DYNAMIC COMMUNICATIONS FOR DYNAMIC SERVICES

A Global Railway in the Digital Age

A global railway in the digital age

Most of us would accept that the mass adoption of Information Communications Technology (ICT), driven by unparalleled investment, has changed the world we live in over the past two decades.

Certainly the digital revolution is changing the way our railways are operated, maintained and marketed. But we should not let today's rapid pace of innovation obscure the historic symbiosis between telecoms and railways. The development and adoption of the electric telegraph occurred almost concomitant with that of the steam locomotive, allowing railways to transmit vital messages along their newly-laid tracks from station to station.

Mechanical signalling emerged as railways became busier and the role of telecoms equipment was enshrined at the heart of safe train operation. That relationship has endured for more than 100 years, and in that time both industries have moved with the times to adopt new technologies — not least electronic relay-based signalling equipment from the 1960s onwards.

So what is new today? Perhaps the most obvious challenge facing today's railway is to overcome the perception that ICT is a simple utility that performs a familiar and necessary function. The days of fitting cables and periodically replacing them are coming to an end. Furthermore, while the investment cycles of telecommunications carriers have accelerated rapidly, the rail industry still believes in the 15 to 25 year life cycle.

Secondly, rail infrastructure managers and asset owners are increasingly asking about ICT network security, how these assets are managed, and ultimately about operational risks and how those risks are managed. So in the following pages we hope to showcase a little of what next-generation communications will bring to the railway. We can split rail ICT into three distinct segments: operations (p4), safety, security and train control (p6) and the passenger experience (p8).

In the operational field, the emergence of the high-bandwidth IP-based backbone offers significant economies of scale by driving convergence towards a single ICT network, with secure separation of safety-critical data traffic. This can add value right across the industry by providing more bandwidth — from rolling stock owners wishing to monitor vehicle performance remotely in real time, to freight operators wishing to deliver a more customer-specific service by using live consignment tracking for individual cargoes.

Bob Herritty
Global Vice President, Transportation
Alcatel-Lucent
Robert.m.Herritty@alcatel-lucent.com

The role of telecoms in safety-critical fields such as train control is also rapidly evolving around the development of communications-based train control such as ERTMS. Neither the ICT sector nor the rail industry is under any illusion that this migration will be easy or rapid — already there have been several examples of teething troubles hindering the rapid adoption of ETCS technology.

Overcoming such obstacles will require close and trusting partnerships between ICT providers and rail industry customers. Railways will come to appreciate that the role of an ICT partner is far more critical than it has been hitherto, while telecoms providers should seek to reassure railways that they have a reliable long-term partner to guide them through the migration process, a particular challenge as many railways have multiple telecoms assets that are heading rapidly into obsolescence.

But there are clear commercial opportunities too: the passenger experience could be transformed by communications-driven services. Already we are seeing widespread uptake of contactless ticketing, and the mass adoption of smartphones should only speed this trend. Broadband wireless services running on faster, more robust networks should also enable rail and metro operators to give their passengers 'the personal touch'. Individual journey plans, tailored marketing messages and, most importantly perhaps, improved customer service during disruption will all become familiar to tomorrow's commuter.

So in short, next-generation information and communications technology is emerging from the shadows. No longer a hidden asset to 'fit and forget', it must be embraced by the rail industry so operators and infrastructure managers can deliver a global railway for the digital age. We invite you to read on.

IP backbone underpins efficient operations

As high-capacity digital technology offers more functionality from a telecoms network, the railway industry is rapidly facing up to the task of integrating an asset that has traditionally been viewed as a relatively simple utility.

No longer: high-bandwidth, IP-based networks promise new possibilities. Central to this evolution is the ability of optic-fibre lines to carry different types of data simultaneously, permitting delivery to the end user in manageable and accessible formats. Safety-critical voice and transmission data is protected and prioritised, whilst the railway operating sphere is brought closer to the customer through use of an IP backbone to deliver real-time journey information or consignment tracking.

Whilst voice and train control data are standard elements of railway telecoms, it has become far easier for railways to 'bolt-on' functionality to give their ICT assets additional capability. One option that is likely to become more prevalent in future is the sale of excess capacity on railways' IP networks in a controlled manner to public telecoms operators, as Swedish rail infrastructure manager Trafikverket (formerly Banverket) is already doing. Others are likely to follow suit.

