COMMUNICATIONS

AN OPERATORS PERSPECTIVE

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1 INTRODUCTION

The planned Locomotive communications projects in Australia's communications network will change the entire Train Control communications network. Communication systems have become one of the most critical components of a locomotive and hence train operations. Inquiry reports of major incidents such as Glenbrook NSW (December 1999), Hexham NSW (July 2002), Waterfall NSW (January 2003), and Chiltern Victoria (March 2003) all clearly emphasise the mandating of effective train communications. This significant change, in this critical area of railway operations, is providing the industry with an excellent opportunity to right the wrongs of the past, thus an integrated and well communicated approach is required within the industry.

2 PACIFIC NATIONAL

Pacific National is Australia's largest private rail freight business. Operating in all States and the Northern Territory, Pacific National is a transport leader, delivering investment, innovation and growth in rail to provide the competitive answer for transport customers.

We have around 3700 staff, 1000 locomotives, 10200 wagons and 100 sites.

Built on a generation of rail experience - two important government rail corporations - Pacific National brings success in logistics reform and business growth to Australia's rail industry.

Our customers benefit from a national focus and a competitive service.

Services include bulk freight (coal, grain, steel, ores), intermodal containers (domestic and export), and specialised services such as express trains and the haulage of long-distance prestige passenger trains.

3 CURRENT STATUS OF COMMUNICATIONS

Communication is a critical component in the operation of trains and terminals around Australia. Several types are mandated for operation of trains in various networks. Good reliable communication is vital for safety of train operation and terminal management.

There are several types of telecommunications that are currently employed by Pacific National. These include:

1. Locomotive communications to train control via radio
2. Locomotive communications to train control via telephone
3. Locomotive local radio communications for train-to-train, shunting and signal boxes
4. Locomotive telephone calls – GSM and Satellite
5. Portable radio (hand held) off-train communications

6. End of Train monitoring systems
7. Data communications via telephone for locomotive position reporting and emergency messaging
8. Portable transferable Train-to-Base radios
9. Train crew issued portable radios
10. Cellular mobile phones – hand held backup phone (GSM or CDMA)
11. Satellite phones – hand held backup phone
12. Wireless data networks in Freight terminals
13. Freight terminal and driver depot general radio communications
14. Crew coach radios

Australian Train Control Communication Systems

There are numerous Train Control communications infrastructures operating throughout Australia in non-urban areas. There is a mix of open systems (UHF and VHF radio), closed systems (telephone based) and proprietary systems (Victorian TTB, CountryNet). These are summarised in the table below. The geographical areas are displayed on the map in Appendix 1.

Table 1- Australian Train Control Systems

SYSTEM	Equipment	Comments
NSW CountryNet	UHF radio and satellite telephone	Proprietary signaling
NSW MetroNet	UHF radio	Proprietary signaling
Victorian TTB Voice Only	UHF radio	Proprietary signaling
Victorian TTB Text Authorities (ASW)	UHF radio	Proprietary signaling
WestNet (WA)	UHF radio	PMR with CTCSS
QR – (QLD)	UHF radio and DTC	Proprietary signaling
ARTC (SA, NSW and WA)	UHF and VHF radio	PMR with CTCSS
ARG (Darwin Line)	Satellite telephone	PSTN dial up telephone
TasRail	VHF radio	Selcall

Trackside phones are also still available in various areas, however they are unreliable, impractical for train crews and in diminishing numbers. ARTC has indicated that phones attached to signals will be progressively phased out over the next few years. These should not be considered as a viable alternative in today's advanced technological environment.

Locomotive Communications

Communication required for train operations takes numerous forms. There are over 350 rail radio channels installed in PN locomotives to cover Train Control, Signal Boxes, Terminal Channels, Shunt Channels, Train to Train, off-train, and Train Manager channels.

Listed below are the various systems currently in use in the PN locomotive fleets.

