CONNECTION

CONNECTING RADIO USERS AND EXPERTS

COMMUNICATIONS ON ICE P4

MANAGING A RADIO NETWORK IN ANTARCTICA

ISSUE 6

tait communications

Editorial

Welcome to Connection 6

The tragic events in Nepal recently reminded us here in Christchurch New Zealand just how devastating earthquakes can be, not just in the immediate timeframe, but ongoing, as infrastructure at every level is painstakingly rebuilt from the ground up. Meanwhile, the southern US has been hit with devastating rainfall, flooding and loss of life. Our thoughts are with you too, as you begin your recovery. One thing we can all do is share what we have learned, both nationally and globally, so others can be better prepared. We are revisiting our own research from the events in Christchurch and elsewhere, on page 39.

Throughout this magazine's three years of publication, our aim has remained to inform and educate – and perhaps entertain a little – while bringing you a diverse roundup of ideas and opinions connected with wireless communications. We have learned that our readers and subscribers are equally diverse. Naturally, not everything we publish will meet with full agreement from every corner. Without being deliberately contentious, we don't back away from controversy and welcome your input and opinions.

On a lighter note, we are sure you'll enjoy reading about the life and times of the world's southernmost radio technician. As he "winters over" in Antarctica, Anthony Hoffman's entertaining and informative article shares the triumphs, challenges and incredible diversity of his unusual role.

We also bring you an interesting commentary on how wireless communications are radically changing the oil and gas industry, a thought-provoking opinion piece about the work still needed on P25 standards, and more insight from Ian Graham on the science behind radio coverage.

As always, we welcome your contributions, your opinions and your discussions. Enjoy.

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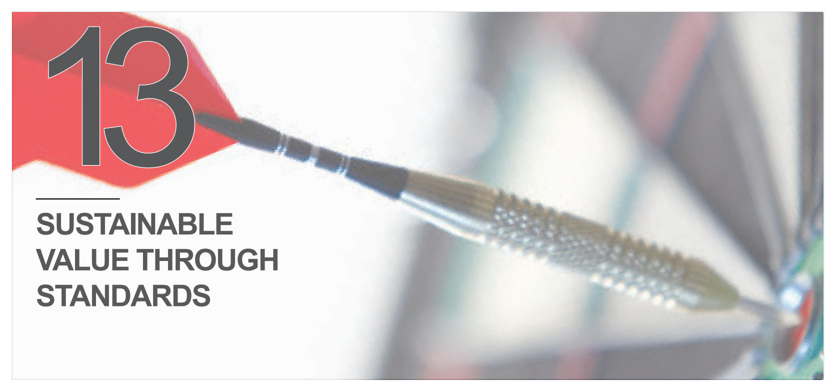
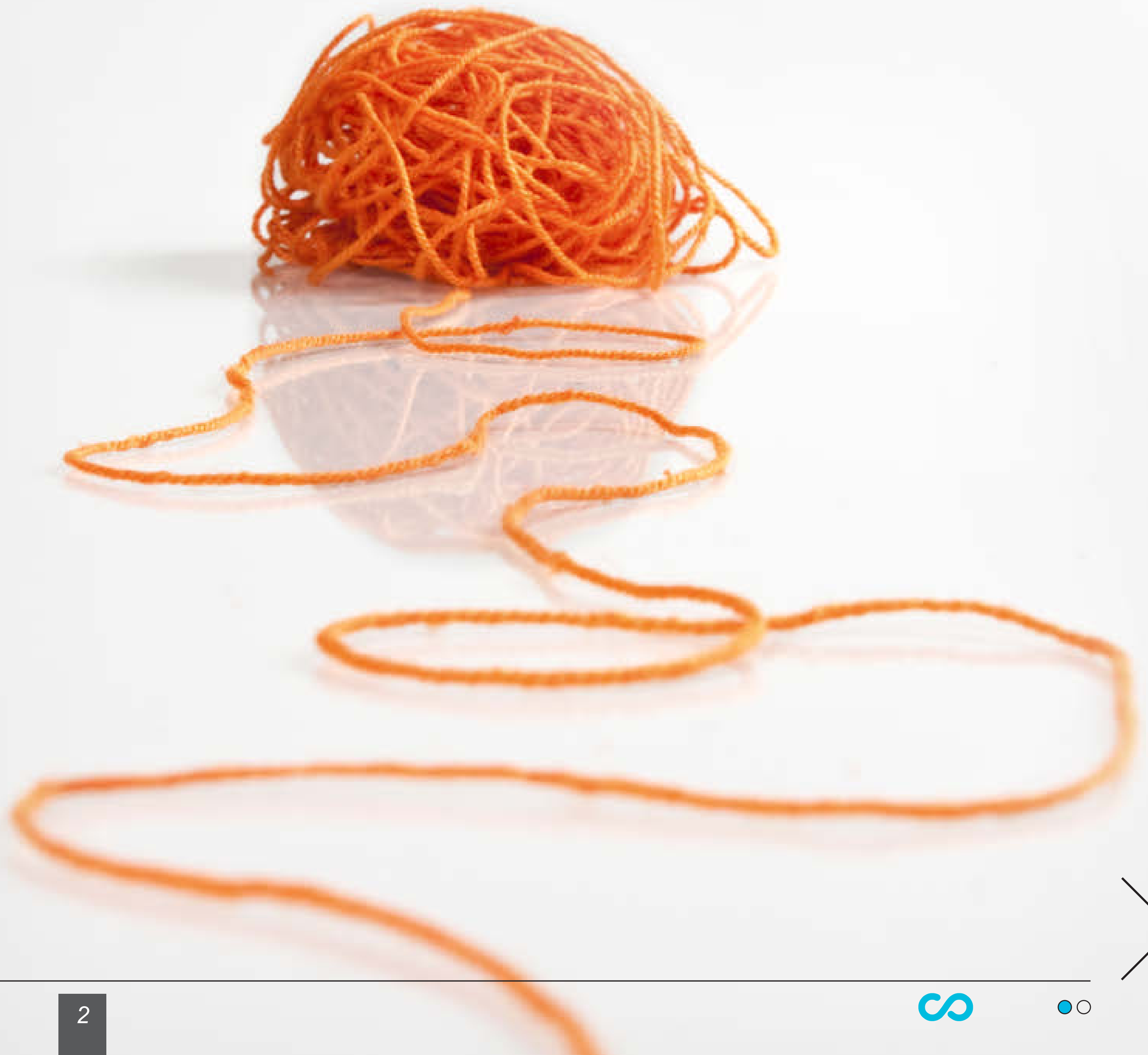



Unraveling the Internet of Things

Every day, we read about the rapid pace of technological change that affects every aspect of our lives. Without doubt, the Internet of Things has been receiving a large share of comment, as we investigate a world in which everyday objects have network connectivity, sending and receiving data. These are objects that respond to each other and take applicable, pre-ordained action according to a complex set of information from multiple sources.



Far from being the distant vision it seemed just a decade ago, we have begun to see household applications where "Smart Homes" undertake household chores without human intervention.

Central to these diverse networks is robust, ubiquitous communication. By unifying critical communications - a significant aspect of the Internet of Things - multiple communications bearers are integrated into a single IP-based network, creating new possibilities for smart services and applications.

Remote monitoring, automated notification, and self-correcting components improve communications system availability. These components will use whatever communications technology is most available and most appropriate to connect into the communications network.

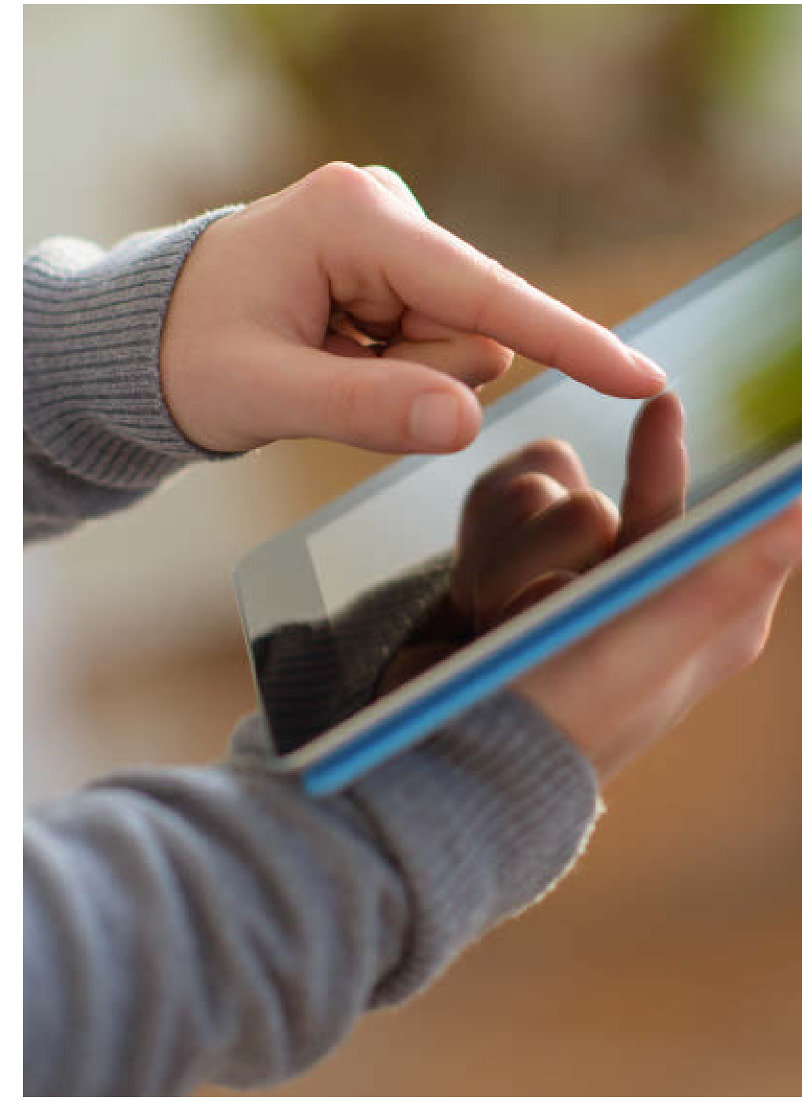
Applications designed to process the vast quantities of data generated by smart, interconnected devices can develop a more detailed and dynamic picture of an organization's business operations.

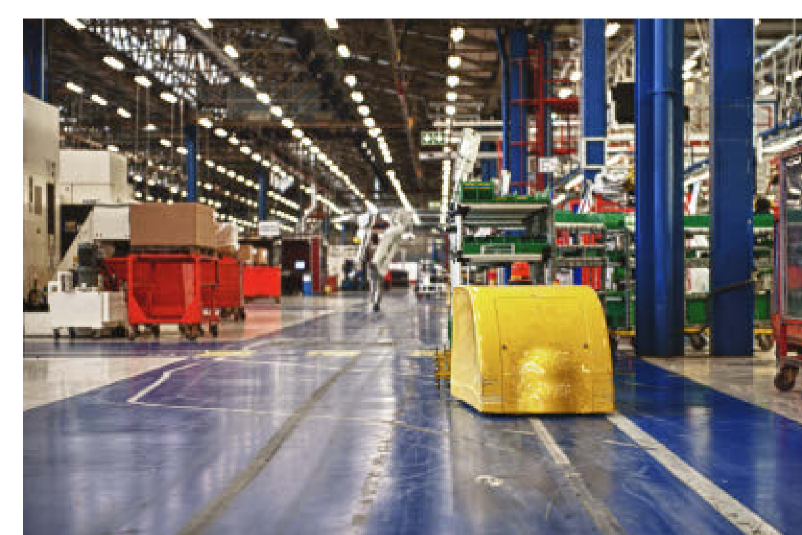
So far, we've hardly scratched the surface.

Ultimately devices and technologies must become interdependant. For this to occur will require unprecedented cooperation and commitment to open standards at every level - vendors, manufacturers, regulators, even governments.