At the heart of this technological transition is the replacement of multiple disparate networks with a single carrier-grade, IP-capable platform. This single, fully managed network gives lowest cost of ownership and additional robustness for safety-critical traffic above the scalability and reliability offered by an IP/Ethernet option alone.

Photo: SBB

***Bridging the gap:** Adoption of multi-purpose, high-bandwidth communications networks puts ICT at the heart of modern rail operations, bringing the rail and telecoms industries closer than ever before.*

Beyond supporting the safety-critical area of train control and signalling data, an IP/MPLS network gives the railway the potential to deliver several other forms of communications traffic over the same network (Fig 1):

- Site access control
- Alarms
- Freight consignment tracking (RFID)
- Corporate LAN
- Public address
- Public internet access
- Video surveillance
- Corporate intranet data
- Remote asset monitoring and equipment telemetry
- Managed bandwidth for third parties

'The ability to migrate all traffic progressively and efficiently from several legacy data networks to a much simpler and cost-optimised MPLS platform was extremely important'

Bengt Vidin, Deputy Head of Operations, Trafikverket

Pan-industry benefits

Migrating to an IP/MPLS platform can benefit other players beyond passenger rail and metro operators, such as infrastructure managers or freight operators.

Infrastructure managers will of course be aware of the basic necessity of 'signal and telecoms', but IP/MPLS could benefit other parts of an Infrastructure Manager's (IM) business too. A high-capacity IP-based radio network would permit the transmission of high-quality video footage from a track patrol team back to a control room to give a real-time update on the condition of infrastructure assets, potentially allowing safer maintenance techniques by reducing the number of lineside staff required. Similarly, video-based monitoring of track geometry and overhead line equipment from passing trains is an emerging focus for many IMs, and a reliable, fast and comprehensive transmission network would be an integral part in encouraging uptake.

With the increasing prevalence of multi-year fleet maintenance and support services, rolling stock leasing companies, manufacturers and component suppliers could also expect to share data from an integrated network to monitor the performance of the fleet and troubleshoot any faults remotely before services are affected. Depot managers and fleet controllers would then use the same data to track reliability issues over the medium term to detect patterns in train performance. This data could then be fed back into the maintenance regime, delivering longer-term benefits for fleet availability and procurement of spare parts.

Understandably perhaps, much of the most high-profile investment in railway infrastructure is seemingly directed at the passenger market, but it is easy to forget that freight traffic is still the 'bread and butter' staple of many railways around the world. Freight customers expect ever-increasing standards of customer service just as passengers do. Fortunately, next-generation ICT can help freight operators too, by bringing them closer to their customers with real-time tracking of wagons and containers. Freight operators could then relay this data to customers to allow them to track their individual consignments — such technology will become increasingly relevant in markets where there is a shift away from a traditional focus on heavy traffic such as coal and metals in favour of a more logistics-led offering targeting higher value goods.

In short, train operators and IMs need no longer view telecoms assets as a 'necessary evil' simply to be maintained in working order. Instead there is clear potential to derive real operational benefits and additional revenue as part of a managed, gradual and affordable transition from existing telecoms networks.

CASE STUDY: COMMS ACROSS THE STEPPE

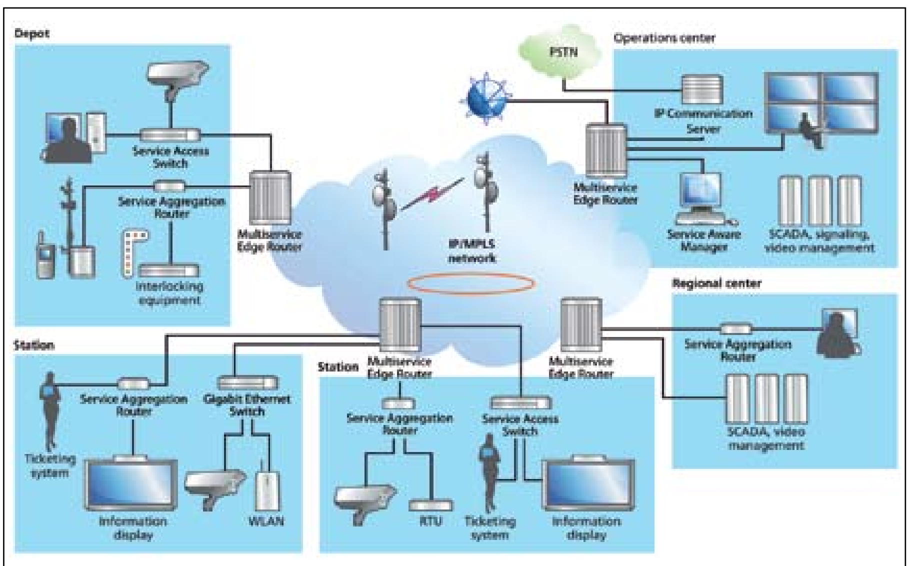
KAZAKHSTAN: State railway Kazakhstan Temir Zholy manages a network of around 14 200 route-km across a country roughly the size of western Europe. Needless to say, ensuring ease of communications across such a vast territory is a strategic priority for both KTZ and the national government.