Table 2 - Locomotive Systems

SYSTEM	COMMENTS
Train Control	UHF radio, VHF radio and satellite phone
Local Train radio	Train-to-train, shunting, wayside, etc
Train to Train Manager radio	For GSR passenger trains
Off train radio	DOO and repeater mode
Cellular phones	For connection to the public access telephone network
Satellite phones	For connection to the public access telephone network
Communications Control Centre	For switching phone calls to/from locomotives
Satellite Position reporting	Location reporting to TMS
End of Train Monitoring System	Rear of train integrity monitoring and indication
Automatic Train Protection	Communication based safe working system
Emergency Reporting	Vigilance activated and driver initiated
Distributed Power	Remote radio control of locomotives

Train crews

Train crews also operate with other types of communications that may be additional to locomotive equipment such as:

- Hand held radios
- Transferable train radios
- Cellular phones
- Hand held satellite phones
- Crew coach radios

Mobile Telephones

Various types of cellular mobile telephones are used throughout the company for locomotive related operations. These include:

- GSM fitted to Locomotives
- CDMA hand held cellular phones
- GSM hand held cellular phones
- Satellite fitted to locomotives
- Satellite hand held phones used by train crews in remote locations and as backup on the Ghan passenger services to Darwin.

Communications Control System

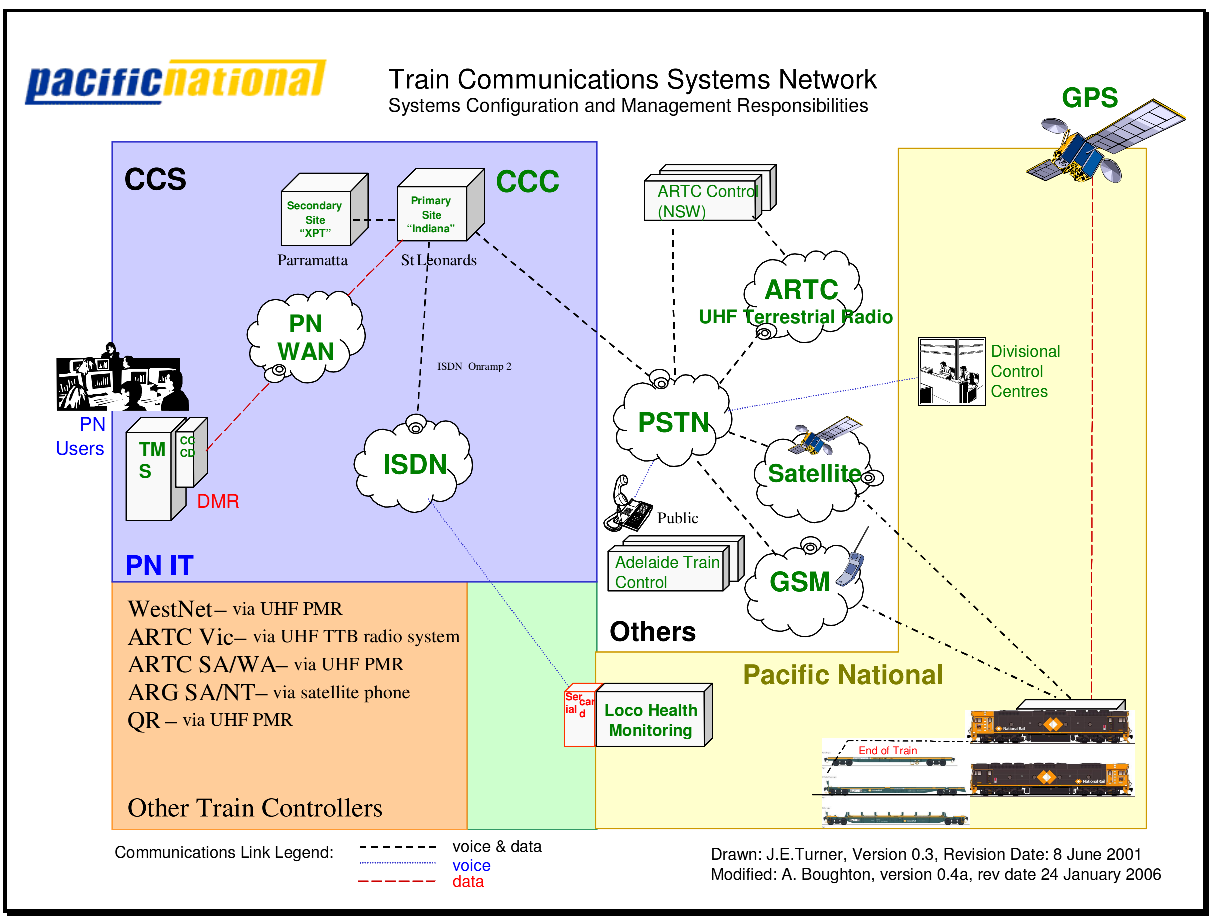
The heart of the Pacific National Communication Control System (CCS) is the Communication Control Centre (CCC). This is a telephone call switching system designed to allow train control calls to be prioritised over standard calls. The pre-emption process is required with most train control systems to ensure safe operation of trains is the highest priority. The CCC is also used to log calls and provide an easy train ID numbering system.