The same concept is already being applied in a variety of industries:

- **Utilities** – the smart grid
- **Oil and Gas** – the digital oil field
- **Fire Control** – smart field operation devices
- **Mining** – mine site automation
- **Manufacturing** – the connected factory
- **Transportation** – intelligent transportation management and driverless vehicles
- **Public Safety** – automated video monitoring and data security analytics





COMMUNICATIONS ON ICE:

MANAGING A RADIO NETWORK IN ANTARCTICA

Anthony Hoffman's move to Antarctica was completely unplanned. One day he was Senior Hardware Design Engineer with Tait Communications' custom integration team in Christchurch, the next he had signed up as Communications Engineer at New Zealand's scientific research station in Antarctica.

He is currently working his third 13-month stint on the ice. In this article he shares the triumphs and challenges of managing multiple communications networks in one of the harshest environments on the planet.

My very-abrupt shift in career came about in 2010. Initially, when I was presented with the Antarctic position, it did not sound at all appealing, working in the cold and dark for months on end. Until they mentioned free food and cheap beer!

In what now seems like a blur, I found myself in a new home here at Scott Base on Ross Island in Antarctica, right next door to the American McMurdo Station and with an active volcano, Mt Erebus in the neighborhood.

My responsibilities primarily involve maintenance and operations of two-way radio networks, the telephone network and the satellite link (voice and data) between Scott Base and New Zealand. Apparently it's not an easy task to find someone familiar with all three technologies, who is also prepared to be away from home for a continuous 13 month period. However, two-way radio is my specialist field, and I had maintained telephone networks in the past. I was given brief training at a satellite ground station, but the final specialist training was cancelled due to the 2010 Christchurch earthquake. So it was a steep self-learning curve on the cryptic Nortel telephone exchange language, how to fusion splice optical fibre cables and many more new skills.

Scott Base is operated by Antarctica New Zealand and while I'm not employed by this government entity, I share some responsibilities with their staff. This includes doing duty as fire crew, kitchen hand, bartender, plus offering my technical skillset to others on base, including the electrician and science technician. (Prior to deployment, Antarctica New Zealand provides two-weeks of intensive Antarctic awareness training and firefighting.) Other responsibilities that come my way include repairing all things electronic, and of course DJ duties for our FM radio station.

The majority of my daily work is with two-way radio as this is our primary form of communications. With no cellular network, reliable radio communications are crucial to operations and safety.

The local area is served by a network of Tait VHF FM analog base stations with Codan HF radio used for deep field work. Mountaintop radio sites are solar powered and are deployed by helicopter in October each year at the beginning of the summer season. With no sun to provide power over winter, the radio equipment and batteries are returned to Scott Base each February at the end of the summer science season.

The telephone and satellite network infrastructure is a mixture of modern analog and digital equipment which usually requires little attention, but the ability to fault-find is essential if and when it fails. The satellite link delivers more than ten off-continent telephone circuits and a number of leased data circuits, ranging in speeds from 32kB/sec to 1.5MB/sec which provide email, internet and other services. When a problem arises, it can be challenging to restore essential communications quickly.

Over summer, the scientists often need training and support with unfamiliar communications equipment. They also have specialist electronic equipment that invariably breaks at some point and needs urgent repairs.

Year-round, field communications at sub-zero temperatures present many challenges. For example the best portable radio battery chemistry for performance in the cold is Ni-Cad, however most manufacturers no longer support this older technology in favour of Lithium batteries, which perform poorly at low temperatures.

In winter we're left with a skeleton crew, between 10 and 14 staff. The long dark haul from March to October is when we maintain, upgrade and keep things working. I've completed many hardware and software projects over past winters, including telemetry systems to remotely monitor and control radio sites, technical documentation and general improvements. There are no flights between March and August, so careful planning is required to get all parts pre-ordered and delivered before that final flight in March. You can't possibly plan for every eventuality, so you become very good at improvizing and making do with what you've got.

"OTHER RESPONSIBILITIES THAT COME MY WAY INCLUDE REPAIRING ALL THINGS ELECTRONIC, AND OF COURSE DJ DUTIES FOR OUR FM RADIO STATION."

Working outside in winter is difficult and time-consuming. For example, coaxial cable cannot flex at -40˚C without shattering the insulation. Flex the cable a little too far and it shatters, and you have to start again. It's impossible to terminate a connector while wearing thick gloves, so you need to work with bare hands. Your hands become numb after 20 seconds, so you then need to spend several minutes warming them inside your thick jacket before doing a little more. This is why a one minute job of terminating an N-type connector can take several hours.

Returning to New Zealand at the end of the 13-month contract is a most unusual and disconcerting experience. When you step off the US Air Force C-17 at Christchurch Airport, the air is hot and humid. Traffic and cut grass smell intense. Common sights like busy roads, rain, children, dogs, television and advertising all seem alien.

I'm often asked if I'll do another season.

Certainly it is interesting work, but what keeps me returning most of all, is the great people I have the pleasure of working with. They're all handpicked for their skillsets, their ability to work together as a team, and to live together as a family.

"COMMON SIGHTS LIKE BUSY ROADS, RAIN, CHILDREN, DOGS, TELEVISION AND ADVERTISING ALL SEEM ALIEN."

ANTARCTIC FACTS

Your hands become numb after **20 seconds in the open**

So you then need to spend **several minutes warming** them inside your thick jacket before doing a little more.

Scott Base is New Zealand's permanent research base for scientific research ranging from environmental and climate research to animal studies.

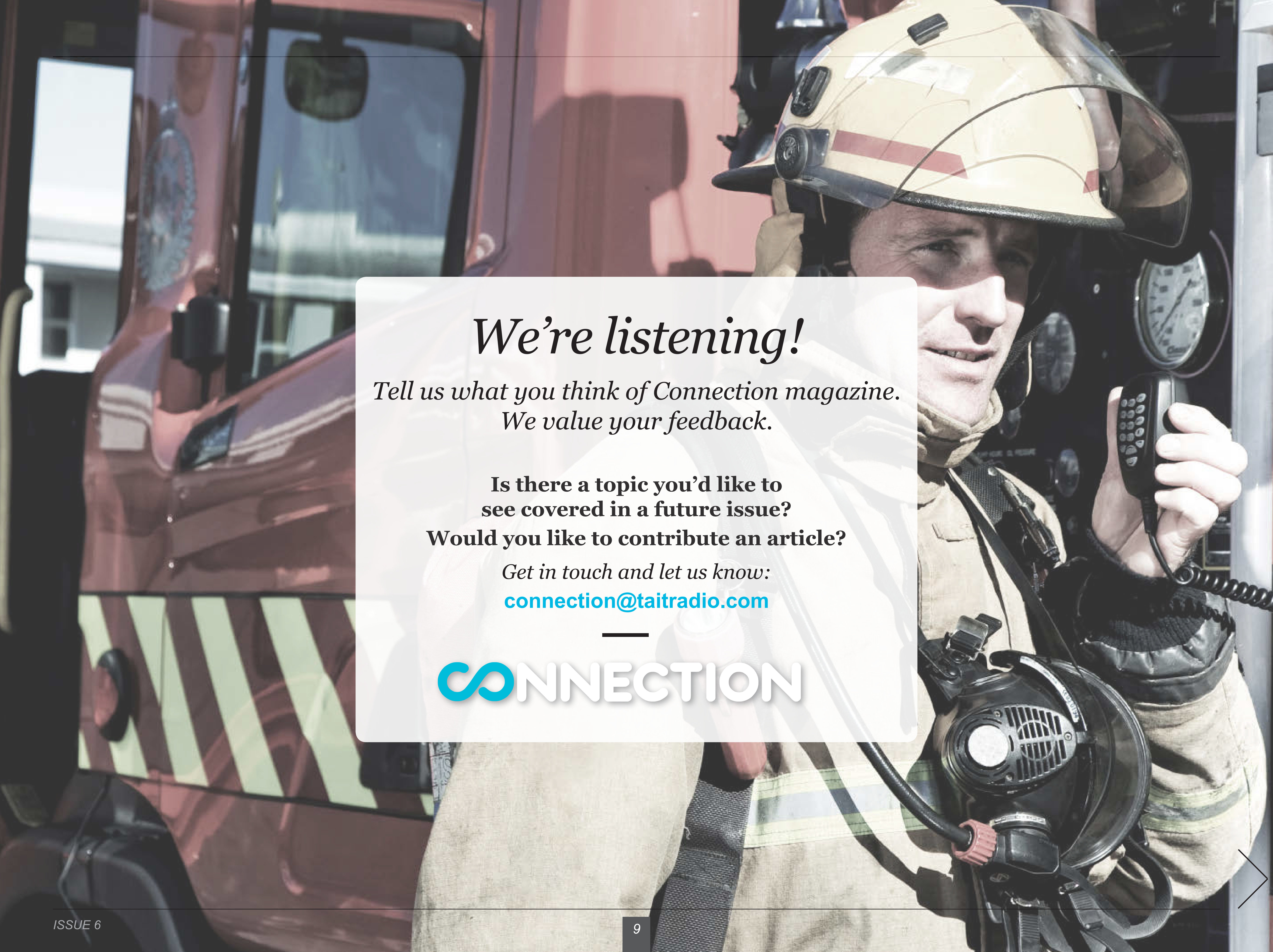
30 minutes

To walk to the US-run McMurdo Station from Scott Base.

Fire at the base is a significant threat as it would leave the crew without shelter in sub-zero temperatures.

In summer, up to
90 people
live on base; 30 base staff, research scientists and invited guests + politicians, artists, etc.

In winter a skeleton crew, between 10 and 14 staff, occupy Scott Base.



We're listening!

Tell us what you think of Connection magazine.
We value your feedback.

Is there a topic you'd like to see covered in a future issue?
Would you like to contribute an article?

Get in touch and let us know:
connection@taitradio.com

CONNECTION

FCC RECONSIDERS NARROWBANDING DEADLINE

The FCC has announced that narrowbanding 700 MHz networks by 2017 is no longer mandated.

In this article, Tait Public Safety Solutions Manager Dr. Russell Watson looks at who will be affected, and what the implications are.

Towards the end of 2014, the FCC announced that the 2017 narrowbanding implementation deadline was no longer viable, or indeed necessary. This decision was preceded by FCC granting a number of waivers to entities who had argued variously that:

- they had no spectral congestion,
- the regulation artificially shortens the life of their existing system,
- the device eco-system was limited,
- the lack of CAP testing for P25 Phase 2,
- interoperability would be impacted by the need to roam across multiple system types,
- replacing their current system would not only create financial stress at the time of replacement but on an ongoing basis.

The decision to lift the deadline reinforced a number of these arguments put forward by the waiver applicants. According to the text of the FCC's report and order, removing the 700 MHz narrowbanding deadline requirement "***will enable licensees to extend the life of existing systems and will provide public safety with greater flexibility in determining the optimal future use of the band.***"

So who is impacted by this change? In the US, the 700MHz band is used by Public Safety organizations. Among urban agencies, less than twenty percent use 700 MHz and in suburban areas, less than ten percent use it. While rural counties outnumber the more densely-populated counties by a ratio of approximately seven to one, the number of rural agencies using 700 MHz is even less.

So the vast majority of agencies are utilizing other bands and, indeed the 700MHz band has often been deliberately avoided by agencies looking to put in new trunked systems, purely on the basis of the ultra-narrowbanding regulations.

Commonly, rural agencies tend to use VHF conventional systems, which, while they may have their own spectral congestion issues, these have not been addressed by the FCC ultra-narrowbanding regulation.

Other agencies do experience congestion in more densely-populated areas, but as we can see, the vast majority did not have a spectral congestion issue or were not covered by the regulation.

So the 2017 mandate meant that many agencies were effectively being forced to solve a problem that didn't exist for them, or they were able to avoid the regulation.

The industry solution to the congestion problem for Public Safety was the greater spectral efficiency of APCO P25 Phase 2, offering effective 6.25 MHz channels via TDMA (Time Division Multiple Access). There are agencies already in varying stages of the Phase 2 procurement process, and it is likely that some of these may now be delayed, to meet more comfortable budgeting and implementation schedules.

