The Australian Manager’s Guide to Digital Two-Way Radio

A WHITEPAPER FROM AA RADIO SERVICES PTY LTD
ABOUT THE AUTHOR

Dan Quagliani has been involved in the Australian Radio Communications Industry for over thirty years. He began his career as a two-way radio technician in 1978 and has since held roles in senior technical, supervisory, sales, program/product management and consultancy. His experience in technologies includes analogue two-way radio, mobile data, P25/TETRA/dPMR/IDAS, Industrial 802.11, AVL, Scada/Telemetry and Microwave. Dan is currently a director at AA Radio within their Systems and Projects Division.

ABOUT AA RADIO SERVICES

AA Radio is a two-way radio solution provider headquartered in Melbourne, Australia. Formed in 1968, AA Radio has evolved from its primary focus of radio sites and repairs, to a full-capability solutions provider.

The company provides sales, repair, system engineering, consultancy and project management for two way and related wireless systems. AA Radio has a long history of providing best in class solutions to meet customer needs and is respected by both the industry and its customers.

ABBREVIATIONS & TERMINOLOGY

The following abbreviations and terminology are used in this paper:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tr>
<td>FDMA</td>
<td>Frequency Division Multiple Access. A channel access method using one or more radio channels directly.</td>
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<tr>
<td>TDMA</td>
<td>Time Division Multiple Access. A channel access method using one or more radio channels divided into time slots.</td>
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<tr>
<td>P25 Phase 1</td>
<td>Abbreviation for APCO P25 digital two-way radio standard using FDMA channels access. Can be trunked or conventional. Used mainly for Mission Critical applications.</td>
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<tr>
<td>P25 Phase 2</td>
<td>Two-slot TDMA based version of P25 Phase 1, trunked.</td>
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<tr>
<td>Conventional</td>
<td>Straight use of a radio channel without any switching</td>
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<tr>
<td>Trunking</td>
<td>The sharing of multiple conventional channels to support a network of multiple users and talk groups.</td>
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INTRODUCTION

Two-way radio is a essential tool that has been used by Industry, Government and Communities for over ninety years. The technology has united our remote communities, made our lives safer, our Government Agencies more effective, and our Industries more productive.

With analogue radio now being modernized by the digital revolution, the choice of technology has never been more confusing. There is a wide variety of options and functionality, backed up by intensive marketing and sometimes outlandish claims from vendors that at times can seem daunting to people who do not come from a radio communications background.

Historically two-way radio has been the domain of an in-house expert or even a specific department in larger organizations. These were usually radio technicians or engineers who had a strong technical knowledge and industry experience. The choice of radio technology would involve extensive research and in-situ testing before a final selection of vendor and technology solution was made.

In modern times the picture is less clear. Often responsibility for two way radio now rests in the domain of the IT department, where detailed knowledge of the technology is not as strong as that of “Mainstream” IT. With the many competing pressures for IT budget and attention, radio sometimes can be relegated or not be given the focus and due diligence it requires.

This then presents a manager with a difficult task when trying to evaluate and select a radio technology platform that will meet or exceed the needs of the organization and have the flexibility to grow and change along with the future evolution of the business.

This paper will attempt to de-mystify some of the issues around the various digital technologies available to the Australian manager.
ADVANTAGES OF DIGITAL RADIO TECHNOLOGY

Digital radio works by encoding the human voice using a device called a vocoder, and turning it into a digital stream of data packets. This voice-coded digital stream is then sent over the radio channel as data and reconstructed at the other end from data back into analogue voice.

The advantages of this approach are many:

- As the entire transmission is data, radio voice is encapsulated into IP packets, which can then be linked together using traditional IT infrastructure and the Internet.
- Interfacing to external data and IT systems is simplified due to the IP structure. Radio systems of disparate frequencies or remotely located from each other can be accessed with a simple Internet connection.
- The vocoding process extracts the human voice from background noise and in fact ignores most non-voice sounds. This means that annoying background noise such as that in the cabin of a truck are virtually eliminated.
- Digital transmissions are clearer in marginal signal areas, providing the illusion that they have more “range” than analogue.
- Digital voice is easy to scramble and encrypt without degrading the voice quality. This makes it an ideal platform for organizations that require security of their voice conversations.
- Digital radio transmissions can be sent over a radio channel with effectively half the bandwidth of an analogue radio channel. This reduces costs for ACMA licensing fees and in the case of TDMA digital radios, reduces complexity of multicoupling and antenna systems.
DISADVANTAGES OF DIGITAL RADIO TECHNOLOGY

As with any technology, there can also be disadvantages that should be considered in any planned migration from an analogue to digital transition.