There are two identical systems in separate geographical locations designed to provide immediate backup in the event of failure.

A major benefit of the CCC is the facility of a simplified phone number system which incorporates the locomotive number, thus eliminating the requirement for maintaining individual telephone unit numbers.

Figure 1 shows the schematic diagram of the CCS. The CountryNet system and the Phone Augmented Communications Environment (PACE) system also use various functions of the CCS. Whilst the PACE system operates similarly to the Australia Wide Augmented Radio Environment (AWARE) system, the CountryNet equipped locomotives only utilise the TMS emergency messaging system.

Figure 1 - Communications Control System



4 COMMUNICATION TECHNOLOGY

Technological Advancement

Today, electronic technology is said to have a three to five year life cycle. The rail industry needs to be mindful of this limitation when selecting new equipment and reviewing existing systems.

There have been a number of technological changes in wireless communications over the last few years. The rail industry is currently embracing these new technologies and implementation of new infrastructure is planned to occur in various areas over the next 5 years.

The largest project to impact operators locomotive equipment requirements and train operations is the planned changes to the ARTC network. ARTC is considering a 3G cellular telephone based Train Control Communications system for their network.

Other projects currently under consideration will include new systems in Metropolitan Melbourne, Metropolitan Sydney and Regional Victoria. It is important to facilitate interoperability between systems such as the replacement Melbourne Urban and Victorian Non-urban networks.

New systems such as the communications based Automatic Train Protection (ATP) in Queensland will broaden the role of the communications systems to become more integrated into the control of the locomotive. Systems such as Driver Initiated Control Equipment (DICE) on the Alternate Safe Working (ASW) corridor and the proposed In Cab Activated Points System (ICAPS) on the Nullarbor extend the communications system to in-cab signalling functionality. The Advanced Train Management System (ATMS) has interfacing to the locomotive including brake pipe pressure monitoring, brake control, speed sensing as well as the End of Train Monitoring System (ETMS). The system uses these interfaces for speed and brake monitoring and intervention.

Train Position Reporting

Train position reporting has an increasingly higher focus within the rail industry, with the capability of Train Control to track trains with a high degree of accuracy in real time. Freight tracking (via satellite position reporting) by operators is also of significant benefit to their customers.

Emergency message reporting to Train Managements Systems (TMS) is also available on these fleets.

The accuracy of a GPS tracking system is determined by the time interval between reports. The more reports; the closer the tracking in real time, however the cost of the data calls increases correspondingly.

Future proposals could provide operators with satellite position reporting without the requirement for additional on-board equipment or the cost of data calls.

Worlds best practice

New technologies have been implemented around the world in rail communications and these systems, such as the European Rail Traffic Management System (ERTMS) in Europe and Positive Train Control (PTC) system in the USA have proven to be a quantum leap in train control. These systems are based on cellular telephone networks such as GSM-R and CDMA.