However, while the pressure is off as far as the time scale is concerned, competitive cost, future-proofing and the promise of greater efficiencies remain. In future, owners of P25 Phase 2 systems can expect:

- significantly longer battery life compared with Phase 1,
- improved channel efficiency with increased number of voice paths,
- meeting future FCC spectral efficiency requirements,
- interference mitigation via bi-directional signalling,
- improved emergency management with alerting and informed pre-emption.

SUSTAINABLE VALUE THROUGH STANDARDS

This article, from Helmut Koch's presentation at a Tait-sponsored partner seminar, looks at standards and why they are still not working the way they should, to serve the communications needs of public safety agencies.

The best thing about standards-based solutions is that standards create sustainable value for our customers who are operators of mission critical communications systems.

How much value we can create depends on our customers. If they are well educated, they will look critically at the radio system, 911 call-taking system, dispatch system, recording system, and all the peripherals of a public safety communication system to understand how they all fit together. Those who do their homework, and who work with informed consultants (who will also educate them) have the most successful outcomes because they choose vendors and solutions based on value. Conversely, the most difficult projects are unduly influenced by particular manufacturers, and therefore more likely to accept proprietary solutions.

Standards transcend companies, models and product lines. Companies and technologies may come and go, but one thing that we can all do to help sustainability for our customers is to demand and enforce standards.

The current convergence of technologies means manufacturers, vendors and consultants need to work together to create complete communication solutions. For instance, a public safety installation is not just about P25; it's also about 911 communications and the convergence of APCO P25, NG911 (driven by NENA i3 standard), and VoIP telephony.

Convergence of mission critical communication technology consists of audio, video and data which are subject to two primary IP-based standards:

- APCO P25 ISSI/CSSI on the radio side,
- NENA NG911 i3 on the 911 telephony side

Additionally, there are AES and DES encryption standards for public safety and radio communications with numerous manufacturers of key loaders, manual key loaders and key management facilities, all of which also need to be considered.

From my perspective as a recorder manufacturer, the time sensitive chronology of multi-media communications is critical, because unlike dispatch console systems or 911 call-taking systems, we have to record everything for incident recreation and review.

So let's consider leveraging standards; APCO P25 ISSI, NENA NG911-i3, and SIP.

I believe SIP is a quasi-standard, because there is no such thing as a standard SIP interface. While it has a generic core, everybody has bastardized it because the standard itself is not specific enough, and therefore open to interpretation. It's wrong and we all know it. In an ideal world, we should only have to develop for Next Generation 911, P25 ISSI/CSSI, and we should be in pretty good shape using SIP for telephone systems.

The biggest issue with standards is that they are not necessarily directed by what operators want or need. We must find a way to collectively communicate with the APCO, NENA and other standards-generating organizations, so that standards stay current with our customers' expectations.

"ULTIMATELY, STANDARDS NEED TO REFLECT WHAT THE MARKET REALLY WANTS, NOT WHAT ENGINEERS AND STANDARDS COMMITTEES THINK THEY WANT."

For lack of standards, recording companies have had to develop six or seven different integrations for P25 – all proprietary – to meet customers' requirements. This doesn't serve anyone's interest.

It is important to note that the APCO P25, ISSI/CSSI standard is fortunate to benefit from the P25 Compliance

Assessment Program (CAP) which has promoted interoperability by minimizing the impact of standards specifications being subject to interpretation. Of course, most recording vendors do individual compliance testing with major manufacturers like Tait, Airbus, Motorola or Harris, but an independent centralized certification lab or program like CAP, which would apply to recording systems, would help to minimize integration issues.

Currently, recording vendors must take radio, 911, paging, intercom, AVL and integrate with them all, to create functionally-useful products. So, recording system interoperability must involve APCO P25, NG911 and the SIP-based VoIP [P.B.X.] telephone systems. Legacy systems such as conventional radio, trunked radio, analog and digital telephony, all add further complexity.

To complicate things further, there are no standards for recorders - and there should be!

What if the multimedia recording database and storage structure actually became a standard?

Customers come to us and say, "Well, you know, we like your equipment, but we have this older system from this other manufacturer, and we have five years of data that we have to maintain and keep legally." And we say: "We're really sorry, but why don't you just keep it kind of mothballed and use it when you need to." There just is not a clean solution.

Our customers want and need a standard, for database and storage of communications recordings. The NENA i3 standard is moving in that direction, but it is not going to happen any time soon, because to become a practical reality, we need to converge standards.

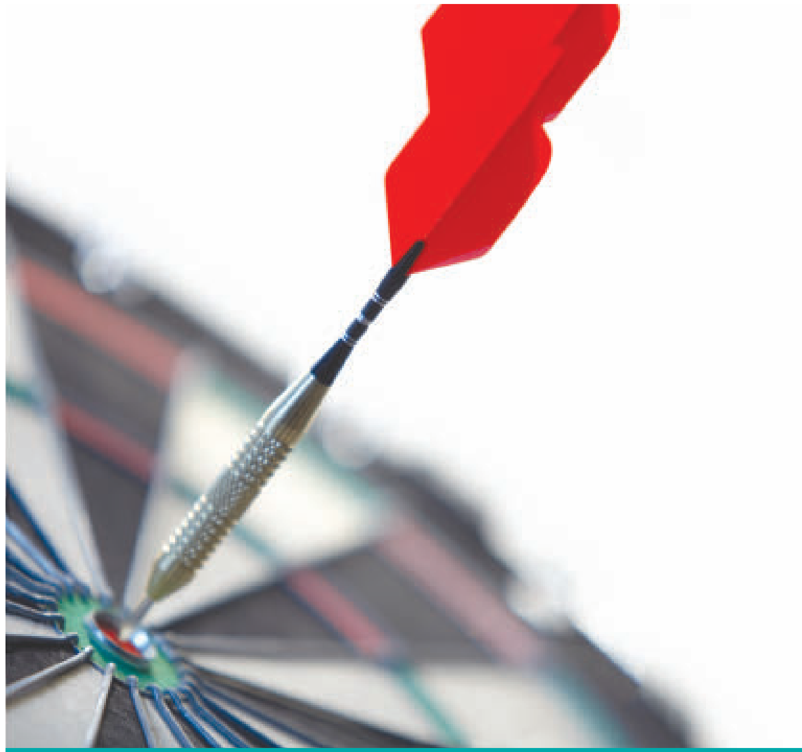
The most important accomplishment of recording standards is increased competition, and competition is good for all of us. It decreases cost to the end-user, decreases dependency on proprietary equipment, and decreases susceptibility to obsolescence. It increases choice and opportunities for service and support; you're not locked in to working with one vendor. Think about the possibility of having service organizations certified to support X, Y, Z systems because they all conform to the ABC Standard.

Ultimately, standards need to reflect what the market really wants, not what engineers and standards committees think they want. Likewise, customers have to become more knowledgeable about their communication requirements. Because here is the reality: customers are going to push their P25 or 911 vendor for features they want. A good vendor will listen to their customer and give them what they want, priced at what the customer will bear. This is why we end up with costly, proprietary systems! Customers can't wait for new standards to be released - they don't care about future promises, they will pay accordingly.

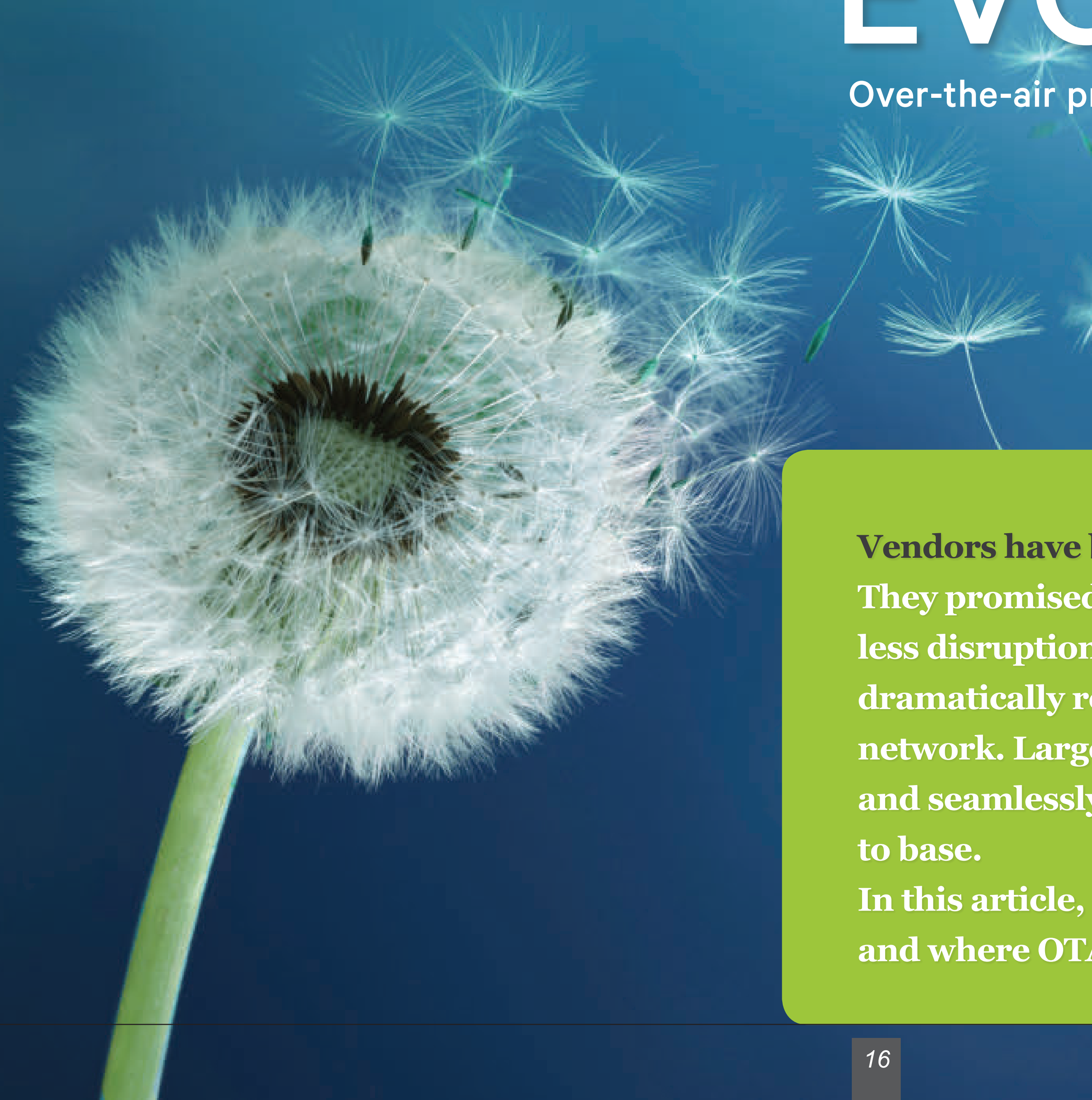
I am a real advocate of sustainability through standards, even though it may mean reduced margin and reduced profits for vendors. The only way to move forward is to make sure that standards stay in sync with needs. I have participated in standards development and watched the process hung up needlessly by special interests and general NIH (Not Invented Here) attitudes.

It can be done, and it should be done well!

Perhaps we need to change the way we create standards, by bringing customer needs to the forefront.



***Helmut Koch** is the co-founder and former President of EXACOM, Inc., manufacturer of multi-media logging recorders for critical communications. After 28 years, the company is now owned by its employees with Mr. Koch continuing his participation as Chairman of the Board, and Director of Strategic Business Development.*



OTAP EVOLUTION

Over-the-air programming meets radio management

Vendors have been talking up OTAP for more than a decade. They promised time and money savings, with less driving, less disruption, and more control over devices. OTAP would dramatically reduce the resource required to operate a network. Large radio fleets would be upgraded simply, quickly and seamlessly, without having to recall vehicles and users to base.

In this article, we discuss why this hasn't always happened, and where OTAP development is currently.

