Tactical Data Links over WD1/TT or 'DON10'

Innovative Approach to Ad-Hoc Network Links and Effective Information Sharing in the Deployed Environment

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ABSTRACT

This paper reviews an Australian Army and industry collaboration that resulted in an innovative product for tactical data and voice links.

The original idea was to overcome the problem of frequently damaged fibre-optic cables (FOC) in a deployed environment. Emerging copper based transmission technologies were considered as a potential alternative. Copper cable (DON10 or WD1/TT type) in contrast to FOC is a 'soldier friendly' medium that has been used extensively since the First World War - and now new transmission technologies allow copper cables' use in a modern tactical data applications - with significant cost and functionality advantages.

The paper reviews how an innovative idea from was transformed in to a successful product that has been operationally proven in major theatres including Timor Leste, Afghanistan and Iraq – as well as its adoption in a wide range of applications, including data distribution and sharing in a tactical environment.

The rationale for designing a new communications product that uses an old medium of copper wire (DON10 or WD1/TT) will be explained along with functionality comparisons to fibre-optics and wireless technologies – especially where their limitations are concerned.

The resulting new product – 'P3' and its applications will be reviewed from its early trials through to current operational deployments with the British, Australian and New Zealand Armed Forces. In addition, the product's unique capability in disaster recovery and civil defence applications will be presented.

This Defence and industry collaboration earned the AFCEA 'Golden Link' award, as well as a number of industry innovation awards citations.

1. Introduction

Rapidly deployed, simple, effective and reliable communications are vital in modern military operations. This is even more so when troops are operating in a geographically harsh environment.

Traditionally, deployed networks use fibre-optic based communications FOC. However, fibre-optic cable is bulky and frequently damaged in the field – typically, within two or three days of its roll-out. FOC is also can be expensive and impractical to repair in the field.

Wireless systems often do not operate in mountains, road tunnels and similar terrain where radio signals do not propagate. Often radio signals can not be used due to transmission 'signature' and security implications.

A frequently overlooked issue is the establishment of network links amongst modern coalition partners for effective information sharing.

With this in mind, Australian Army Signals Corp had a vision for a technology that could use existing 'soldier friendly' medium of copper cables for the establishment of simple and effective tactical data links – that addresses the problem of frequently damaged FOC.

In close collaboration with Australian Army Signallers DCI undertook research into a new data transmission technology. Suitable technology, already available for providing internet over existing telephone lines was identified as a starting point; with a number of design adaptations to meet the needs of the needs of a tactical environment.

Specifically, it was important to produce a portable and stand alone package – i.e. be independent of telephone exchanges or ISPs infrastructures. Overcoming this issue was a major breakthrough in the design and establishment of a new product (now called 'P3') as a simple and effective tactical LAN extension device.

The initial application for P3s was data and voice links extension for the Army's Field Deployed Logistics system (FDLS). Typically FDLS links are 2 to 3Kms in length and by its nature need to be relocated every few days. In such an environment, traditionally used FOC systems have a major common drawback – frequently damaged fibre. This is a common problem experienced by all deployed forces, due to heavy machinery present in various logistical units and most frequently during night time operations.

The strength of the copper transmission technology for defence and disaster recovery applications is that it enables high speed data applications over a simple and sturdy communications medium. Copper remains the preferred infrastructure in many military and industrial applications and while fibre-optics may offer greater bandwidth, the cable often breaks under strain with its repair being at the very least impractical in the field environment. Copper can be rolled-out rapidly and easily, is soldier friendly and, used with P3s offered the fast transmission speeds necessary for field communications.

Importantly, DON10 can be used where fibre is difficult or impossible to roll-out and where wireless or radio signals cannot reach – e.g. collapsed building sites, mountainous terrain or under water.

On the technology side: P3's transmission circuits use rate adaptive, DMT modulation that ensures secure and extremely noise tolerant data links. Each transmission channel outputs less than 3 watts of power that is spread over 300 individual frequency carriers – meaning a balanced transmission with an extremely low noise signature that is dissipated into copper cable – an advantage where 'EW' (electronic warfare) may be a factor. The data across these 300 frequency carriers is randomly scrambled which offers inherent security. However, in order to further increase security to a Government level, network or serial (KIV7) cryptos can be used with P3s.[1]

In its basic functionality, P3s extend data at 8Mbs over distance of up to 8Km. Its most significant advantages however were the ease and the speed with which copper cable is rolled out, retrieved and repaired when damaged. In addition, early Army trials indicated a major cost difference – a factor of 10 to 20 times less then the traditionally used FOC systems[2].

