vs Cellular

An important question facing potential LMR users is which option will provide them with the most efficient service: providing the service themselves with LMR using a PAMR provider, or using a standard cellular service provider.

1. Advantages of LMR over Cellular

A two-way radio is typically equipped with a “Push-To-Talk” PTT button to activate the transmitter. User just simply presses the PTT button and can immediately start to talk. User releases the PTT button to listen to others. The key characteristics of this feature are as follows:

- Speed Sub-one-second call set-up (the time it takes for the first volley) and sub-second latency (the time it takes for users to volley back and forth). This key reason why many organisations rely on two-way radio for their tactical or operational communications. If you are using a cellular phone, for example, you need to dial a number, wait for a while when the call is being set-up and connected, ring at the other side and finally answered. This process can take a few seconds and during that valuable time an emergency situation can become worse.
- Simplicity Easy to understand, access and use, as simple as pushing a button to initiate a call. The signal is broadcast to all users within range - anyone with a radio switched on can hear messages, hands free, together with everyone else on the frequency.
- Call Burst Less than a minute in talk time on average, allowing users to 'get things done' quickly without taking the time that is common for typical phone calls
- Group communication (Group Calls) : Another distinct feature of two-way radio is its capability to facilitate “one-to-many” group communication (also known as "group call") very efficiently. By efficient means that one user can talk to one, five, tens, hundreds, thousands of users at the same time. Users don’t need to repeat the same message over and over again if he/she needs to convey to more than one user. In addition, two-way radio performs the group communication using minimum RF channel resources. If all of users reside in the same area, most of the time, you only need one channel resources to talk to these hundreds of users.
  Compare this with cellular network with inefficiencies of scheduling calls, reserving conference bridges, and waiting for participants to join.

Other reasons why LMR have advantages over traditional cellular are:

- Security and specialized dispatching services
- Adequate coverage

- To reduce cost. The costs of two-way radio are fixed. There are generally no on-going line rental charges or airtime costs, users communicate free of charge within the range of the radio.
- To provide supplementary services
- Rugged PTT handsets built with military-grade specifications to ensure durability, coupled with special accessories for ease of operation (e.g., a wireless speaker microphone).

However with the development of good public cellular radio networks the traditional advantages of LMR are challenged. In particular:

- Coverage in cellular system is improving to the point where it can equal and for many users exceed the dedicated coverage provided by LMR.
- The cost of public cellular operation is reducing as well. While LMR is cheaper for large numbers of users or for operations in limited areas the balance is swinging against LMR.
- In the past, LMR handsets operated over a limited range of frequencies perhaps with manual frequency selection, and with very simple call control. This made them far less complex than cellular handsets. The cost advantage is being lost as LMR handsets become more complex with the move to digital and the drive to increase flexibility, capacity and security.
- The relative site of the LMR marketplace means cellular users have the advantages of economies of scale.

It is these factors that have lead some commercial organisations to switch from LMR to Cellular but for many others, particularly emergency services, Cellular is problematic unless it can meet the following public safety communication requirements:

1. Reliability functioning satisfactorily over long periods
2. Resilience functioning satisfactorily under adverse circumstances
3. Push-to-talk / group call with low call setup time
4. Direct communication between terminals
5. Off-network communication (direct mode)

2. Cellular for Emergency Services: LTE

(see reference 1 and 5)

To address the needs for Public Safety, work is underway in Release 12 of 3GPP LTE standards to enhance LTE to address this application in the two following areas:

- Proximity services that identify mobiles in physical proximity and enable optimized communications between them.
- Group call system enablers that support the fundamental requirement for efficient and dynamic group communications operations such as one-to-many calling and dispatcher working.

Associated with these areas will be security features to protect the system from fraudulent users, eavesdropping and other malicious attacks.

Proximity services (ProSE)

Proximity services consists of two main elements: network assisted discovery of users with a desire to communicate who are in close physical proximity and the facilitation of direct communication between such users with, or without, supervision/transiting from the network. This is designed to support the following public safety requirements:

- Off-network operation
- Operation outside network coverage
- Resilience against power outages or major disasters in which network infrastructure is destroyed
- Additional secrecy for covert operations
- Network to terminal relay
- Extending coverage of network infrastructure

The definition of proximity services includes some features that are exclusively for public safety applications in public safety spectrum. In the feature "User equipment to network relay" one mobile acts as a relay for another and provides access to network services outside the normal network coverage area. In the feature "User equipment to user equipment relay" one mobile act’s as a relay point between two others and allows communication to take place without going via the network even if the communicating mobiles are out of range for direct communication.

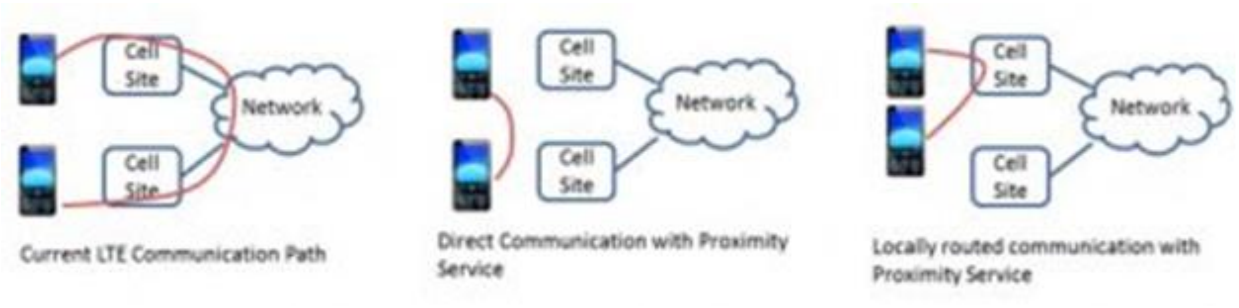

Figure 26: Proximity Service Examples

In the commercial area proximity services can support features like new modes of social networking, convenient file transfer between devices belonging to the same user and targeted advertising. In the commercial context 3GPP's standards will ensure that use of licenced spectrum is controllable and billable by the network operator.