What OTAP brings to Radio Fleet Management

Despite the market demand, the time taken by vendors to develop a sophisticated OTAP offering for digital LMR has not kept pace with other developments in wireless communication.

There is some advantage in current OTAP offerings; currently OTAP does replace the wire. But it is not significantly better or faster, still takes too long, and is only able to program one radio at a time.

The technologies surrounding LMR have developed, fuelled by demand and expectation from consumer communications devices. In this context, we can look at OTAP not as a solution in itself, but as one component of the wider, radio management solution.

The delay has given developers the space to view wider issues - beyond the programming task – to look at all the associated information flowing seamlessly between devices and applications.

No longer confined to the single function of upgrading and programming software and firmware in radios and radio devices, OTAP becomes a vital tool in your radio management system. In the future OTAP will be more useful, more featured and save more resource.

What to look for in an OTAP solution:

Flexible, scalable implementation

Implementing new features and processes is often associated with costly change management projects or worse, confusion and frustration. OTAP can now be implemented more gradually, without the organizational impact, yet maintaining security and control. Users need much less support, as programming will often take place without their knowledge or input.

Fire and forget

It is difficult to connect to all radios at a convenient time for the programming technician. Some solutions were unable to confirm whether programming had been completed, or even initialized. Users may be on leave, off duty or simply have the radios turned off for any of a multitude of reasons. Now, when radios are scheduled for programming, it is cached and configured to commence as soon as the radio is turned back on.

Voice pre-emption

In the past when a portable radio was reprogrammed via OTAP, the target device would, effectively be out of communication, leaving the radio user vulnerable. Now, should the radio receive a voice call during programming, OTAP is immediately suspended, so that the user can take the call. Once the call is completed, programming can recommence automatically.

User-selectable programming

At the time when the radio is to be programmed, the user may be busy, involved in a situation where they are dependent on their radios for information or safety. Users can be advised that programming is about to commence. The radio indicates that updates are waiting, and the user can select a convenient time to action the change.

Exceptions only

Maintenance and upgrades to software are often urgent, impacting on operation and safety. Unfortunately, LMR data capability is limited, so upgrades can take much longer than is desirable. OTAP can now upgrade software by sending only the exceptions – the differences between the old version and the new, so the entire programming task is dramatically shortened. This development means that OTAP can conceivably make changes to firmware also.

Where next for OTAP?

Not so long ago, iPhone users needed to initiate and download each software upgrade – whether urgent or not – directly from iTunes, to their cellular phone. This used the same process as manual programming, except it was carried out by the user rather than a technician.

Granted, this was not difficult, but it did mean that devices in service used a variety of software versions, resulting in some operating sub-optimally.

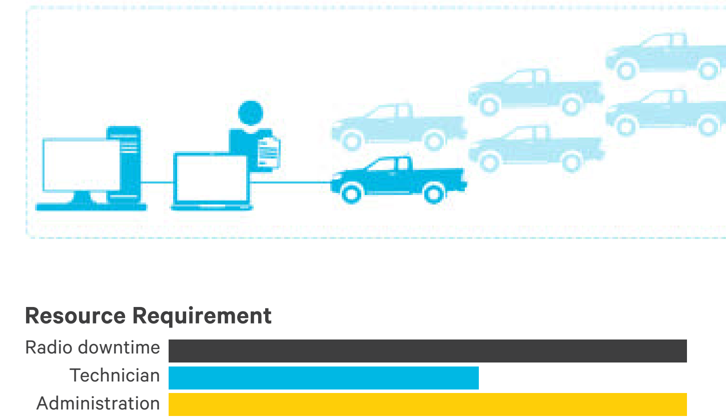
Those same phones are now updated automatically, wirelessly, and usually without any input or knowledge of the user. For both Apple and the users this has huge economic advantages:

- Upgrades have no need of hardware intervention. They can be undertaken at off-peak times to suit network loads and programming resource.
- Users are not inconvenienced, so maintain their loyalty to the product and manufacturer.
- Fewer software issues mean less support is needed, reducing the support overhead for Apple.

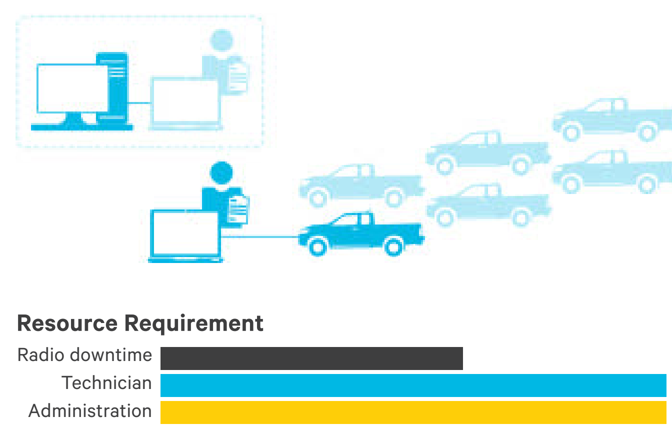
This is the kind of advancement LMR software developers are refining. LMR network operators should demand these benefits from their radio fleet management.

The diagrams describe the progression of OTAP development from its most basic, to programming multiple devices in parallel via LTE and/or Wifi. The bar graphs show the dramatic reduction in resources required, with each subsequent evolution.

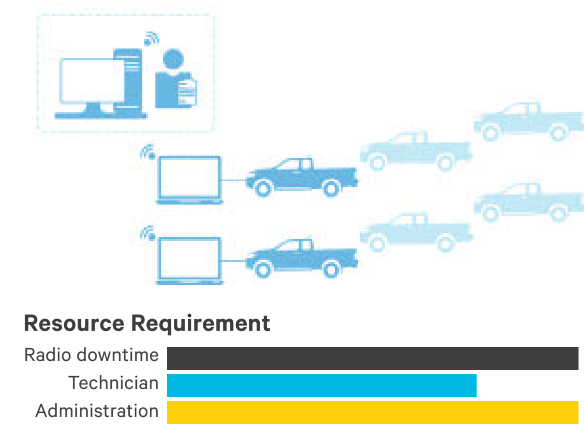
1. BASE / DEPOT Scheduled upgrade, programmed serially via cable.



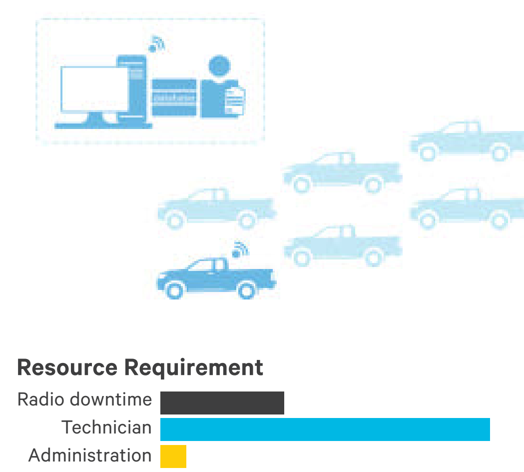
2. BASE / DEPOT Scheduled upgrade, programmed serially via cable or via LMR if remote.



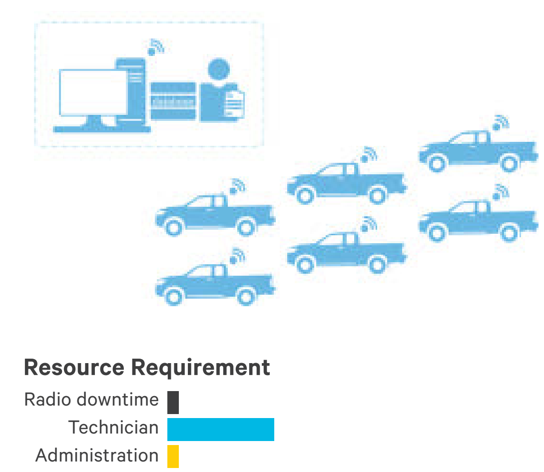
3. BASE / DEPOT Wireless programming to laptops in field. Vehicle (or portable) units programmed via cable.



4. BASE / DEPOT Wireless programming to vehicle (or portable) units via LMR, serially.



5. BASE / DEPOT Wireless/LTE programming to multiple vehicle (or portable) units in parallel.



Dispatch Solutions for Organisations of All Sizes

Choosing the right dispatch console can be a confusing process. Omnitronics recognises this and has done the hard work for you to provide solutions that are powerful, cost-effective, interoperable, flexible and easy to use

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RediTALK - Designed for Small to Medium Organisations who want a true server-less, IP solution.
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Click here to Download the White Paper:

"5 Questions to Ask Before You Implement a Dispatch Solution with DMR"

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Over 30 years creating Reliable Dispatch Solutions

WHAT TODAY'S RADIO TECH IS DOING

As LMR and IT converge, the responsibilities and skills required of radio technicians are changing fast. In this extract from "Tougher LMR Systems: 10 way to protect and strengthen your LMR system" we look at what today's techs need to be doing, to take care of P25 equipment.

The role of Public Safety radio technicians is rapidly changing, and their willingness to learn and attack any technical challenge is paramount. For example, intimate familiarity with the discrete elements of the equipment they are responsible for, is being replaced with greater understanding of network and system configuration, high-level troubleshooting and programming. Component-level repairs are important only where legacy equipment is no longer serviced by vendors.

Conversely, increased system complexity demands the ability to troubleshoot at network level and diagnose and resolve the source of system failure - antenna system problems, power problems, backbone issues, system configuration errors.

In this digital environment, we've outlined three key responsibilities that remain the responsibility of technicians.

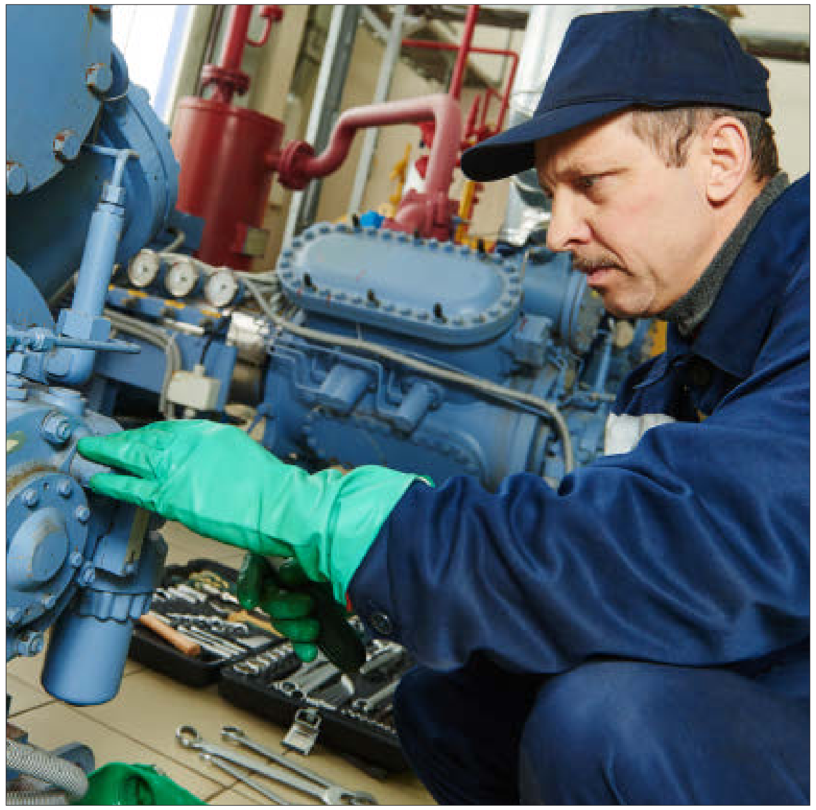
1. REPAIRS

Virtually all electronic boards are built with surface mount devices, rendering them unserviceable except in highly specialized settings, so the scope of repairs that can be performed in the field is systematically decreasing. Field repairs are typically limited to replacement of antennas, knobs, switches, display boards, speakers, and microphones. For all other problems, radios need to be returned for factory-based repairs. For network elements, field repair is now limited to swapping faulty boards or even entire devices.