By 2009, it had become apparent that many of the railway's existing telecoms assets were life-expired, and renewal using a high–capacity WAN backbone with IP/MPLS functionality was required. To deliver the upgrading, the Kazakh government selected the country's second-largest telecoms provider, Transtelecom, which in turn chose Alcatel-Lucent to construct an optic-fibre carrier network under a US$100m turnkey contract.

One immediate benefit to KTZ from the upgrading would be the ability to monitor track and structures remotely, a huge advantage when so much of the rail network passes through very remote regions. KTZ and Transtelecom also hope to commercialise the network by selling excess capacity to carry internet services for other businesses and consumer use.

'This project will enable our company to provide innovative communication services to third-party operators, businesses and residential customers both locally and in international markets', according to Transtelecom President Ayupov Mirbolat. Alcatel-Lucent is supplying Light Managers, Optical Multi-Service Node systems, MCC connectors, switches, network monitoring and management equipment, as well as power supply systems.

Fig 1. *Alcatel-Lucent IP/MPLS communications network for rail operations.*



GLOSSARY

ICT	Information and Communications Technology
IM	Infrastructure Manager
IP	Internet Protocol
MPLS	Multi-Protocol Label Switching
LAN	Local Area Network
TDM	Time Division Multiplex
SONET	Synchronous Optical Network
SDH	Synchronous Digital Hierarchy
WAN	Wide Area Network
LTE	Long Term Evolution
PSTN	Public Switched Telephone Network
RTU	Remote Test Unit
WLAN	Wireless Local Area Network

Telecoms integral to next-generation train control

The rail industry's steady convergence towards communications-based train control means that railways must select a partner to ease the transition from legacy comms equipment to current standards such as GSM-R.

The signalling industry continues to drive the development of electronic train control systems to replace conventional mechanical and electro-mechanical equipment and increase the throughput of trains on existing tracks. Movement data is now often transmitted to electronic interlockings via optic-fibre trunk lines, whilst the metro sector is rapidly migrating towards radio-based technologies, collectively known as Communications-Based Train Control, that allow the widespread automation of train operation.

The importance of a robust, dependable and capacious communications infrastructure has grown as vital data transmission has steadily emerged as the lynchpin of modern train control.

ERTMS covers the use of both GSM-R as the data bearer and ETCS lineside and onboard equipment for train control. GSM-R provides bearer services for voice and data. At ETCS Level 2 and beyond (the notional ETCS Level 3, which would permit moving block operation), the movement authority is passed continuously by radio from the Radio Block Centre to the train, which the driver receives via a Driver-Machine Interface in the cab. Intermittent updates of the train location are given under ETCS Level 2, while Level 3 would provide continuous updates on movement authority and train location, and train separation would be enforced by position data from the train rather than trackside detection.

Successful deployment of GSM-R in a complex landscape such as a railway network requires not merely the purchase of the equipment, but its successful end-to-end integration, so that the transition from legacy equipment is as straightforward as possible. Selecting an ICT partner that understands this transition, such as Alcatel-Lucent, is crucial.

According to Michael Liem, Solution Manager for GSM-R at Alcatel-Lucent, 'the end-to-end reliability of the GSM-R network for the data transmission is of key importance for the operations of ETCS, and therefore the reliability must be substantially higher than for a public GSM network.'

In addition, the detail of radio frequency design required in railway applications is substantially greater than for public GSM bearer networks — not least because of the railway's linear coverage that includes tunnels, bridges and cuttings. 'The higher RF level requires specialist engineers with specific knowledge,' says Liem. 'It is an aspect that is often underestimated, especially as it represents — particularly when GSM-R is used as the bearer system for ETCS Level 2 — the most critical technical risk.'