The aviation industry continues to use open channel analogue radio communication between mobile units and Controllers. Open channel communication is also used to provide pilots with awareness of other local area traffic. However, they also have the advantage of position reporting via radar, and therefore have an accurate view of traffic separation. This is not possible with Train control, except through satellite position reporting.

Digital radio communication is becoming more prevalent due to enhanced flexibility and extra functionality. Analogue technology can only provide voice and limited data facilities. Digital communications can provide better data capability, enhanced security, improved noise reduction, multiplexing, fast processing, and faster validation and verification techniques.

Security of communications has not historically had a significant focus within the rail industry. Privacy, caller identification and validation (authentication) should be important factors in the protection and integrity of rail communications to ensure the highest levels of safety and criticality. Communications security should be an important consideration not only in terms of rail safety but also to ensure company confidentiality.

Rail Train Control Systems

The Australian Railway Association (ARA) network provision guidelines call for train control communications intelligence to be located centrally, rather than all on-board the locomotive. This allows operators to enter a network with minimal equipment required.

Two important considerations in assessing future requirements for new train control systems are interoperability and the cost to operators.

Communications Based Train Control replaces the traditional use of track circuits and signals with on-board equipment interfacing to a central system via wireless telecommunications. This is becoming the preferred method of train control due to the reduction in trackside infrastructure required. It is a continuous automatic train control system utilising high-resolution train location data and independent of track circuits. It also has high capacity, bi-directional train-to-wayside data communications, and train borne and wayside processors.

Satellite Position Reporting

Train position reporting has become an essential tool in train management in terms of:

a) Train Control
b) Asset management
c) Customer freight tracking and management
d) Emergency messaging, and
e) Driver assist displays

Satellite position reporting for Management Systems is generated from a location report out of a GPS receiver on board the locomotive, sent out via GSM or satellite telephone to the CCC and then through the LAN to TMS.

The CountryNet Train Control communications system in NSW also accepts satellite position reports from trains via radio and satellite telephone.

Communications based signalling systems such as CountryNet and the proposed ATMS rely on GPS for train position reports, rather than the older concept of track circuits.

Other on-board systems such as Fuel Management Algorithms use GPS to determine track location, gradient and train speed.

In the event of failure of the satellite position reporting system, other processes such as dead reckoning (using last known position versus train speed and distance travelled) should be considered in operational procedures.

Data Communications

Data communications from locomotives and wayside infrastructure is a key feature in any communications upgrade to be performed in the future.

High-speed data communications are not currently available with the systems used in the Australian rail industry. In order to have added facilities such as remote health monitoring, remote downloads and Internet access the communications medium and equipment needs to be capable of high-speed data.

Data communications will be an important feature for future technology advancement on locomotives due to the expanding innovation of remote health monitoring.

TCP/IP platforms can be used to allow a great deal of flexibility with system design. A base system can have additional peripherals added to allow enhanced functionality.

Local Train Radio

Local train radio is required for train-to-train, shunting, trackside or perway, signal boxes, ICAPS, DICE, repeater mode (off-train communications), train manager, and trackside detectors such as hotbox.

Local train radio has been identified in incident investigations as a major factor in incident prevention. Trains operating on the same track or parallel tracks need to have immediate contact with each other in case of emergencies or potential incidents.

Safety practices such as roll-by reports are also important reasons for local train radio availability in an open channel format.

Equipment Safety

Due to the harshness of the environment on a locomotive (eg vibration, temperature, power supply fluctuation) communication equipment should be robust and designed to a rail standard. The equipment should be compatible with other on-board systems, and EMI and EMC standards compliance is important. This will ensure that no degradation of system performance is encountered.

Intrinsic safety is defined as electrical or electronic equipment that does not contain hazardous materials, high voltages, bare terminals, or potentially dangerous parts. The equipment will not cause arcing or sparks that could ignite flammable material.

Due to the nature of the environment the equipment operates in, especially with regard to portable hand held equipment, it should be certified to an Intrinsically Safe standard such as Factory Mutual Approved wherever possible. This is required to minimise the possibility of incidents with dangerous or flammable goods.