2. UPGRADING HARDWARE AND SOFTWARE

Upgrades are seen as a necessary evil to be avoided by most system administrators. However, every aspect of your P25 system is dependent on software, so it is important technicians fully understand the implications of upgrading (or not upgrading). Upgrading equipment can affect:

- interoperability with mutual aid partners,
- compatibility with other network components,
- costs – upgrading is typically less expensive in the long run,
- impact of operating system obsolescence on your upgrade plans,
- taking advantage of useful new features and functions.



It is important to avoid having to roll back – this can have huge implications for your network, and leave communications vulnerable while issues are resolved. Nevertheless, it is wise to have a rollback plan for worst-case scenarios.

3. ROUTINE MAINTENANCE

Frequency and thoroughness of routine maintenance varies greatly, from weekly structured checks to a fully reactive approach. Scheduled maintenance checks should account for local geography and weather patterns. Obviously, as your system ages, you will need to schedule maintenance more frequently, but an annual check is the recommended minimum.

Run regular tests and reports on your microwave system. Microwave links will typically have the means to check their operation on site, so your maintenance technician can measure and record parameters such as signal strength, BER or others.

For backhaul networks, you should simulate failure conditions to test automated switchover functions periodically.

Electronic hardware is becoming ever more reliable. Systems with appropriate environmental (temperature and humidity) control can manage with annual checks, but systems working at high capacity or in difficult environments should be checked more often. Maintenance for any base station should include thorough examination of the receiver, transmitter and, above all, antenna system.

Site maintenance

Site inspections should be scheduled regularly – more often in regions with challenging weather or geography. Inspections should include:

- generators, including batteries, propane tank levels,
- fencing,
- cameras,
- security measures,
- on-site spares.

Spring and autumn equipment checks are particularly important in mountain regions. Remote sites should have the most robust equipment to reduce the chance of failure, and minimize winter callouts. And while it may seem obvious, make sure that you have all necessary spares and tools for remote site checks – returning to base to pick up overlooked or forgotten items is costly and inefficient.

One of the most-often overlooked subsystems at the radio sites is back-up power – generators and UPSs. Make sure UPS and DC-bank batteries are maintained to manufacturer recommendations and back-up generators are periodically exercised so they start easily, and have sufficient fuel for extended emergencies.

Subscriber equipment

As digital portable and mobile radios become more reliable and less field-serviceable, routine tune-ups become less common. Instead, radios are usually tested when they come to the local shop for other reasons, such as reprogramming or repair. This may be supplemented by remote monitoring.

However, every radio needs to return to base regularly, especially portables, which are subject to physical damage as well as malfunction. Give them a checkup whenever they are in the shop, and update your records.

It is more difficult to check your mobile fleet so you should consider a program of radio maintenance alongside your vehicle maintenance schedule.

Read more at www.taittough.com

OIL AND GAS INDUSTRY FACES UP TO THE DIGITAL CHALLENGE

Oil and gas companies are investigating the concept of a Digital Oil Field, to integrate their business operations using advances in communications technology. Independent consultant Dr Jan Noordhof looks at the challenges these organizations face, and the changes they are adopting.

Oil and gas producers face challenges in controlling costs, locating new, harder-to-reach sources, meeting increasingly-stringent regulatory and environmental guidelines, as well as developing and maintaining business in politically unstable regions.

Oil companies also face a volatile market. For example, in June 2014 the price per barrel of Brent crude was USD$115 – by October of the same year it had dropped to USD$85 and at the time of publishing was even lower. So oil companies need to work smarter.

Exploration, field development, and production (E&P) are expensive and risky. They offer no guarantee of commercial success, and upstream companies are now forced to explore new fields in ever more remote and dangerous locations, or to squeeze more production volumes out of older fields. In 2015 capital expenditure by these companies is estimated to reach USD$500bn (of which over 10% is IT alone), at the same time experiencing a shortfall in skilled labor of 500,000 over and above the current workforce of 3.5 million as they seek increasingly-scarce engineers and experienced technicians. Non-productive time, such as downtime due to rig failure, costs the industry over $26 billion each year.

Of course, other industries face similar challenges: power utilities for example have embraced the Smart Grid concept, using digital telecommunications technologies to improve productivity, control costs, increase reliability, security and worker safety.

But no single technology can fully service this integration, when companies must consider cost, coverage, spectrum availability, bandwidth, latency, ease of deployment, and flexibility. The solution lies in unifying multiple technologies: an integrated mix of different communications technologies, ranging from VSAT satellite, to WiMax or LTE broadband, to WiFi, cellular, and digital LMR, each with its own strengths and weaknesses.

With the right communications solutions in place, the degree of real-time control that operators can exercise in the Digital Oil Field is remarkable. For example, with Remote Drilling, data such as bit RPMs, circulation solids, and downhole pressures are captured by a Measurement-While-Drilling (MWD) system, integrated, Logged-While-Drilling (LWD), and sent to an operator who can remotely steer the downhole tools. The result is more accurate drilling, optimized path and drilling processes in real time, and significantly less reliance on specialists and service personnel onsite in isolated locations. A 2003 study by Cambridge Energy Research Associates (CERA) estimates that this reduces drilling costs between five and 25 percent.

COMPANIES MUST CONSIDER COST, COVERAGE, SPECTRUM AVAILABILITY, BANDWIDTH, LATENCY, EASE OF DEPLOYMENT, AND FLEXIBILITY.

Other capabilities of the Digital Oil Field include:

- SCADA networks that directly manage facility process systems, for example by controlling pumps and valves,
- real-time surveillance of production system performance and reservoirs,
- surface-controlled equipment that continuously monitors underground conditions and responds as required,
- visualizations and dynamic modelling of changes in a reservoir using 4D seismic data,
- collecting and analyzing equipment status and performance to predict and respond to equipment faults before they occur, thus minimizing downtime,
- on-site field staff and offsite experts collaborating remotely to share information via voice, data, and real-time video, to improve the quality and speed of decision-making,
- managing historical data and workflow analyses to create standard 'best company practice' workflows for teams that monitor, operate, develop and maintain a field, freeing up engineers from this responsibility,
- standardized production data and production allocations for accurate forecasting and efficient real-time decision-making,
- integrating representations of the reservoir, production, injection network, wells, economics and planning tools, modelling the entire field so operators can optimize field production and run forecasts.

In short, this approach brings, as one report put it, "the field to the operator rather than the operator to the field."

9 CHANNEL CONCEPTS EVERY SYSTEM DESIGNER NEEDS TO UNDERSTAND

Successful system design is heavily dependent on the designer's understanding of the channel and its properties. Tait Principal Engineer Ian Graham continues his radio theory series with examples of channel properties that are critical to overall RF system design.

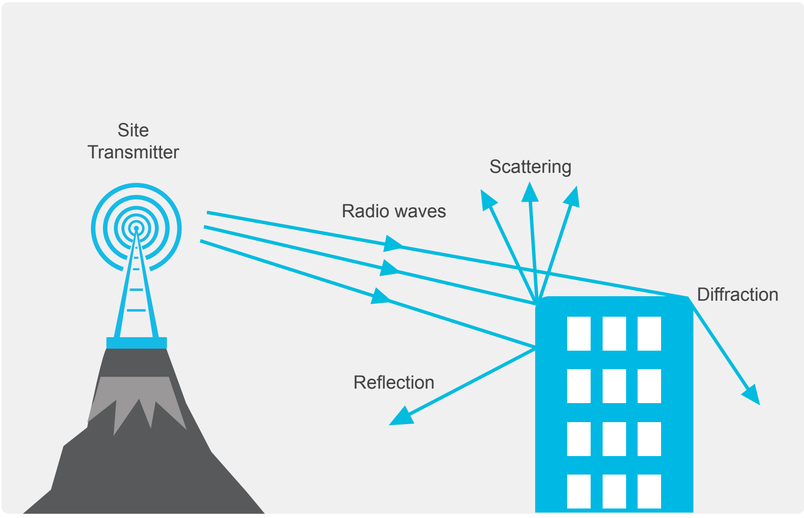
In a radio system, there may be large distances (including hills, forests, buildings etc) between the transmit and the receive antennas. This is the channel, the medium over which we propagate the signal from the transmitter to the receiver. Here we look at nine key channel properties that it is important to understand.

1. Reflection, Diffraction and Scattering

Reflection occurs when a radio wave hits a smooth surface that is much greater than a wavelength and effectively bounces off.

Diffraction (or shadowing) occurs when the path between the transmitter and receiver is blocked by a dense object that is much greater than a wavelength, forming secondary waves behind the obstruction. It is also known as shadowing.

Scattering occurs when a radio wave hits either a rough surface or a surface with dimensions of a wavelength or less, causing reflected energy to scatter. Typical scatterers are lamp posts, street signs and foliage.

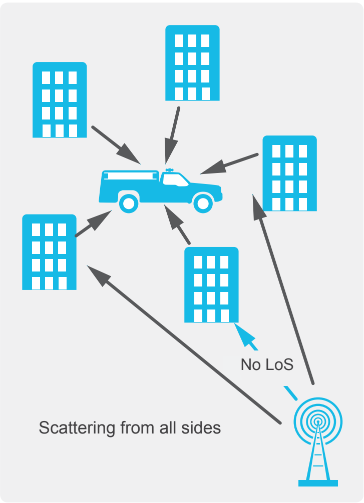


This means a transmitted signal usually reaches the reciver via several different paths, known as multipath propagation. Because these multiple copies of the transmitted signal travel different distances and arrive at the receiver at slightly different times, they can either add or subtract, and cause fluctuation in the received signal strength. This is multipath fading.

The two main types of multipath fading are Rayleigh Fading and Rician Fading.

2. Rayleigh Fading

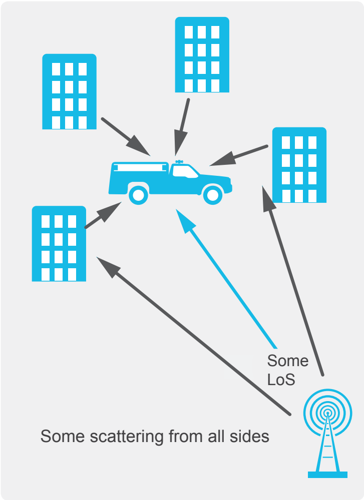
Rayleigh Fading occurs when the received signal consists only of multipath components - there is no line of



sight signal. It is common where there are many tall buildings. Fades tend to be short, but very 'deep', so the received signal strength varies by over 30dB in very short time intervals.