CASE STUDY: SUPPORTING ETCS IN THE FAR NORTH

SWEDEN: The 190 km Botniabanan under construction between Nyland and Umeå is a mostly single-track railway in the northeast of the country paralleling the Gulf of Botnia. Freight services began running on a 26 km section of the line in December 2008, and the full route was due to open for passenger service by the end of August 2010.

Significantly, infrastructure manager Banverket (which became Trafikverket on April 1 2010) decided to equip the Botniabanan exclusively with ETCS Level 2 signalling using Bombardier's Interflo 450 lineside equipment. But the operating environment is challenging — maximum line speed will be 250 km/h, and the alignment includes 140 bridges and 25 route-km of tunnels.

Alcatel-Lucent is responsible for the design and deployment over a three-year period of tunnel radio communications covering 13 tunnels. The radio system is designed to provide GSM-R coverage for train control data in the tunnels and enable communications at 400 MHz with and between first responders in the event of an emergency in the tunnel.

The radio network will ensure continual coverage along the route, allowing train crew to communicate with control personnel in real time. Alcatel-Lucent is contracted to deliver 99·96% availability using the Swedish International Railway Radio network.

THE EMERGENCE OF LONG TERM EVOLUTION (LTE)

New train-borne applications are driving the extension of 'ground-to-train' communications to support a larger mix of commercial and mission-critical applications such as on-board passenger internet access, passenger information, video surveillance and remote monitoring of rolling stock.

'A number of these services today are implemented over digital radio standards such as GSM-R and TETRA. Alcatel-Lucent is currently investigating the applicability of fourth generation (4G) mobile technology known as the Long Term Evolution (LTE) radio standard in the rail environment', says Alain Bertout, Solution Expert for Strategic Industries.

Initial findings indicate that LTE systems should be compatible with train operation at up to 350 km/h. LTE will offer approximately 20 times the performance of past 2G solutions, and can even co-exist with GSM-R over similar frequency bands.

Now is the time for the rail industry to seriously consider LTE as a replacement for aging GSM-R systems. Today the preferred model of the International Union of Railways and railway companies is to develop rail-specific applications instead of commercial off the shelf LTE systems.

Alcatel-Lucent is actively working with the UIC community to ensure that both critical applications for rail (shunting, emergency calls, group calls) and new services (video protection, internet access) can run together on an LTE-based network. Migrating to LTE, which is a completely IP-based architecture, will mean transforming existing railway communications to an IP environment. This transformation will ultimately bring more efficient and more reliable support for both fixed and mobile services to the railway business.

How secure is your ICT network?

When discussing communications technology in a transport security context, perhaps the most obvious example that comes to mind is closed-circuit television (CCTV). But there is more. Now railways must think in terms of critical infrastructure protection: rail industry players also require resilience for rapid recovery and a comprehensive network security policy.

CCTV nevertheless remains a key driver for network transformation. There is a need to expand network capacity to support additional CCTV coverage as security and regulatory standards become ever stricter. IP-based CCTV offers many advantages over analogue systems, including multicast, high-quality compression and the ability to archive and review video. This requires a scalable, high-availability infrastructure to ensure video data is fully transmitted at critical times when network traffic would normally peak.

But CCTV is just one part of the passenger security 'eco-system'. Other components include help points, information screens, motion detectors, secure entry points and mobile radios. All of these elements connect into the ICT infrastructure. But the ICT network also needs to allow simultaneous supervision of vital functions such as tunnel ventilation, evacuation walkways and fire protection equipment.

An integrated operational management system is therefore an increasingly necessary investment to ensure such a disparate set of security functions can be managed effectively in tandem across an entire rail network.

Internal and external threats

A broader emerging security question centres on the rail operator's own ICT network, and its resistance to both internal and external threats.

The network must be secure from any attempts to attack it from outside, such as hacking, but it must also be secure from internal threats. Equally, it must enable segmentation via a virtual private LAN to separate safety-critical operations such as CCTV from customer-facing services such as Wi-Fi for passengers. This is an essential component of critical infrastructure protection — the network must be secure and resilient.