All terminal hand-held equipment should also be certified Intrinsically Safe (IS) to ensure safety integrity levels.

5 FUTURE OPERATOR COMMUNICATIONS REQUIREMENTS

There will be significant movement in rail communications in the next few years. With projects underway including the ARTC ICAPS and CDMA/ATMS systems, and planning for new systems in Metropolitan Melbourne (Victrack), metropolitan Sydney (RailCorp) and regional Victoria (Victrack, Pacific National), there will be substantial changes to infrastructure and mobile equipment.

The ARA has taken on the challenge of recommending the rail industry adopt a national strategy for interoperability of all communications systems. This should cover both suburban and non-urban areas. They have also taken the view that the industry should work towards standardising to two systems for Australia – one for suburban and one for non-urban networks.

Implemented correctly, communications can add value through enhanced operational efficiency and safety.

Notwithstanding commercial arrangements with track access managers, operators require functionality from their communications systems (which include train control networks) that allows high levels of capability and flexibility in line with business needs. It will therefore be necessary to determine the functionality that is required above that supplied by the primary operation of the networks (eg train control purposes).

Locomotive Equipment

Operators will continue to require generic systems fitted on-board locomotives to provide basic capabilities such as

1. Train to Base (Train Control),
2. Train to train (driver to driver),
3. Off train radio (repeater mode),
4. Driver to train manager,
5. Telephone to PSTN (cellular and/or satellite),
6. Wireless Data transfer (eg satellite position reporting, remote health monitoring),
7. End of train monitoring, and
8. Emergency reporting.

Interoperability

Standardisation of rail communications is required in order to harmonise the movement of trains between networks. Interoperability is necessary at the system level rather than manual links (eg PSTN phone calls) between train controllers.

Interoperability is required with all systems around Australia, not only in non-urban networks, but also with urban networks in some form. There is a mix of shared lines and varied gauge parallel lines that require direct communication between train to train and train to base (train controller).

Changeover in mobile terminals should be seamless to the operator regardless of what infrastructure the mobile system is interfaced to. Operation of the system and MMI (Man Machine Interface) should remain relatively standard whether in an urban, regional or remote location.

Future systems should be based on open standards rather than proprietary protocols, and be available from a range of vendors rather than limited to one (as has been the case in many previous rail communications systems).

Systems designed around non-proprietary, off-the-shelf equipment and software generally provide a lower priced solution.

Standardisation

Standardisation of locomotive cabs is an important factor in ensuring minimal restrictions between locomotive classes. There is currently a wide range of system types in use throughout most operator fleets. This variation often generates maintenance issues in terms of the complexity of spares holding and skills required.

Standardisation of hardware and software can have many benefits including:

1. Minimising the range of spares required,
2. Narrowing the training and knowledge required by maintainers,
3. Narrowing the training required for operators,
4. Improved economy of scale on procurement,
5. Improved economy of scale on maintenance,
6. Minimising crossover issues for operators,
7. Reduced variation in configurations, and
8. Less engineering required for upgrades, changes, enhancements, etc

With any infrastructure system changes, Rail Operators require adequate migration time to enable on-board systems to be developed, tested, commissioned and bedded-in. Insufficient changeover times in the past have invariably caused reliability issues after decommissioning of the previous system, without back-out processes in place.

Functionality of a communications system should be based on critical versus non-critical requirements to help assess the complexity of the system. The addition of non-critical or low priority options should in no way impede the critical or primary communications functions.

Communications Coverage Requirements

Railway operators today operate trains not only in urban areas where various communications network infrastructures are available, but also in some of the remotest parts of Australia. Thus, wherever a train operates, reliable communications are required with as close to 100% coverage, 100% of the time as practically possible. It is acknowledged that there can be black spots in coverage footprints of a communications network, and operational requirements need to be assessed against a cost benefit analysis of additional coverage of these restrictions.