3. Rician Fading

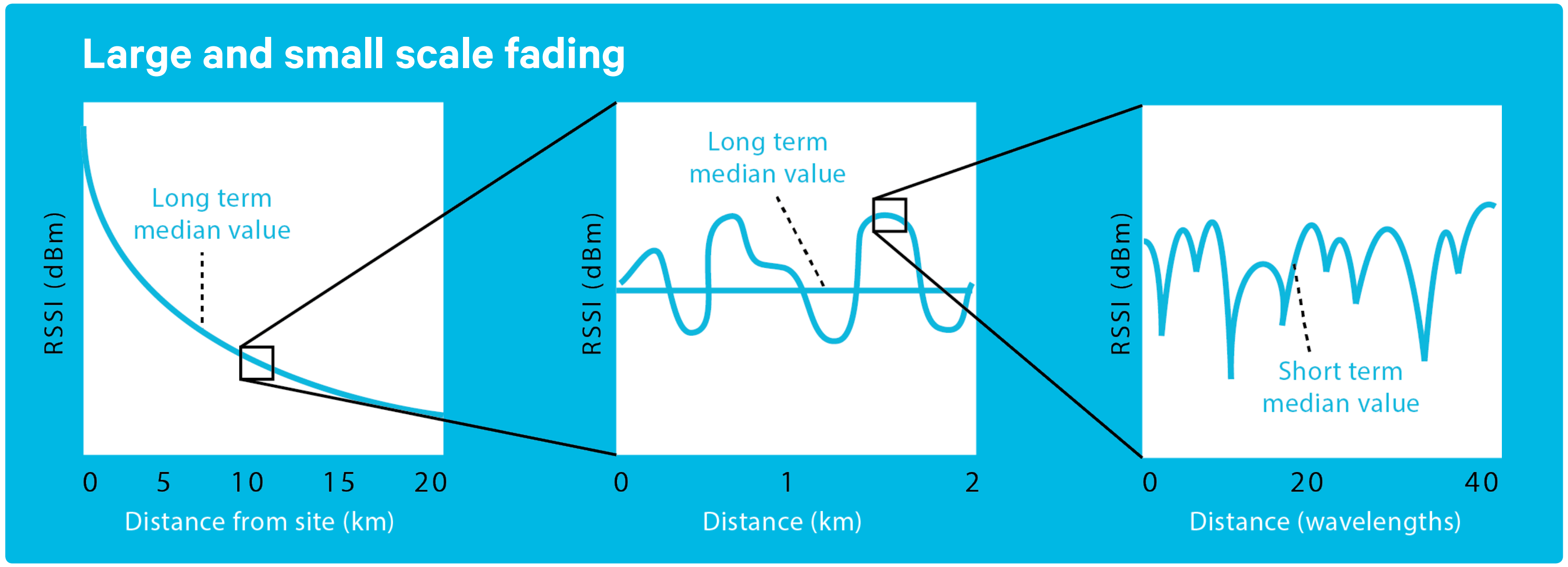
Rician Fading occurs when the received signal consists of both line of sight and multipath components. Rician



Fades tend to be short, and because the line of sight signal is the strongest, received signal strength variations (the 'depth' of the fades) are less than Rayleigh Fading, typically around 10dB.

4. Large Scale and Small Scale Fading

Fading can be categorized as either large or small scale fading. Large scale fading describes the slow changes in received signal strength due to traveling over large areas. Shadowing can cause this. Rayleigh and Rician Fading are small scale fading, where the received signal strength varies dramatically over very small distances.
A mobile-equipped vehicle traveling a large distance experiences large scale fading with small scale fading superimposed. The following diagram illustrates this.

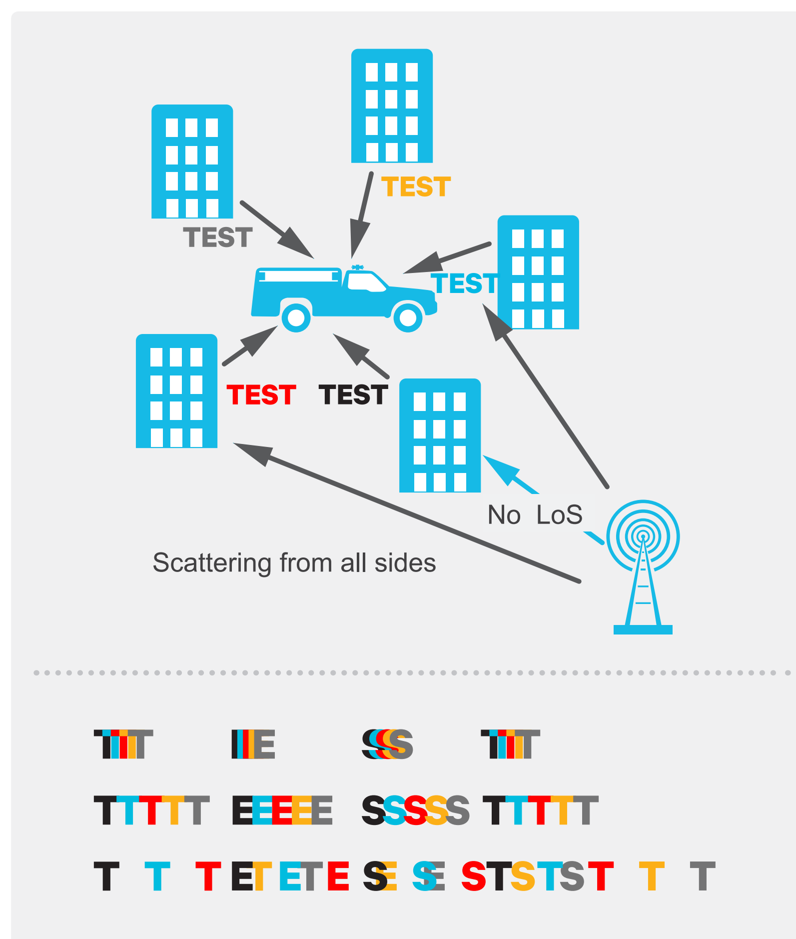


5. Delay Spread

The time difference between the arrival of the first multipath component of the signal and the last (which will have arrived via a different path) is known as Delay Spread.

Obviously, if a signal is received at a given time, and then a replica of that signal is received a fraction of a second later, the information will 'blur'. As the delay spread increases, quality of the received audio degrades and eventually communication is lost, even when the signal level is above the receiver's sensitivity level.

In the first line, the multipath components of the signal S1, S2, S3, S4 and S5 all arrive at the receiver within a short time. While there is some degradation, the information is still understandable. In the second line, delay spread increases and it is harder to understand. In the third line, delay spread exceeds symbol time and communication is lost.



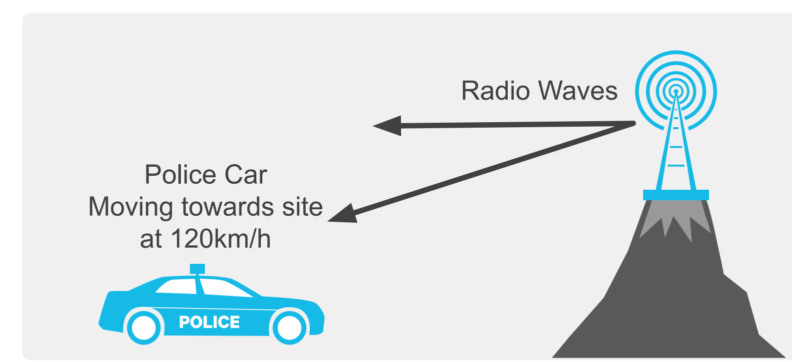
6. Doppler Shift, Doppler Spread, Coherence Time and Fading Rate

These three properties are closely related.

Doppler Shift

The simplest illustration of Doppler Shift is the increase in the frequency of the engine note you hear when a car drives towards you, and the decrease you hear once it is moving away. The same effect happens with radio. Doppler Shift is the change in frequency that occurs when a vehicle receiver is moving towards or away from the transmitter.

Take the example of a receiver moving toward a transmitter operating at 900MHz.



As the receiver is moving towards the transmitter, Vrx is +ve, so:

$Vrx = 120km/h = 120*10^3 / 3600 = 33.33m/s$

$Frx = Ftx * [(C + Vrx) / C]$

$= 900*10^6 * [(3*10^8 + 33.33) / 3*10^8]$

$= 900.000100Hz$,

ie: Received frequency is 100Hz higher.

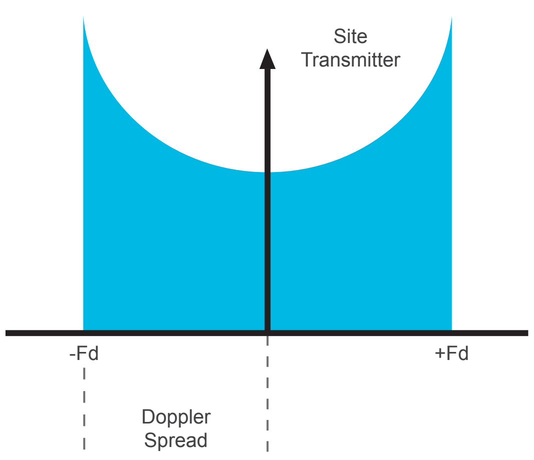
At a glance:

Vrx = *velocity at which the receiver is traveling*
Fo = *transmitted frequency*
Frx = *received frequency*
Fd = *Doppler shift*
To = *coherence time*
Bc = *coherence bandwidth*
Ts = *symbol time*
Td = *delay spread*
C = *spread of radio wave in free space (3x108m/s)*
rms = *root mean square*
Bs = *signal bandwith*
ISI = *inter-symbol interference*
OFDM = *orthogonal frequency division multiplexing*

Doppler Spread

When a receiver is moving in a multipath environment, the frequency of the multipath components we are heading towards appear to increase; the frequency of the multipath components we are heading away from appear to decrease. Frequency spreading of the received signal is called Doppler Spread.

If the received signal multipath components come from all directions with equal power, a plot of the received power at each frequency in the received signal would look like this:

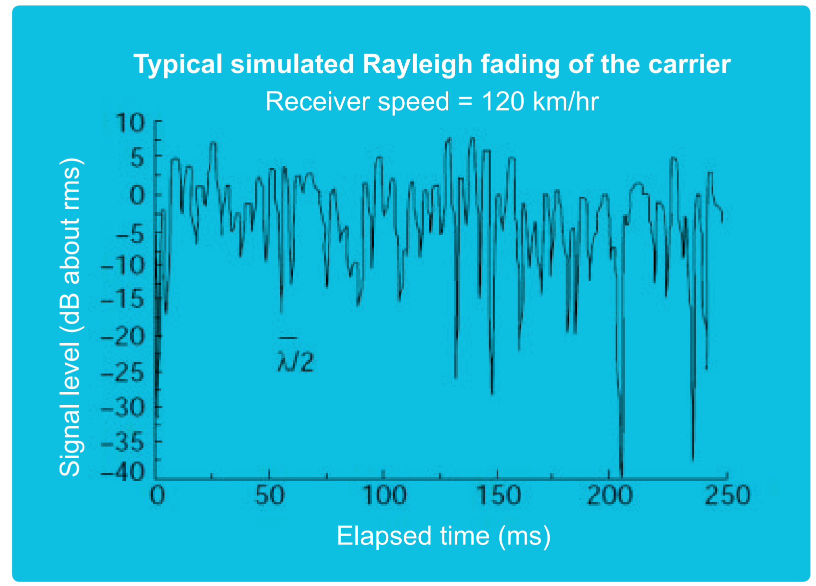


Coherence Time

This is the duration for which the channel doesn't change noticeably. The Doppler Spread (Fd) and the Coherence Time (To) are reciprocally related. The approximate relationship between the two parameters is:

To ~ 0.5 / Fd

For example: the Rayleigh Fading envelope of a received signal at 900MHz is shown in the diagram.



The distance traveled corresponds to two adjacent small-scale fades and is roughly half a wavelength. From this, we can work out both the Coherence Time and the Doppler Spread.

Transmitted Frequency, Fo = 900MHz
So: $\lambda o = 3 \times 10^8 / 900 \times 10^6 = 0.33$m
The receiver is traveling at 120km/h, so:
Velocity, V = 120km/h = (120 / 3600) *1000 m/s = 33m/s
(Note that 3600 is the number of seconds per hour)

Because the distance traveled by the receiver between fades is about half a wavelength, the coherence time is time taken to travel this distance. So we can express coherence time as:

To = (λ/2) / V
So: To = (0.33 / 2) / 33 = **5ms**

Now we know the Coherence Time, we can calculate the Doppler Spread:

Fd = 0.5 / To = 0.5 / 5 x 10^{-3} = **100Hz.**

Fading Rate

This is the number of fades an object travels through in one second. The greater the fading rate, the greater its destructive effect on the received signal. Fading rate is a function of frequency; the lower the operating frequency, the higher the speed of the object before communication is lost. So for high speed trains that travel at some 300km/hr a lower frequency gives best RF operation.

7. Fast and slow fading

These are caused by the receiver moving towards some multipath signal components and away from others.

Fast Fading

Corresponding to Doppler Spread is the concept of Coherence Time, effectively the time duration over which the channel is flat. It is inversely related to Doppler Spread, Fd:

To ~ 0.5 / Fd

If the baseband signal varies more slowly than coherence time, ie: Ts > To, then distortion from Doppler spread fading is significant, because the channel condition has changed significantly in the time taken to transmit one symbol. This is fast fading: if you are traveling fast, you experience a rapid change in channel condition.