P3s were quickly established as a viable alternative to FOC systems especially on a brigade level and below. A range of new applications for the product were developed and operationally proven. P3s, already in use in Australia, New Zealand, UK and Canada are

[1] This point is further detailed in the Transmission Security over Copper chapter

[2] Please see typical ADF rollout costs comparison graphic on page 4

continuing to enhance what has proven to be a truly successful collaboration between Army and industry.

1.1 Rationale for the New Product

An early 'proof of concept' prototype – 'P4' was designed specifically for the Australian Army to prove that 'DON10' (reinforced copper cable) can be used *'or resurrected'* for modern Command and Control (C4SI) applications.

Army trials of eight functioning prototypes proved the effectiveness of this technology in the following way: during the trials, the fibre optic cables used as primary data links would succumb to damage within 2 to 3 days of deployment with DON10 and 'P4s' used in its place to provide equivalent 'back up' functionality.

In another significant trial, JWID-05 in Portsmouth UK, P3s were used as a single back up link connecting main LAND and AIR Command and Control systems. Overnight, strong winds blew apart most of the satellite dishes being used as primary data links; in the morning, much to the surprise of senior officers, the effectiveness of a single DON10 link and P3s was extremely plain to see.

In short, the rationale for the new product was to offer a simple and effective solution to the endemic problem of damaged fibre-optic cables in a tactical (field deployed environment).

1.2 The Concept

Field deployed data applications demand rapidly established communications links of high bandwidth, particularly so in the areas of defence and emergency relief. DSL was identified as one of the best technologies to cope with this demand in field deployed communications.

P3 - first production model March

Based on this, a new type of product that is independent of public telecoms infrastructure and remains portable was to be developed. RADSL *(Rate Adaptive DSL)* transmission technology was especially selected for its robustness to noise, speed and superior distances.

The new product was set to provide transparent LAN (10BT Ethernet) extensions over copper wires. Its integrated voice telephony operating independently of the data, would therefore continue to function even when external data links are down. Specific design features would provide flexibility in bandwidth configuration and much greater transmission distance than by standard telecoms DSL systems.

This design innovation was achieved with adaptation of transmission circuits making their configuration a programmable function of the device. In contrast, public telecoms DSL circuits are offered in two variants: a customer premises modem and telephone exchange equipment. P3s with their design adaptation became inherently deployable due to their transmission circuits' configuration capability.

The new product design was further enhanced by making it free of any additional computers for its set up and operation. A rechargeable battery and high grade components made it possible to operate the device in extended climatic conditions: from -20 to +50ºC. And finally, the ruggedized integrated case ensured that P3s would be a fully field deployable product.

It should be emphasised that copper, besides being a robust medium is significantly cheaper than fibre-optic cable based infrastructure. [3] Fibre-optic cable is damaged easily in an operational environment and it is in this domain that the humble copper cable comes into its own. Copper wire if damaged, can be as easily repaired as tying a pair of shoelaces. It can be deployed and retrieved rapidly and in combination with DSL technology, becomes a viable broadband communications medium, especially in areas where radio waves cannot propagate. Distances bridged by the new equipment over copper cables are in excess of 8Kms and are extended further by daisy chaining any number of P3s. This distance is partly achieved due to the 'DON10' cable construction (4 strands of copper wire, reinforced by 3 strands of steel in each of its two conductors) and

[3] see Page 4 Cost Comparison - Copper Cable vs Fibre

partly due to the fact that when rolled out, it is not subject to adjacent cable electrical interferences (a major factor in public telecom cables). Copper cables, plain or reinforced re-emerge as a desirable infrastructure for a range of military, emergency and industrial applications including the following:

- *telemetry, weather monitoring,flood warning*
- *Civil Defence & Emergency Services*
- *Police ' on the scene' operations*
- *underground mine communications*
- *disaster recovery applications (diplomatic missions and embassies)*
- *restoring communications in earthquake zones and to/from refugee camps*
- *ideal interface between coalition networks especially when operating in a 'low tech' environment*

2. Current Product – P3

Following the success of the functioning prototype P4, the product was redesigned to incorporate the latest RADSL technology, higher tolerance electronic components and custom ruggedisation. The optimal number of fully configurable RADSL channels was determined to be three – i.e. main link, a back up link and spare extension link. In addition, telephony functions were designed to combine analogue (Order Wire and Tel/Fax extensions) and digital VoIP modes

.The **'P3'** ***(P**ortable **3** channels)* requires no external devices to configure or operate - all of the units management is established via the internal microprocessor, keypad and display module.

