The AREC DMR Network

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Introduction

Thirty years ago, amateur radio operators in Auckland and Wellington worked together to install a Wellington to Auckland link in the 70cm band. Later known as the National System, the network now covers New Zealand from the Bay of Islands down to Balclutha with 28 connected repeater stations operating independently of telco infrastructure.

While still an invaluable AREC resource, the National System is an analog network using 20th century technology. The Internet has driven an increased demand for networked applications, increased availability of communications, and created expectations for services such as digital messaging, GPS location, and potential applications such as job ticketing where tasks can be presented directly on radio screens.

Overview

AREC provides assistance to Police and the Rescue Coordination Centre under a formal Service Level Agreement (SLA) set in place by the New Zealand Search and Rescue (NZSAR) Council [1]. NZSAR provides some funding to AREC to cover various costs and to encourage acquisition of technology appropriate to the AREC mission. NZSAR also funds other volunteer SAR organisations such as LandSAR [2].

One challenge presented by our SLA partners is to move the communications resources available to AREC into the 21st century with the development of an all-digital radio network to meet the needs of AREC and SAR partners. A trial system was established in Wellington for testing before a gradual roll out to other centres, as funds permitted. The AREC network is called the ZL-TRBO DMR network.

Technology

Choosing the right technology has not been an easy task. On one hand, AREC are well aware of the APCO P25 standard development in the whole of government space and used by Police in the three main centres, on the other hand amateurs have their own D-STAR™ standard. Icom New Zealand is of course a stalwart supporter of NZART, DSTAR equipment provided by that company along with homemade adapters are popular and used by amateurs around the world. However, a new AREC network would need to be adaptable, supporting AREC in amateur frequency allocations as well as supporting non-amateur SAR volunteers using commercial frequencies and type-approved equipment. It would also be difficult to justify to our funding agency the purchase of equipment available only from a single vendor.

For these reasons and after much discussion the AREC Management team decided to build a network based on the ETSI DMR digital mobile radio standard. DMR equipment is available from Harris, Hytera, Kenwood, Kirisun, Motorola, Puxing, Selex, Sepura, Simoco, Tait, Yaesu Vertex, and various other vendors. Icom is a member of the DMR Association but does not market equipment.

So let's review the technical choices P25, DSTAR, and DMR.

APCO P25 was one of the oldest digital radio standards considered for the new network. A pre-standard system known as ASTRO™ was developed by Motorola using an air interface 9600 bps 4FSK fitting within a 12.5 kHz for use by police in the USA. It was based on experience with analog trunking systems and used the then state-of-the art VSELP[3] audio to digital encoding/decoder (codec). It was first tested in NZ by amateurs John ZL2TRV (now ZL4JY) and Peter ZL2ARW through the Belmont 710 repeater in 1995. Later the US Association of Police Communications Officers (APCO) started working with Motorola and the TIA (Telecommunications Industry Association) on an open version of the system with a common multi-vendor air interface standard and a much improved IMBE [4] vocoder. P25 is widely used in the public safety area and is well supported by with more than two dozen manufacturers. Again, amateurs in Wellington were testing the standard in 1997 and continue to make limited use of P25 mainly at VHF but this activity is not directly related to AREC.

The original development of **DSTAR** (digital smart technologies for amateur radio) occurred just before the turn of the century with the first equipment becoming available from Icom in 2004 [5]. New Zealand DSTAR activity was well underway by 2009 in Auckland. Further south in the Waikato Brian ZL1HN had a homebrew repeater operational in 2010. DSTAR has been quite well covered in recent *Break-In* articles and Upper Hutt Branch 63 have been partcialury noteworthy since 2011 for both promotion and deployment of the mode. Like P25, DSTAR is a FDMA system, one voice conversation is carried on each RF carrier. The AMBE [4] codec is used with two level GMSK RF modulation with an occupied bandwidth of around 8 kHz (implementation dependent). Unlike the other standards discussed here, DSTAR has specific provision for embedding individual amateur and repeater callsigns within the radio frame header.