Slow Fading

Conversely, if the baseband signal varies faster than the coherence time, (Ts < To), distortion from Doppler spread fading is negligible. Slow Fading is when the channel condition has not changed significantly within the time taken to transmit one symbol.

Intuitively, if you are traveling slowly, you experience a slower change in channel conditions.

8. Coherence Bandwidth

The Coherence Bandwidth is the bandwidth over which the channel conditions don't change, where two multipath components of the received signal have strong potential for correlation.

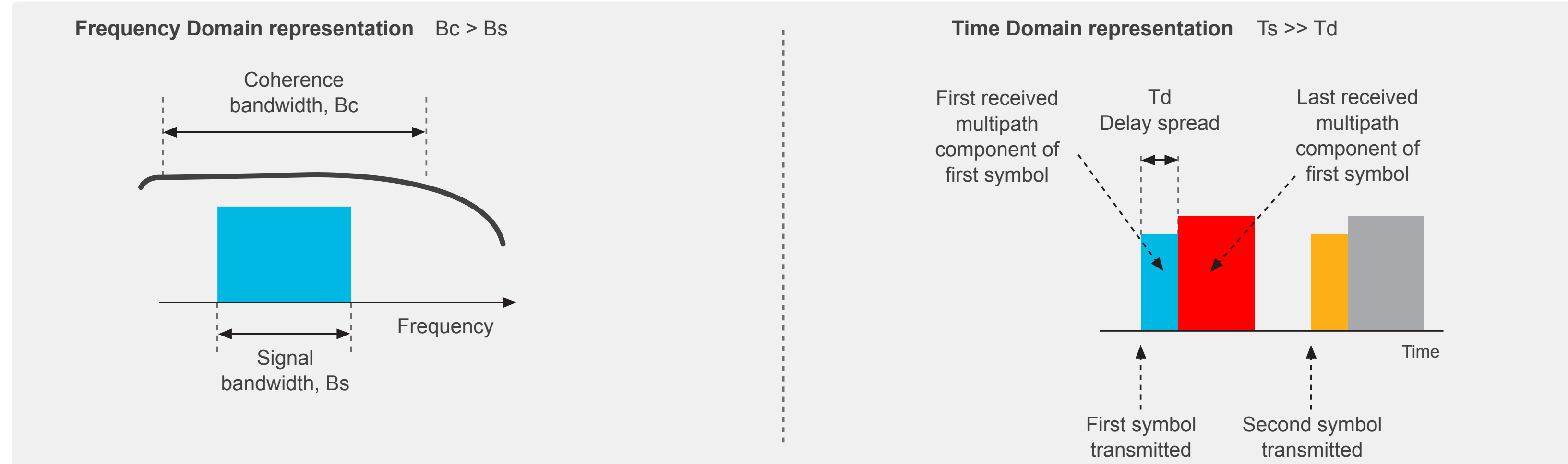
Coherence Bandwidth (Bc) is related to delay spread so if Td is the rms delay spread, then:

$Bc = 1 / (50 * Td)$ for 0.9 correlation.

9. Flat and Frequency Selective Fading

Flat Fading

Flat Fading occurs where all frequencies within the signal experience the same fading. It occurs if the symbol



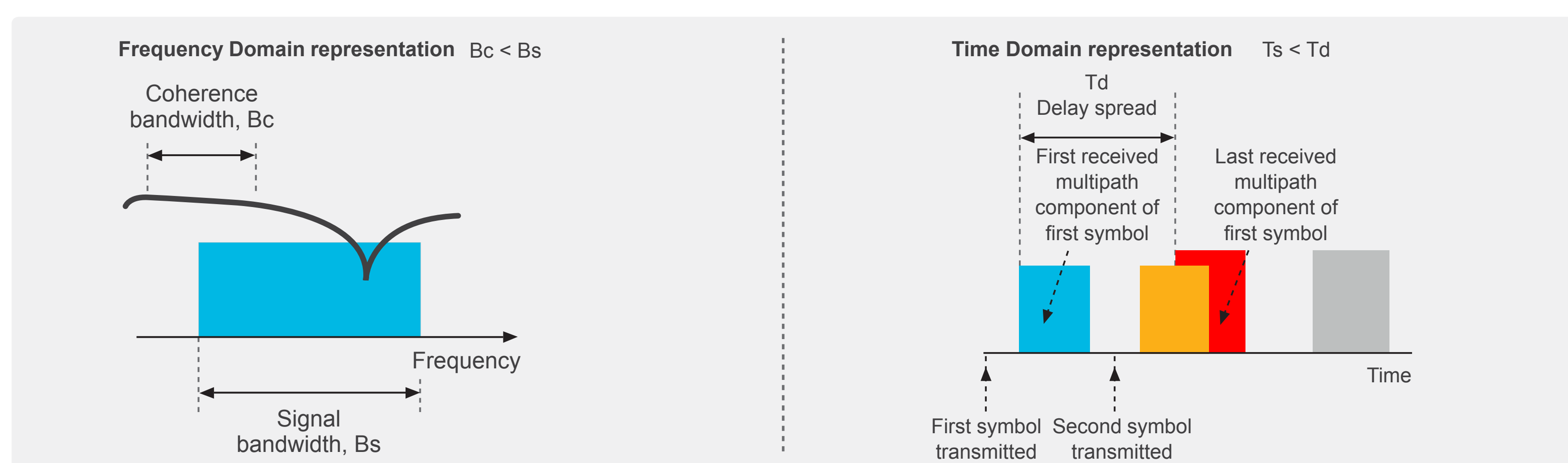
time is much greater than delay spread, so all multipath components arrive well within the symbol time. Another way of looking at it is flat fading occurs when coherence bandwidth is greater than the signal bandwidth.
The coherence bandwidth over which the channel is considered flat is greater than the bandwidth of the signal.

Frequency Selective Fading

This occurs where different frequencies within the signal experience different levels of fading. In the time domain, it occurs when symbol time is less than delay spread. The delay spread is so long that components containing the next symbol are received before all the components containing the previous symbol, causing inter-symbol interference (ISI).

In the frequency domain, it occurs when coherence bandwidth is less than signal bandwidth. The coherence bandwidth is less than the signal bandwidth, so different frequency signal components experience different fading.

If you think that this is a problem for a broadband signal, you're right. This is why LTE systems use OFDM techniques. Rather than transmitting on very wide band signal modulated at a high symbol rate, the broadband signal is divided into many slowly modulated sub-carriers. These sub-carriers then only experience flat, rather than frequency-selective fading.



THE THREE Cs OF SUCCESSFUL PARTNERSHIPS:

Comprehension
Collaboration
Communication

Glentel Inc. is one of Canada's leading telecommunications companies and in 2013, celebrated its 50th year. Their success has not been without significant challenges.

Clients differ tremendously, as do their needs and the nature of their concerns. Glentel has overcome this challenge by developing and maintaining a great relationship with clients.

Successful partnership requires three key elements: comprehension, collaboration and communication. These are not ground-breaking concepts. In fact, they are simple and applicable to any business. But it is how you perform them that says a great deal about your company and what you can do for your clients.

Firstly, get to know your customer, build trust, determine their needs and establish a relationship. **Secondly,** find a suitable supplier that will provide the equipment needed to support the client and your proposed solution. Then collaborate with the supplier to ensure that design and functionality of the system meet specifications. **Lastly,** communicate with the supplier, the client and your team so that all issues are addressed in a timely manner before project completion.

Glentel has always stressed the importance of partnerships. In the last fifty years, they have formed great partnerships with several suppliers such as Motorola, Zetron, Kenwood, Tait and Airbus DS. However, it is their relationship with clients that Glentel believes drives their organization.

According to Rick Christiaanse, General Manager at Glentel Inc., "Building a solution to a telecommunications problem is all about the customer. We want to ensure that all requirements are satisfied and that all concerns are addressed. As a solutions provider, Glentel's vision is to not only offer unparalleled expertise but to also serve customers so that they themselves can succeed in their line of work."

For Glentel, a recent example of a successful client-contractor partnership is the Kawartha Lakes Police Service. Kawartha Lakes is a small community located north of Lake Ontario and has a population of approximately seventy thousand people. The Police Service's communication system was approximately ten years old. It had reliability issues with uptime that caused an immediate public safety concern. Glentel learned of the problem with their radio system through an invite from KLPS's Inspector Mark Mitchell. As a result, Glentel's team of technical services specialists offered to do a technical consulting and needs analysis.

Glentel's needs analysis involved understanding how the Kawartha Lakes Police Service did business and how they communicated. They conducted focus groups and interviews at all levels of the agency, job-shadowing the officers, supervisors and dispatch people to determine the organizational structure, communication protocols and procedures and essentially, how they went about their work day both in the office and in the field.

Through these activities, Glentel was able to gather information for a comprehensive report, which addressed their suggestions and concerns. Significantly, the process meant Glentel was able to build a relationship with their client that resulted in appropriate recommendations and solutions that met the Kawartha Lakes Police Service's specific needs.

The Glentel report outlined three different system solutions, each detailing technical details such as the types of devices, the life cycle and longevity. All three solutions were designed to meet the needs of the Kawartha Lakes Police Service but also addressed varying financial constraints. By doing so, the Kawartha Lakes Police Service was better able to make a decision based not only on their communications needs but the finances available to them.

BUILDING A SOLUTION TO A TELECOMMUNICATIONS PROBLEM IS ALL ABOUT THE CUSTOMER.

After further discussion and consideration, the Kawartha Lakes Police Service chose the highest spec solution of the three. Glentel then immediately began the 18-month process of collaboration with suppliers. During which time Glentel was readily available and contactable, building on the relationship already established with their client. The end result was a successfully implemented Tait P25 System with three-site microwave backhaul.

At the end of the project, the Kawartha Lakes Police Service's new radio system not only resolved the reliability issues but drove team performance and overall efficiency. KLPS Inspector Mark Mitchell said: ***"Glentel is one of the leading companies in this industry and was more than capable in meeting our needs. We appreciated the initiative they showed in reaching out to us and the persistence they exhibited during the bid process. They were proactive every step of the way."***

BRINGING THE HEAT

The greatest motivation for physiological monitoring technology is to prevent occupational loss of life. Tait has integrated physiological monitoring into our critical communications solutions, where firefighters and other workers in dangerous environments can be monitored.

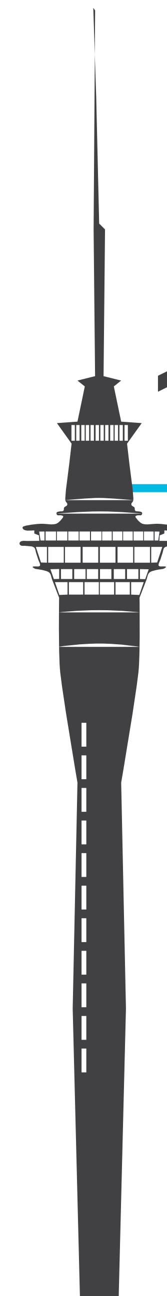
But rather than talk about physiological monitoring as part of a critical communications solution, we have been taking it out into the field. Two of our in-field tests were firefighter stair climbs, simulating real life activity - well, minus the actual burning building!