P3s can be set up in a diverse range of configurations, from a simple point to point transparent LAN link to a complex web of units, including full redundancy links. The data repeater mode of operation means a number of P3s can be cascaded together establishing flexible high speed data links over long distances *(e.g airport perimeter video monitoring).*

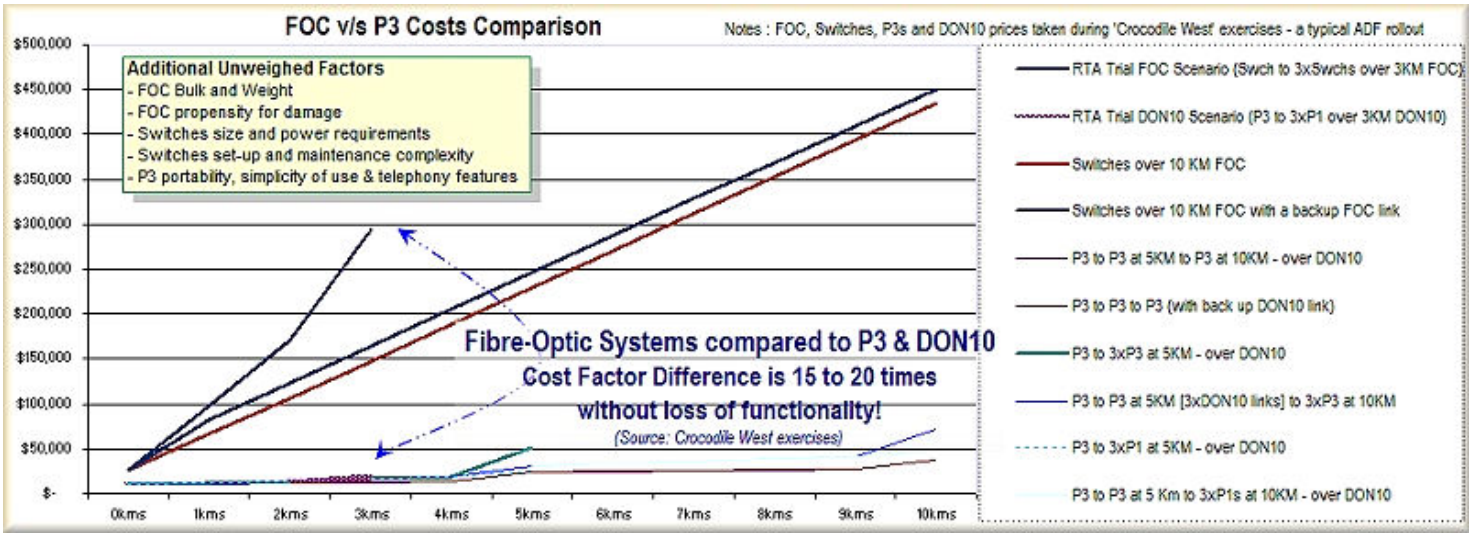
Three transmission channels can be individually configured for 'master/slave' operation, thus allowing effective on demand bandwidth management. This simple facility provides bandwidth where it is required (e.g. a refugee camp sending out bandwidth intensive content of photo or videos of survivors to the disaster management centre and receiving mainly email or text based content, requiring minimal bandwidth.

Six Ethernet (10/100 BaseT) interfaces provide direct connectivity with external LAN networks and a range of 'off the shelf' optional accessories such as video camera, sensors, controllers, etc. Any of these devices' functionality can be transparently extended over copper cables.

Each P3 unit contains an integrated telephone handset for voice over the same copper wire as for data, independently of the LAN traffic. In the event of LAN failures this will continue to operate as a backup field telephone. Standard PABX lines can be extended by any of the P3 operating channels. VoIP will allow for secure voice communications in a meshed network to any of the other P3 locations. For large scale deployments of P3s, management of the comms network can be done remotely via integrated TCP/IP protocols (e.g. Telnet).

The DMT (Discrete multi-tone) modulation, the preferred standard for Defence, provides superior resilience against electrical noise and allows for point to point transmission security (scrambling of data packets).

Internal batteries provide backup operation for up to 8 hours under full load conditions and for longer still, if only one or two of the RADSL channels are active.



The external AC adaptor can be plugged into power sources such as generator, truck battery or solar panels.

This independence of power is particularly relevant in disaster recovery conditions – as often power and other infrastructure is not available for considerable periods. This is the advantage of P3s which are infrastructure independent and extremely simple to use devices.

3. Secure Transmission over Copper

P3, with its rate adaptive DMT modulation technology represents highly secure transmission of voice and data over copper in the tactical environment.