Many current analogue users claim that digital vocoded voice sounds poor in comparison. Adjectives such as “Mechanical”, “Tinny”, “Robotic” are often used to describe this situation. Users tend to eventually get used to the sound quality, however it needs to be introduced carefully to users of analogue radio to avoid a potential backlash.

In the analogue radio world it is possible to build systems by adding on things such as voice recorders, audio management consoles, mobile data, simulcasting, GPS tracking and so forth. These add-ons are routine and taken for granted when designing an analogue radio solution.

With digital systems however this integration is not so simple. For example, an audio console connection to a trunked analogue radio system is a straightforward and readily available item. To achieve the same functionality in digital, there are different proprietary solutions for DMR, dPMR and TETRA, whilst only very high end consoles currently support the DFSI and CSSI standards needed for P25.

SUMMARY OF DIGITAL PLATFORMS

In order to summarize the most commonly available digital platforms in Australia, we should break them into two categories with the following definitions:

1. MISSION CRITICAL

A Military standard grade of performance and high security is required where lives, property and public safety are at stake. Examples: Police, Fire, Ambulance, Military, Emergency Management.

2. BUSINESS CRITICAL

A grade of service is required to protect Employee Health and Safety, Business Operational Continuity and Efficiency or where significant Commercial Losses are at stake.
1. MISSION CRITICAL

1.1 APCO P25

Often referred to as simply “P25” this is a public safety standard driven from the USA for use primarily by Public Safety agencies. In Australia its use has been mainly in these markets, although there has been some systems also deployed in the Mining and Oil & Gas sectors. The technology is not new, as the standard has evolved over 20 years.

There are two ‘flavours’ of P25, Phase 1 (FDMA) and Phase 2 (TDMA) which is still evolving.

All systems sold in Australia are currently Phase 1. Vendors, in anticipation of a stable standard in the near future, are now releasing “Phase 2 Capable” terminal equipment.

Due to historical ACMA policy, radio spectrum was not widely available for TETRA, so P25 was effectively the first and most widely adopted digital radio technology for Mission Critical Applications, particularly in Government Agencies.

P25 ADVANTAGES

P25 provides excellent performance for voice encryption and security, with voice quality maintained throughout the encryption process. It coexists with current analogue frequencies and radio infrastructure in many cases while providing an “analogue fallback” mode for legacy radios. This makes it an ideal choice for Public Safety, Military and First Responder applications. Organizations such as these who have a large sunk cost in multicoupling, antennas, towers and feeder systems can transition to digital operation with little incremental cost of the need for specialized radio channels.

Because the radio performance is very similar to analogue, P25 also provides excellent coverage limited only by typical RF physics.

P25 DISADVANTAGES

P25 has very specific functionality and limited flexibility compared to analogue. Integration of P25 into third party add-ons such as trunking voice consoles and digital voice recorders is difficult and costly. Simple text messaging between terminals is not part of the Phase 1 standard and some manufacturers have implemented this and GPS reporting in differing proprietary ways.

In trunking, console availability is currently restricted to high end/ high cost units and call set up times can approach one second. P25 hardware and terminals are also very expensive when compared to analogue or Business Critical digital radio.
1.2 TETRA

TETRA is a TDMA trunked digital radio technology that is widely used around the world today. This mature standard was driven by the needs of users in Europe and has evolved since the early nineties. It is very reliable, rich in functionality and very stable in its operation. As well as basic TETRA functionality, there is a suite of additional functionality recently made available in the TETRA Release 2 standard, such as enhanced data speeds. Most manufacturers now ship TETRA 2 capable equipment as part of their standard offering.

With spectrum now being made available for TETRA as part of the 400MHZ re-planning process, there will be many more opportunities for users to adopt this technology in Australia.

TETRA ADVANTAGES

TETRA provides very rich functionality not only as a trunked radio network, but also as a part-time mobile telephone system. The technology supports full duplex phone capability, so that users can “dial” a TETRA radio from their desk or through any telephone and have a normal telephone conversation without having to hit PTT every time a user wishes to speak. At the conclusion of the phone call, the radio reverts to its normal operation as a two-way radio and finds its talk group automatically, even if they are involved in a conversation.

The system also provides a number of advantages for the System Operator and Administrator. Users can be divided up into multiple talk groups with varying degrees of functionality and coverage permissions; which can be assigned independently to certain users or groups of users.

Key up times are excellent with typical delay for a talk group on a single site are around 220mS and calls do not need to be manually terminated when completed. This makes the technology easy and intuitive to operate and is ideal for users who need many talk groups to operate independently and together as required.

TETRA DISADVANTAGES

TETRA mobiles and terminals use a lower transmit power than P25, so slightly more sites are required to achieve the same coverage footprint as an equivalent P25 system. The TETRA signal uses time synchronization, which limits its theoretical maximum coverage range from a site to around 60km.