EVENTS

Auckland Sky Tower Stair Challenge	Melbourne Firefighters Stair Climb
Flights of stairs **51**	Flights of stairs **28**
Weight of firefighting kit **25KG**	Weight of firefighting kit **25KG**
Average completion time **19mins**	Average completion time **6mins**

WHAT WE MEASURED

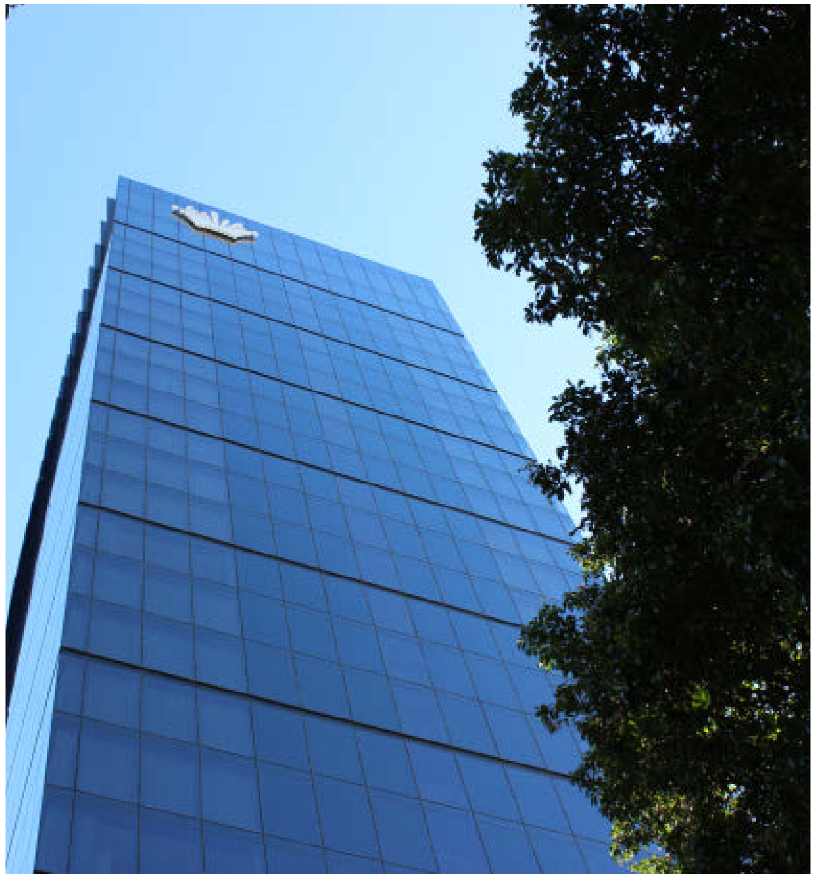
Heart Rate	Breathing Rate	Core Body Temp	Activity	Acceleration

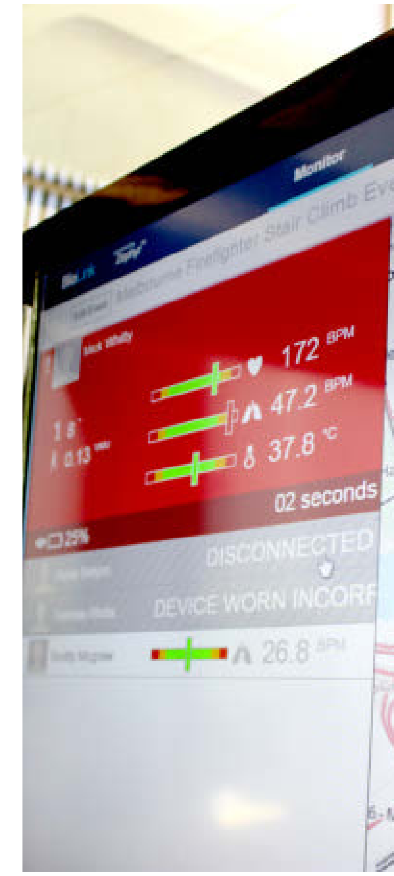


SKY TOWER STAIR CHALLENGE, AUCKLAND NEW ZEALAND

Three fire fighters took part in the Sky Tower Stair Challenge, including an elite team member and a first-time participant, who all wore Tait BioLink as they climbed the tower. The fire fighters climbed the 1,103 steps to the top of Auckland's Sky Tower in full firefighting kit weighing 25kg.

Engineers stationed at the tower base were able to keep an eye on each participant's heart rate, movement and core body temperature to make sure they stayed within the safe range as they gave it everything to reach the top of the tower.





FIREFIGHTERS STAIR CLIMB, MELBOURNE AUSTRALIA

This event simulates the actions of a firefighter entering a burning high rise building, with competitors donning 25kg of kit, including full structural firefighting protective clothing, and Self-Contained Breathing Apparatus. Again, three firefighters wore the Tait BioLink as they climbed the tower.

From the lobby of the hotel, the Tait teams were able to keep an eye on the firefighters' heart rate, breathing rate, core temperature and posture to make sure they stayed within safe ranges as they raced.

Leading firefighter with the Melbourne Metropolitan Fire Brigade, Scott McGraw, is an endurance athlete in his spare time and has competed in Ironman triathlons as well as previously taking on the Melbourne Eureka Tower 31 times without stopping which is the equivalent to 51,000 steps. When asked about finishing the Melbourne Firefighter Stair Climb in 3 minutes and 43 seconds he said, "Running up the stairs was brutal, horrible, but wearing the Tait BioLink was comfortable and I didn't know it was on. As an endurance athlete I am obsessed with information, so it was quite cool to know that the information was public, there on the screen and having someone monitor it. I think for extended work, where firefighter health is a bigger issue, it definitely has merit."

THE RESULTS

Whether it is a better understanding of an individual's fitness and limits of endurance, establishing how long a tank of oxygen will last under certain conditions or data-gathering to improve procedures, physiological monitoring can improve the safety of workers in challenging, dangerous or remote environments.

WHY BIOLINK

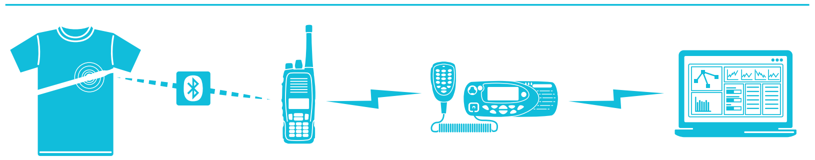
When fire fighters are out there fighting blazes and protecting our communities, they're focused on the task at hand and not necessarily on the physiological stress that they're under themselves. Even in routine situations, this can be the case. BioLink can automatically detect when an emergency responder is under physiological stress so that the necessary action can be taken to keep them safe.

According to the U.S. Fire Administration, 46.5% of firefighter fatalities from 2007–2011 were as a result of heart attacks (http://apps.usfa.fema.gov/firefighter-fatalities/fatalityData/statistics). Physiological monitoring of firefighters can provide a significant improvement in situational awareness on the emergency scene, and positive outcomes for workers.

HOW IT WORKS

Monitoring provides an objective measure of the wearers health status; it means commanders and support crew can intervene when personnel are in distress—even if they do not yet know it, or deny it.

Other applications for this technology include regular, scheduled physical examinations for workers in harsh, dangerous or remote environments. Instead of workers leaving their duties or work site for the examination, their vital signs can be monitored remotely, as they continue their tasks. This saves considerable time and cost, provides more authentic measures, results in greater work efficiency and creates less resistance from workers, compared with the disruption of the physical examinations.



www.taitradio.com/biolink

RACE AGAINST TIME

12 QUESTIONS THAT CAN SAVE LIVES

Are you prepared for a major disaster? The first 72 hours are the most critical for emergency teams to respond to those in need and prevent further damage. Lives depend on it.

In the last decade, the world has experienced a spate of major disasters, from earthquakes in Chile, Haiti, New Zealand, Japan, Turkey, and Nepal to tsunamis in Indonesia, the Pacific and Japan, fires in Australia, floods in the Philippines, volcanoes in Iceland, droughts, hurricanes and tornados in the US. Hundreds of thousands continue to die or suffer. And increasing population density means the scale of disaster in terms of loss of infrastructure and human life will only increase.

Planning for a disaster is far from straightforward; in the months after the Christchurch earthquake, we sought insight into the importance of being prepared, and what can go wrong with the best-intentioned plans. One of the best ways to prepare is to learn what worked for others – including what they wish they had known before disaster struck.

How you answer these twelve questions today could save lives when you're faced with disaster in the future.

1 Do we have an emergency strategy or Business Continuity Plan (BCP)?

2 When was the last time we updated and tested our emergency strategy?

3 Have we considered every contingency?

4 Are our service providers or partner agency BCPs robust and well-practiced?

5 Will we know where emergency personnel and vehicles are if the power is down or the roads are closed?

6 Do we have an 'incident management system' and suitable technology resources?

7 Do we have effective lines of communication with our service providers and other emergency agencies?

8 Are we prepared for disaster? Do our emergency personnel train for major disasters every year?

9 How do we make ourselves aware of everyone's needs, and find, communicate with, and help those in our community who can't reach us?

10 Do we have established relationships with our stakeholders, local businesses (hardware suppliers, concrete cutters), and community groups with whom we can correspond and work with in an emergency?

11 Do we have a communications plan and team to communicate appropriately with both the media and public via a range of mediums, including social media?

12 Is our community aware of the risks, and ready and able to survive by themselves for up to three days after a disaster?

If you have searched for survivors in collapsed buildings, or rescued flood-stranded victims you will know emergency crews rely on their training and the lessons of others to get them by when it's their turn to experience a once-in-a-lifetime major disaster.

Find the full paper here:

http://www.taitradio.com/our-resources/white-papers/race-against-time-emergency-response-preventing-escalating-chaos-in-a-disaster

ANALOG SIMULCAST A RELIABLE, ECONOMIC UPGRADE SOLUTION

Despite the digital communications revolution, a significant number of LMR operators continue to specify modern analog radio networks to serve their communities. Many others are successfully operating legacy analog LMR systems that continue to be optimized and fully supported. Beyond their support role, some manufacturers are developing solutions that upgrade the performance of these analog networks, giving existing and new analog operators ongoing value for the life of the network investment.

When considering radio network design, acquisition costs, crowding or other restrictions on spectrum, it may be necessary to overlap a single frequency's coverage to guarantee seamless operation across the entire area. Obviously, multiple radio transmissions in the overlap zone on that frequency will experience interference.

One solution is to deploy a trunked system. Alternatively, a simulcast system, which utilizes equalization techniques to carefully time these transmissions, minimizes any interference by moving the affected regions of 'interfered' signal to 'less desirable' areas. This can create system architecture that is ultra-reliable, spectrally-efficient and robust enough for mission-critical comms. Installing analog simulcast base stations provides these benefits, without the need to replace existing analog portable and mobile fleets. This results in additional savings, removing the inevitable admin overhead associated with new equipment rollout, and dramatically reducing the need for radio user training.

Tait analog quasi-synchronous (QS^2) systems simultaneously broadcast the same information from all sites in a network using Digital Signal Processing (DSP) techniques to automatically equalise the received audio in terms of bulk delay, phase delay and signal amplitude.

Any differences in site linking characteristics are automatically corrected, ensuring that users receive distortion-free audio or data in the coverage overlap areas.

Linking QS^2 systems requires a very stable and minimal delay, and the delicate time balance must be constantly maintained across the radio network. This stability is non-negotiable for simulcast systems, as whenever the propagation time between sites changes, the system needs to retrain, allowing for the new time by adding the necessary delay. That results in short periods of unavailability, which is simply unacceptable in business or mission-critical environments.

High performance MiMOMax radio links with 4-wire audio interface between base stations provides low latency, low jitter, throughput capacity and reliability, so that an analog simulcast system, such as Tait QS^2 can efficiently and reliably cover a wide area with a single FM radio network channel. Combining this technology with a MiMOMax NDL linking system ensures the highest possible analog simulcast performance, with ultra-high throughput capabilities, and low latency and jitter rates. At 64QAM the MiMOMax NDL linking provides 5m/s latency with less than 10nsec jitter to support up to four QS^2 channels.

MODULATION MODE	LATENCY	CHANNELS SUPPORTED	JITTER
64QAM	5M/S	UP TO 4 CHANNELS	<10NSEC
16QAM	6M/S	1 TO 2 CHANNELS	<10NSEC
QPSK	8M/S	1 CHANNEL	<10NSEC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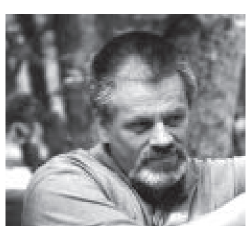

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CONNECTION MAGAZINE

Published by Tait Communications.

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ISSUE 6