Digital signal modulation effectively encrypts the data transmission by individually initialising each of the 300 data carriers and testing each for its integrity. At that time, data packets are scrambled across active carriers. The effective result of the data transmission can be equated with that of a 'one time pad' – a unique transmission, as data scrambling parameters exist only between any two directly connected P3s. The greater the number of users on any given data link, the greater the scrambling effect. No external device would be capable of "listening in" to the setting up of the transmission parameters process, as the technology provides for two terminal devices only during the line initialisation. In the event of a copper line being cut, the transmission stops. Similarly, should an external 'listening' device be introduced, the initialised transmission parameters will alter and interrupt transmission. The user is able at all times to monitor the line conditions.

For a higher level of data security (e.g. DSN) serial data encryption devices such as KIV7 can be used with P3s with the aid of an additional RS530-Ethernet interface device. Alternatively, a network encryption device can be connected to a P3 directly (Ethernet interface) with P3 remaining a 'black box' that simply passes the data through. It is of course possible to combine both DSN and RDN type traffic within a single P3 link thus offering further significant costs reductions to Defence.

Following early equipment trials, Australian Army conducted an assessment of the cost differential between the use of transmission using copper cable compared to fibre optic cable. This is based only on the cost of infrastructure and does not take into account costs of damage and replacement of cables, commonly experienced with fibre optic.

Using a variety of scenarios, the following chart shows the exponential cost escalation over distance, and with the addition of backup links.

The starkest example of cost escalation in the RTA Trial scenario (blue line), but in all cases it can be seen that the costs of extending copper rises only marginally in contrast to fibre optic cable where the increase is rather more dramatic.

4. Areas of Application

Australian Defence had identified the need for a solution that allowed its Land Local Area Network (LAN) Communications to be extended to its field deployed logistics units. The in-barracks logistics system (Standard Defence Supply System SDSS) was to be extended to provide support for its logistics business, whilst being deployed operationally in the field. The resulting deployment of SDSS supported by its stand-alone version (called FLMS Field Logistics Management System) provides seamless 'in and out of barracks' communications.

The extension of the LAN comms was largely made possible with the use of P3 and is now part of Army's new standard for field deployed communications.

Another important issue addressed by ADF was the need to provide redundant links (backup) for downed fibre optic networks – a regular occurrence in the field. Signallers can easily and cheaply repair copper cable, in sharp contrast to fibre optic cable, resulting in significant cost savings with no loss of capability.

The British Army, in seeking to improve its out of barracks logistics and supply support, (UNICOM OOB) successfully trialled P3 in 2003. P3 is now in service with the British providing remote access and enhancing the capability of the existing UNICOM system.

The Canadian Army has also trialled the product for an innovative 'Fire Control' application where the device provides data as well as voice command extensions from a ballistics computer to individual gun positions. Again, the use of copper as the main communications medium is not only significantly cheaper but enhances functionality by providing seamless back up links using the spare P3 transmission channels.

Another important application for P3s is provision of data links amongst coalition partnenrs i.e. Joint Forces Operational Environment. This is an essential and often overlooked are of information sharing in a tactical environment. Tactical data and voice links established over 'DON10' cables and P3s not only offer fast, inexpensive and reliable means of information sharing – they can be rolled out and retrieved with an unprecedented speed making its redeployment (as well as repairs) easy and to effective.

4.1 Civil Defence & Emergency

Communications are of paramount importance in the management of emergency situations. In crises such as fire, flood or explosions, existing communications infrastructures (typically fibre optic networks) are often damaged or destroyed, and an immediate task for emergency response teams will be to enable communications to and from the damage site. There is a further demand for interoperability of equipment between civil emergency response teams and the military.

It is commonly thought that wireless communications will provide an immediate and all encompassing solution. However, in a typical disaster area where no power and other infrastructure may be available it takes considerable time and resources to deliver and setup for wireless. As well, this technology has limitations in propagating in difficult terrain.

In such disaster situations, P3s have a proven functionality. A portable device that is weather proof and independent of power or other infrastructures can be deployed on site instantly. Multiple P3s may be interconnected expediently with field wire (reinforced copper wire) thus creating an independent data and voice network to allow affected communities to exchange video, email, voice and other data sensory information.

An issue which arises at the site of major disasters is the sheer number of personnel needing to communicate with each other. The presence of multiple government agencies and NGOs often results in their duplicating each others efforts and, more frequently, being unable to provide aid and relief due to unavailability of one or the other infrastructure. The P3 system, being compatible with industry data and voice networks as well as with each other, means an agency or NGO can tap in to the P3 communications, from initial through the ongoing stages of operation. The ease with which links are extended between relief camps and actual disaster area of operation, makes it extremely effective to "reach" personnel via voice, data or video, provide full telemedicine capabilities and to offer affected groups communication with the 'outside' world.