The systems also require special radio spectrum that is not easily compatible with existing analogue equipment, making slow migration from analogue legacy equipment difficult and in may cases a full replacement is necessary.
2. BUSINESS CRITICAL

2.1 DMR

DMR is one of the newer digital radio technology standards to have recently entered the Australian market. Originally there was virtually only one Vendor, Motorola, who marketed the technology heavily under the “MotoTrbo” brand. This is changing as more vendors announce DMR products. Using TDMA, this technology is often referred to as “TETRA Lite” as it offers a subset of the many features and functions provided by TETRA.

DMR ADVANTAGES

Because of its TDMA architecture, a DMR radio can effectively support two voice conversations over the one 12.5KHz channel, whereas P25 for example can only support one voice conversation. This provides a talk path for many users who have been traditionally limited to only one talk path on one channel. There is also rich functionality in this technology for things such as Radio Stun/Revive and Signalling options.

The TDMA architecture also means that multicoupling for large users is effectively halved which can result in significant cost savings for users who have to pay significant amounts for high-density antenna site fees.

Portable radios in a DMR system will exhibit superior battery life when compared with analogue or FDMA based technologies, around 30% less consumption is claimed by vendors as possible under ideal conditions.

DMR radios coexist well in analogue spectrum, and the use of dual mode (analogue and digital) radios means that graceful migration from old analogue equipment to digital is greatly simplified.

DMR DISADVANTAGES

In Australia there is a very limited choice of terminal vendors. Currently trunking can only be provided by proprietary methods with only one certified trunked DMR vendor about to release infrastructure products and two certified terminal vendors.

Voice Console interfaces are either proprietary or very limited in scope and functionality. Simulcasting is very difficult and currently offered by only a single vendor. Car-to-Car direct communications requires a full 12.5KHz channel although this is expected to change in the near future as products evolve.
2.2 dPMR/NXDN

dPMR is an FDMA based digital technology that uses a very robust air interface which was originally marketed by Icom and Kenwood as NXDN. dPMR is a genuine open standard with some specific requirements driven by European users. Effectively dPMR can be thought of as some extended commands and functions over NXDN.

There are various claims made during the “marketing wars” of vendors that dPMR is a technology best suited to low-end users only. This is not correct. It is the technology of choice for the demanding US Rail market where dependable operation is vital. The technology has proven itself to be reliable, high in functionality, is cost effective and provides a similar grade of service to DMR.

dPMR/NXDN ADVANTAGES

The FDMA architecture of dPMR allows one voice conversation to occupy only a 6.25KHz channel, whether via a repeater or in direct (car-to-car) mode. This means lower licensing costs, as ACMA moves to allocating 6.25KHz channels to encourage spectral efficiency and is currently consulting with industry stakeholders on a “cost per bandwidth” pricing regime.

As with DMR there is lots of functionality with advanced features such Radio Stun/Revive, Radio ID display, Multiple talk group addressing and Messaging.

Mode 3 Trunking is well defined and a worldwide announcement was recently made by Icom and Fylde about an integrated product with other vendors to follow.

The technology is cost effective, reliable and highly flexible and is often overlooked or overshadowed by strong competitive marketing emphasis.

dPMR/NXDN DISADVANTAGES

As with DMR in Australia there is a very limited choice of terminal vendors due to the newness of the standard. This may cause problems for customers who want a wide choice of competitive terminal brands.

Voice Console interfaces are either proprietary or currently very limited in scope and functionality. Simulcasting is very difficult and currently not offered by any vendor.
WHICH TECHNOLOGY IS BEST?

Our customers and prospective clients often ask us this question. AA Radio is a vendor-independent solutions provider and in this role we are able to approach this issue without bias.

As seen in this paper, every wireless technology has its advantages and disadvantages and in our opinion, there is no single wireless technology with a “one size fits all” application. Whilst there are many commonalities, each customer project has unique needs, technical requirements and operational or business drivers.

Our approach is to look closely at the customer requirement and their business and operational environment, then build an appropriate solution that:

- Meets or exceeds the project requirement
- Delivers the functional and operational benefits stated
- Fits within the project budget
- Is flexible and can change as future needs evolve
- Is supportable for the planned life of the system

For many customers we work with, our first step is to work with them and help identify the key areas and benefits they wish to obtain from a radio solution or system. Once these requirements are clearly known, the task of designing and implementing the solution are much simpler and the project easier to manage, measure and deliver.

We have found by our experience that a bit more effort spent in this phase will ensure a successful outcome with maximum benefit.

Additional References

www.tetramou.com
www.project25.org
http://dmrassociation.org
www.aaradio.com.au