The **DMR** standard is a tightly defined European Standards Institute (ETSI) standard first published in 2005 and made popular originally by Motorola and now supported by more than a dozen manufacturers [6]. Originally aimed at high end commercial users, DMR is a two slot TDMA standard that allows one RF carrier (or repeater) to support two simultaneous conversations. This saves on antennas, duplexers, and other necessary repeater equipment. The AMBE2+ codec is used and the RF modulation is four level FSK fitting within a 12.5 kHz channel. All equipment has basic compatibility and DMR, like DSTAR, is particularly suitable for networking. An early amateur DMR network was established by amateur radio clubs in Germany and the USA with New Zealand joining on August 23, 2011 connecting to the K9MOT repeater in the USA. At that time DMR was a curiosity and the DMR equipment in use was owned or borrowed by individual amateurs.

Networking

For an effective wide area radio network covering a county like New Zealand, it is necessary to consider both the ease of linking as well as the range of radio vendors. Amateurs often link P25, DMR, and D-STAR networks over the Internet for temporary events [7].

The AREC network operates in the 70cm UHF amateur band and is available to all amateurs. A small number of VHF repeaters are also included but operate on dedicated commercial frequencies reserved for SAR use. Conversations between the repeaters in the amateur band and those on the SAR frequencies is not enabled but some of the infrastructure costs are shared. Wide area linking of the present DMR network is mainly occurring using telco provided Internet (cable, fibre, and temporary connections via cellular) but a small number of 5.8 GHz microwave links are also being employed. It is hoped to gradually extend the direct linking to reduce reliance on telco services to improve resilience. One lesson from both the tragic Christchurch earthquake in 2011 and from the North Canterbury earthquake last year was that while these were major disasters they were local in scope. Communications systems within the immediate area, such as cellular, were affected but services such

as the Internet and other telco infrastructure in the reminder of the country continued to function normally.

The network makes extensive use of peer-to-peer connections between local repeaters and regional master repeaters with a central server computer bridge used to interconnect the masters. The advantage of peer-to-peer method is that if a master or the bridge fails, the remining peers will still have connectivity. The purpose of the bridge is to maintain connections between the masters and to connect the masters to the international DMR MARC and DMRplus networks.

Repeater Sites

The following repeater sites are operational at the start of 2017:

ZL1BQ Auckland 439.7000 MHz
ZL1UX Hamilton 439.7250 MHz
ZL1TEC Tauranga 439.7500 (connectivity limited with 3G connection)
ZL2DMR Porirua 439.7500 MHz
ZL2OA Wairarapa 433.8250 MHz
ZL2KO Manawatu 439.7125 MHz
ZL2KB Kapiti 439.7000 MHz
ZL2WA Wellington 439.7250 MHz
ZL2GK Tasman 439.6875 MHz (some connectivity issues)
ZL3DMR Christchurch 439.7000 MHz
ZL4AA Dunedin 439.7000 MHz
ZL1DMR STSP is testing in Warkworth 438.7500 MHz

ZL4AA DMR Repeater

Stewart ZL4DC and Bede ZLKX wrestle the duplexer

The sites have generally been chosen to provide solid handheld coverage within the area of the repeater's name. All repeaters are set to operate with 20W output and beacon every two minutes to allow for advanced radios to find the nearest available site. A suitably equipped mobile can travel from the Manawatu through Wellington to the Wairarapa without having to change channels.

Operation

The provision of two TDMA timeslots in the DMR standard allows the network to support international connections on timeslot 1 with local conversations carried on timeslot 2. When an AREC need arises timeslot 1 can be pre-empted for dedicated AREC use. In a major emergency event both timeslots can be used for AREC traffic, just as with the existing analog amateur networks. The type of QSO is identified by talkgroup and the users are also identified by means of a single world-wide amateur ID system used for P25, DMR, and some DSTAR applications.