"….one of the the most pressing needs emerging in the wake of September 11, is effective communications among civilian and emergency response personnel." Signal magazine June 2002

5. Future Enhancements

The newly emerged data modulation over copper cables technologies will add significant distance and bandwidth capability to the new generation of P3s to around 50Mbs - an unprecedented bandwidth for

copper cables. New battery technology and form factors will contribute towards the products versatility and weight reduction – guaranteeing continued use of copper cables in modern Network Centric environment.

Variants of the new P3 would become a basic data and voice link module that would be used across a wide range of field deployed C3 type applications – from stand alone tactical data links to vehicle or artillery pieces mounted comms elements to essential links Civil Defence and Disaster Recovery applications.

6. Conclusion

As a result of the past three years, substantiation of the product by ADF and others, it has been determined that a considerable demand in both defence and civilian markets exists for this type of specialised product. The decisive factors for this are the dramatic savings in cost, setup and maintenance. Copper continues to be a soldier friendly medium and P3 resurrects its role in meeting today's communications needs.

While fibre optic will retain its role as the communications backbone, P3 provide Command and Control extensions on the brigade level and below. P3s will function as simple and effective means for rapidly established data and voice links in a tactical environment.

Australian Army Field Trials Report
"New Technology WD1/TT (don-10) network"

Army uses fibre-optic cable to provide a communications infrastructure for logistic support. The fibre optic cable, kevlar-armoured especially for Defence, is an expensive medium and suffers breakages from being caught up in the track link of tanks or broken by forklifts. These accidents, actual events during Exercise Phoenix, normally occur during night under blackout conditions. Although the fibre can be repaired, such repair requires return to base and expensive facilities.

Army traditionally uses Don-10 copper wire strands reinforced with strands of stainless steel wire to carry voice in the field. This cable, capable of withstanding heavy stress, still gets broken but is easily repaired by users. Wire cable deployment is also considerably easier to achieve than laying fibre optic cable. P4 xDSL was employed during Operation Phoenix and Crocodile West to prove an ability to replace fibre optic cable segments with Don-10 on selected long runs.

The following are some first hand impressions and feedback from Army users of the Don-10 technology on Operation Phoenix; "Soldiers understand this and they can fix it" (meaning wire and breaks that occur as opposed to fibre optic cable); "Can I get some more; "This is great"; and "Hey, it works".
Portable xDSL systems provide data rates over copper or steel cables that are acceptable with significantly reduced capital costs. P4 primary application during Operation Phoenix was to enable transparent LAN extension within a large logistic area, located in the bush near Tindall.

A number of specific future requirements have been discussed. One such special development is a simple back to back xDSL modem, providing the Army with rapid deployment multimedia infrastructure over copper cable. It greatly reduces the cost-per-line factor due to the elimination of the more cumbersome subrack assembly of a standard system. This technology successfully provided the logistic LAN backbone on Operation Crocodile West, 150 km SW of Tennant Creek, when fibre optic breakages and distance limitations proved difficult to overcome.

The WD1/TT (Don-10) LAN extensions are robust, cost-effective and well-accepted by soldiers. Tempest-rated within the restricted environment, the solution is now a Defence Infrastructure standard within the strategic environment however it is not yet formally accepted in the tactical arena.

end of report

'Crocodile West' Exercises, May-1999
Proving the 'P4' Concept for Tactical LANs

7. References

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3. ETSI basic VDSL standard (incl. key functional and electrical requirements) : TS 101 270-1 V1.2.1 and TS 101 270-2 V1.1.1
4. Australian Army early deployment trial results: "New Technology - WDD A/TT (Don-10) Network"
5. Case Study SDSS (a complete Field Deployed Logistics solution)
6. "P3 Transmission over Copper - Security" by A.Umansky 2003

The above material can be viewed in further detail at: www.defence-comms.org or by forwarding your questions to: info@defence-comms.org

BIOGRAPHY:

Alec Umansky began his career in public telecommunications in 1981 with Telecom Australia (now Telstra) in the area of Trunk Switching, following his graduation from RMIT (Royal Melbourne Institute of Technology) in Electronics Engineering and Digital Communications.

At Telecom, Alec's flair for design of innovative microprocessor systems was encouraged and produced a number of award winning data processing systems. He then joined Philips (Public Telecommunications Systems) with work focusing on introduction of new fibre-optic transmission technologies (SDH) into Australia, Germany and UK.

Following a number of European posting, Alec retuned to Australia and formed his own company, Defence Communications Industry focusing on niche Defence applications.

In his spare time, Alec plays guitar, enjoys mountaineering and is a contributing member of AFCEA.

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