Coverage of radio and telephone should provide 100% availability to ensure effective train operations and more importantly safety. At least one form of communication should be available at all times to provide emergency communications. This includes remote areas, built up areas, mountainous areas and tunnels. All tunnels where trains operate should have train control communication coverage, and preferably at least one other form eg cellular phone network. Consideration of this safety aspect should be included in any new infrastructure installations. Where systems require satellite telephone operation, some form of translator is required to ensure coverage in black spot areas such as tunnels.

Backup systems and in-built redundancy need to be incorporated into essential communication systems both in mobile and fixed installations. These may take the form of radios or telephones to connect to the PSTN.

Communication with Train Control should be a priority, with operational traffic taking precedence over general non-vital traffic. Direct and rapid contact with emergency services during incidents is also a vital function of locomotive communications.

Transition

As new technology is introduced there will always be a transitional stage and the impacts of this must be understood and a high level of planning dedicated to ensure systems are supported and the operational environment has minimal disruption. The greatest issue for operators at this time is that existing systems will need to remain operational while the new are installed, especially if the system being replaced has multiple interfaces (such as Pacific Nationals AWARE system).

As industry moves towards a possible solution of CDMA and Digital Train Radio Systems (DTRS) the introduction of these systems within each state will be staggered thus the operator could be left with a situation of having to retain the existing extensive communications systems AND install the new systems. There is also still a real risk that each state will have a different DTRS solution that requires electronic modules and software on-board locomotives to support, the end result being not dissimilar to the present.

Maintenance

There are various management techniques that can be used to provide effective maintenance, such as fix-on-fail (reactive maintenance), scheduled preventative maintenance, periodic maintenance (inspection), reliability centred maintenance, condition monitoring, redundancy, upgrade, etc. They can be used singularly or more effectively in a combination of several types.

Techniques such as Fault trend analysis, Pareto analysis, Six Sigma, root cause analysis, benchmarking, and failure mode and effect analysis are all used today in maintenance management.

Longevity of Technology

Today, technology has an expected life of 3 to 5 years before it is considered outdated. This is an important factor in consideration of new equipment and its expected useful life. Original Equipment Manufacturer (OEM) support is essential when systems are rapidly updated, and technological advancements make relatively short-life equipment no longer supportable.

Future proofing of new systems and equipment is necessary to make changes cost-effective as well as having minimal disruption to normal operations.

Due to the rapid advancement of cellular handsets and modems, systems based on these should be designed with the capability of easily integrating new technology.

Skills shortage

There is a general shortage of experienced personnel within the rail industry, predominantly due to the growth the industry is currently experiencing.

Operators are conscious of the potential for loss of skills and knowledge through staff turnover. Moving forward, communications within the transport industry will become a more significant factor in business requirements in terms of safety, efficiency and competitive advantage. As such the requirement for the appropriate skills will increase.

Data Protocol

There currently is no industry data protocol standard for use in applications such as simulation, fuel algorithm software and driver assistance software thus the data transfer between these systems will be inefficient. It is recommended that a protocol be developed as soon as possible so that these applications run off a single track information database.

Cost efficiency

One of the key challenges moving forward is for Operators is to ensure it has communications systems that are:

1. suitable
2. effective
3. efficient
4. reliable
5. upgradeable
6. easy to use
7. low cost.

In line with the business requirements, communications should be affected with minimal cost over the whole of life cycle. In order for the business to ensure cost effectiveness of the operation of the locomotive fleet in terms of communications, several acquisition and ownership cost considerations should be analysed including:

1. Procurement

2. Maintenance
3. Operating/call costs
4. Upgrades/ expansions.

6 CONCLUSION

The Railway industry has many challenges that it must face in the coming years and the choice of communications requirements going forward is one that certainly has its own set of challenges. These include interoperability, standartisation, coverage requirements, how to operate through transition and skills shortages. Operators such as Pacific National are aware of these issues and working with industry to progress towards an optimal solution. There is however, still a large element of risk that we will not 'right the wrongs of the past' and further collaboration of all parties is required to focus on these issues.