Talkgroup Information

There are a number of talkgroups carried on the ZL-TRBO DMR network. The talkgroups are coded as numbers but referred to by name. They are:

ZL (TG530) is a nationwide talkgroup carried on all ZL-TRBO DMR repeaters. This is the primary New Zealand wide talkgroup.

ZK (TG8) is a second nationwide talkgroup carried on all ZL-TRBO DMR repeaters. It differs from ZL in that it is carried in timeslot 1 not timeslot 2, thus ZL and ZK can be in use simultaneously. It is intended primarily for wide area AREC use but is available for general use if TS1 is not busy. In an emergency overseas talkgroups may be removed from timeslot 1 to allow unimpeded use of the ZK talkgroup.

LCL (TG9) is carried only on a master repeater and its immediate peers. Currently there are only ZL2DMR Central and ZL3DMR Midland area masters, so LCL covers the South Island or North Island depending on your home repeater. In the longer term the North Island may split in to upper and lower north as the network grows.

WW (TG1) is the original World Wide talkgroup, primary language is English but you will hear contacts in other languages. It is should now only be used as a calling channel.

WWE (TG13) is the World Wide English language talkgroup. This is the preferred talkgroup for international contacts.

UAE1 (TG113) and UAE2 (TG123) are the so called 'user access' talkgroups. These are intended as overflow groups for WWE. They differ in that use of WWE keys up over a thousand repeaters worldwide and ties up the timeslot that it is carried in for the duration of the contact on all those repeaters. On the other hand UAE1 and UAE2 only key up the local repeaters at each end of the contact and free up the timeslot on the rest of the network. The idea is that you would make contact on WWE then change to UAE1 or UAE2 if you are going to have a long QSO. UAE1 and UAE2 are intended for English language contacts.

UAA1 (TG119) and UAA2 (TG129) are the equivalent user access groups for WW, QSOs in any language can occur in these groups.

DMRplus US (TG133)

DMRplus UK (TG143)

DMRplus South Pacific (TG153)

The above DMRplus groups are being carried on a trial basis. The DMRplus network supports a wider range of connected devices for experimenters.

Radios

One of the nice things about DMR is there is a radio price point for every budget. From second hand TradeMe deals to brand new top tier commercial radios, there is no shortage of choice. Some top of the line Japanese radios offer up to four RF bands and both P25 and DMR digital modes as well as legacy analog operation. Radios made in China are particularly popular with amateurs. Because DMR radio can be a little complex to initially program a range of ready-made codeplugs are available for download [8].

AREC and LandSAR DMR radios

LandSAR have more than 400 VHF New Zealand made Tait TP8100 portable analog radios. AREC sections have a mix of Tait and Icom analog radios. With the work being done on the DMR network AREC have been helping the most active AREC sections with new TP9300 dual mode analog and DMR radios. Tait has generously supported the AREC DMR initiative and deserve considerable thanks.

These radios are type approved to allow use on the commercial and government frequencies used for SAR. The LandSAR/AREC TP8100 radios, the AREC TP9300 radios, and Police SAR squad P25 TP9400 share the same battery, antenna, and accessories greatly simplifying logistics during operations. Cooperation on colour choice has largely resulted in LandSAR choosing orange for their VHF radios, AREC red for VHF and lime green for UHF, Police use black for theirs, and recently the New Zealand Fire Service have chosen yellow for dual band and lime green for UHF. This year LandSAR will start buying the TP9300 radios for their groups.

One issue that has been extensive tested by AREC is the newly developed VHF antenna seen on the new Tait DMR radios. SAR operations use frequencies ranging from 136 MHz below the amateur 2m band, through the marine band at 156 MHz, up to the EE band at 169 MHz. Conventional short helical antennas are very inefficient but the longer style shown provides a much more efficient solution and will be used on all new radios. A follow up article will explore less technical aspects of the AREC ZL-TRBO DMR network.

References

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