Group Call (GCSE_LTE)

Public safety users frequently need to communicate in dynamic groups that might involve both mobile users on the scene and fixed users ("dispatchers") working in a control centre. Often these groups operate in a "push to talk" mode. Work on LTE group call system enablers will optimize support in LTE for this mode of operation and provide appropriate group management and floor control facilities. Commercial users of group calling include critical communications applications such as operational teams in transport hubs. Improved support for group calling in LTE will expand the opportunity for commercial cellular networks to address this market.

3. Progress

As from mid 2014 the above enhancements to LTE are expected to be available in LTE Release 12 and commercial implementation not until late 2015 as implementations generally lag the Release by a year.

Work is still on going to identify and prioritize other enhancements needed for LTE. Both commercial cellular and public safety systems need to be able to survive network equipment failures and overload situations but the requirements for public safety are more rigorous. In June 2013 3GPP agreed to study how to enhance the resilience of LTE networks for public safety applications.

4. Push to Talk over Cellular (PoC)

(see reference 3)

Push to Talk over Cellular (PoC) is a service that allows subscribers using a commercial cellular network to turn their handset into a walkie-talkie but without the range limitation and high cost

of LMR systems. PoC has been available since 2G(GSM) but it only with 3G/4G that it has been seen as viable alternative to the same service over LMR (PTT).

In 2005, the Open Mobile Alliance (OMA) first defined PoC as part of the IP Multimedia Subsystem and developed the first OMA PoC standard. In 2011, OMA approved PoC v.2.0 as a new standard to take advantage of LTE to provide high performance of IP-based P0C. The goal of OMA-PoC is to provide interoperability among equipment and software manufacturers and avoid market fragmentation by developing the PoC service in a widely standardised manner.

PoC provide the following advantages over LMR:

- Cost savings: Instead of purchasing expensive LMR radios, which typically run between $2000 apiece, organisations can simply add PTT service to an existing cell phone plan at a low incremental cost per user per month.
- Convenience: A mobile worker can carry just one mobile device (a PTT-enabled smartphone or tablet that supports both instant voice communication and data applications).
- Advanced data capabilities: Commercial cellular networks using 3G/4G technologies provide hundreds of times more data capacity than current LMR systems.
- PoC platform supports interoperability with existing LMR networks. A PoC enable cellphone can be used to communicate with LMR radios.

Though the current version of PoC is considered suitable for commercial applications there are reservations regarding it use for emergency services. Hence 3GPP who are working to enhance LTE to meet public safety application requirements are also collaborating with the Open Mobile Alliance (OMA) to define service requirements for push-to-talk functionality over LTE suitable for critical communication use; “Mission Critical Push-To-Talk over LTE” (MCPTT).

6. Cellular Network Resilience and Quality of Service (QOS) Considerations

(see references 2 & 4)

When emergency situations like natural disasters or terrorist attacks happen, demand in telecommunication networks goes up drastically, causing congestion in the networks. This was the experience during recent disasters and terrorist attacks e.g.

- Christchurch Earthquake (Feb 2011).
- Tornado that struck Joplin, Missouri (May 2011) where the cellular systems in that area were off line for up to four days.
- During the 2011 riots and the London bombings in 2005, mobile services across the capital collapsed under the sheer weight of traffic.
- Boston Marathon bombing (April 2013) where commercial networks were unavailable for voice calls because they were overloaded.

If emergency services were reliant on the cellular networks during these disasters then their response would be severely handicapped.

To address this concern and support emergency services (ES) in public cellular networks, ES users need to be identified to provide better guaranteed services including both high admission probability and quicker access than general customers. This can done by using special admission control policies based on access codes presented by ES users at a the base station.

However providing this guaranteed access creates a problem for public cellular networks where its main purpose is providing services for public customers. For these networks to be commercially viable there is trade-off between the costs of providing the necessary infrastructure and passing those costs onto the users. If ES traffic is light, low blocking probability for public use should be guaranteed but if ES traffic becomes unexpectedly heavy then public traffic should be protected through guaranteeing a certain amount of resources for public use. This trade-off in turn could potentially constrain the network in providing the guaranteed service needed by ES,

These admission policies arising from the above considerations may not be deemed to be sufficient by ES users to shift from LMR to cellular as the prime communications network. Therefore in a number of countries e.g. USA and Australia frequency 4G spectrum is being reserved for ES private cellular networks. This spectrum is limited and the cost these networks are high relative to the organisations involved and hence ways of sharing resources between Public and ES cellular networks are being considered (e.g. Australia).

The key principle involved is parallel operation of a public LTE network and an ES network on a common physical infrastructure where the costs of providing network hardening and resiliency

is shared. Capabilities can also be enhanced through different levels of prioritised access for voice and data. This approach can be likened to a motorway with a multi-lane thoroughfare for the majority of traffic (the commercial network) and an additional or reserved transit lane for emergency traffic (ES channel). Ultimately the use of QoS to provide ES traffic access to public spectrum can be complemented by also allowing public traffic to have un-prioritised access to the ES spectrum – essentially allow public traffic managed access to the transit lane when not required by the ES users.

Appendix K: References

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