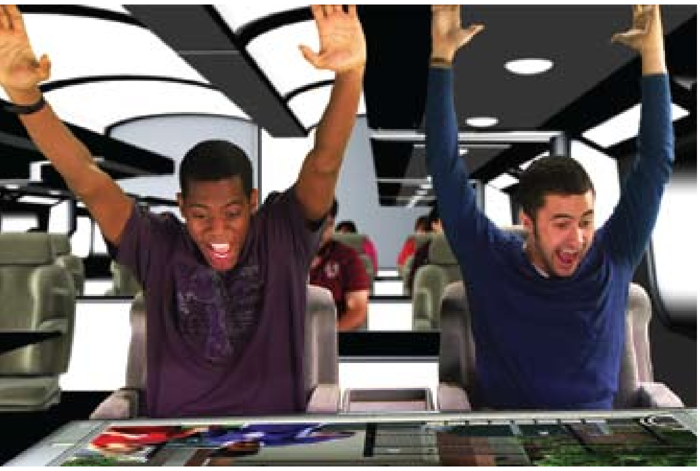
Telecoms assets must be resilient with fail-safe modes and in-built rapid recovery from any element or path failures. Wi-Fi or other wireless systems for passengers or freight customers must not inadvertently offer a 'back door' into vital operations — again, an advanced operational management system could assist railway managers to detect incident patterns and undertake effective security audits.

Perhaps most importantly, rail operators and IMs need to develop an understanding of the contingency measures required if a serious cyber attack were to disable their telecoms and IT networks — a disaster recovery plan offers that critical Plan B if the worst were to happen.

> 'Advanced operational support systems will become more and more necessary to prevent failures and security breaches'
>
> Rocco De Donato, System & Application Integration Director, Alcatel-Lucent

Passengers expect the personal touch

Rail operators must prepare for a future that includes 'enhanced reality' and Station 2.0 concepts, under which individually-tailored services will be delivered via web and smartphone applications.



LED display screens, information points and automated ticket vending machines are now considered standard elements of the modern station. But rail operators can hardly afford to be complacent: passengers' expectations are heavily influenced by trends in the wider consumer market.

As a result, there is a clear distinction emerging between what passengers expect as standard and what they desire.

Station 2.0

Operators must be prepared to enable 'Station 2.0' technology to deliver personalised information to an individual mobile device. In addition to more immediately obvious journey planning and delay information, operators should be able to tailor 'enhanced reality' services. These could include live interactive maps to direct the passenger to the correct coach on the right platform via a newspaper kiosk or coffee bar on the way. Social networking applications could be included to show friends or colleagues waiting at a station meet point. Real-time departure information would also be offered, whilst last-minute journey amendments could be facilitated via mobile web access to the train operator's booking service. Tickets or seat reservations would then be delivered to the user's phone directly.

The demise of the paper ticket may have been somewhat exaggerated, but nevertheless as home broadband and mobile phone use has become almost universal in many Western countries, opportunities have arisen for rail operators to trial more flexible ticket media.

There appears to be little sign as yet of convergence on a particular international standard for e-ticketing — indeed, it is likely that specific delivery platforms will continue to be favoured by particular operators, regions or cities. In the urban sector, contactless smart card ticketing is becoming increasingly common, and we can expect widespread uptake of extra functionality in future, such as small purchase payments.

Mobile phone-based ticketing is likely to become increasingly prevalent purely because of the ubiquity of the personal handset. Near-Field Communications technology would allow rapid validation of the passenger's ticket, whilst enabling the rail operator to use its high-bandwidth ICT backbone to deliver additional promotional material and live journey information to the handset.

The mobile phone creates a huge opportunity for rail operators to enhance services. As they gather data (dependent on local privacy laws), operators would be able to customise messages and services for frequent travellers — one could imagine a ticket inspector being able to greet an individual in a reserved seat by name, or know that a person requiring assistance has passed a ticket barrier destined for coach 'X' and be waiting at the door.

Onboard opportunities

Once on the move, passengers can expect to be able to be kept right up-to-date with their journey as the train operator uses broadband technologies to stream data to flat screens in the train, giving live running information and details of connections from stations served *en route*. Taking the concept one stage further, live weather updates on the destination city or tourist and cultural information could be broadcast on long-distance journeys.

Video on demand and other onboard entertainment options could also be offered, although on a train, unlike on an aircraft, passengers would most likely choose to use their own devices for entertainment, making high-capacity broadband networks an essential requirement for inter-city train operators.

At the destination, live maps, local transport connections and hotel reservation services could all be offered on a personal basis as the 'Station 2.0' concept kicks in again.

Rail operators will need to ensure that any applications or web services they support can be easily and immediately accessed by passengers. Either way, the digital revolution shows no sign of slowing, and the world's railways must strive to keep up.