DYNAMIC COMMUNICATIONS **FOR INNOVATIVE RAILWAY TRANSPORT**

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INNOVATIVE COMMUNICATION AIDS EFFICIENCY **ON DELHI AIRPORT METRO EXPRESS**

AT THE SPEED OF IDEAS™

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NEXT GENERATION COMMUNICATIONS
TRANSFORMING RAILWAY TRANSPORT

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>>> The demands on railway infrastructure are changing. After many years of managing decline, the last two decades have seen a marked reversal in rail usage and investment. Rail infrastructure is under pressure to provide more train paths, higher availability, and better value for money. Furthermore, passenger and environmental trends mean rail must align itself more closely with other modes to offer more attractive and sustainable journey options.

In its communication *A Sustainable Future for Transport*, adopted in June 2009, the European Commission noted: "Upgrading the existing infrastructure – also through intelligent transport systems – is in many cases the cheapest way to enhance the overall performance of the transport system."

Recent advances in telemetry have expanded the possibilities for real-time monitoring of infrastructure assets, unlocking significant performance benefits and improving operational efficiency. Machine-to-machine (M2M) systems deliver a "live" infrastructure that optimizes itself, communicating real-time data on a host of asset-monitoring functions. This is driving a fundamental shift from reactive to predictive maintenance, which in turn maximizes asset life and brings down costs.

These innovations in infrastructure management provide an opportunity to offer a broader range of services to passengers and enhance operational efficiency. They also mean rail operators have a commercial imperative to consider the benefits of moving to a high bandwidth IP backbone as a first step towards a multi service wireless backbone that will support next-generation Long Term Evolution (LTE) or 4G operations.

The migration to a multi-service wireless backbone with LTE might seem like a big step, but these technologies are already being tested and validated with existing signaling systems, and there is an industry-wide vision within telecommunications that is driving LTE forward. Initially it will be used for bespoke innovative applications that are operational, passenger, or safety-related, but very soon this technology will be capable of acting as a data bearer for future signaling systems.

The rail industry needs to start preparing for these changes now. The transition to wireless multi-service networks means it is increasingly important for rail operators to ensure they are self-sufficient in network coverage. There is no realistic business case for mobile operators to cover empty spaces for the benefit of transport operators and this means the service level agreement needed to carry out mission critical services cannot be guaranteed.

"THERE ARE UNEXPLOITED SYNERGIES BETWEEN PASSENGER COMMUNICATIONS AND THE REST OF THE RAILWAY TELECOMS INFRASTRUCTURE, WHICH MEANS THE BUSINESS CASE FOR ADOPTING NEW SYSTEMS IS CHANGING AS THE ENABLING TECHNOLOGIES MATURE."

Broadband wireless services running on faster, more robust networks will also allow rail operators to add value for their passengers. To see how, look no further than the surging growth in smartphone usage. The worldwide smartphone market is expected to grow 49.2% in 2011 and it is growing four times faster than the overall mobile phone market. This means a rapidly increasing proportion of rail users have the ability to access data services and applications on the move.

Passengers view their journey as an extension of their office time, and they don't expect their social life to be put on hold while they are traveling. Increasingly-sophisticated devices should give rail users the opportunity to use their time onboard productively. Meeting these needs is therefore paramount if rail is to capitalize on the opportunities.
The passenger experience can be transformed through communications-driven services – individual journey plans, tailored marketing messages and improved customer service during disruptions will change the way we travel by train in the future.

Many passengers are already using their devices to access information about their journeys. A quick search for "rail" on the Apple iTunes App Store reveals more than 350 applications. Rail operators need to capitalize on this opportunity to connect with passengers.

The European Commission's recent White Paper on rail emphasizes the need for rail operators to strengthen modal interfaces, recognizing that most rail journeys involve two or more modal changes. Communications technology has a central role to play in building a more integrated transport network, helping passengers to navigate those changes with ease and make the right modal choice for their journey.

Unified platforms combine passenger connectivity and enhanced information services while simultaneously improving operational performance, flexibility and efficiency of infrastructure in a single platform. Innovations such as lightRadio™ and the 400Gb/s FP3 router developed by Bell Labs continue to drive this process forward, paving the way for more exciting possibilities in the future.

INNOVATIONS IN TELECOMS
ADVANCE THE CASE FOR RAIL

LIBOR LOCHMAN
Deputy Executive Director
Community of European
Railways (CER)

>>> With greater demand for rail services in the next few decades, as highlighted in the European Union's recent White Paper for transport up to 2050, there is a need for greater operational efficiency. The public and the funding agencies will demand it. And railway operators will have to provide it. Improved telecommunications systems will inevitably play a significant role in achieving this in three key areas - maintenance, signaling, and communications services.

Libor Lochman, the Community of European Railways (CER) deputy executive director, says that greater interoperability between different network systems and technologies will aid this drive to improved efficiency. He points to the Europe-wide installation of ERTMS as one example of a system that is crossing boundaries. However, the pace of adoption also highlights the challenges facing railways. In particular advancing technology means that the elements of ERTMS systems already installed today will need to change.

"Today it is on the basis of GSM-R, but in 10 years time there will be a need for change in the communications technology when in 2025 the GSM system will no longer be supported," Lochman says. "Railway associations and individual companies are now investigating options that are commercially available and could be used in future signaling equipment." Lochman says that "no decision" has been made at this stage on which technology will form the basis of this post-GSM system, although Long Term Evolution (LTE) appears to be favored by suppliers, including Alcatel-Lucent. He is convinced that railways and infrastructure managers will adapt to new technologies that benefit their operations and/or reduce operating costs.

Lochman says that because suppliers are thinking about the next generation, and are communicating with railways about what will be required to fulfill these expectations, operators should be prepared to adapt their infrastructure and equipment accordingly. While there are differences between how this technology applies to different types of operator, Lochman is confident that they will keep up.

"IN THE FUTURE TECHNOLOGY WILL BE ADAPTABLE TO THE NEEDS OF A SPECIFIC RAILWAY SYSTEM."

With railway operators seemingly open to change, and technology adaptable to specific needs, the greatest challenge is overcoming variations in national regulations. Lochman says that with so many coexisting standards and systems it is difficult for operators to find common ground and to fulfill their domestic obligation.

"On the level of the European countries it is not as easy to implement as it seems, particularly when there are hundreds of companies having to agree" he says. "Finding the right agreement can therefore take a long time. But if we get to the stage where suppliers and railways are on the same page, common availability will provide for the installation of common systems."
Increased harmonization of standards might appear to be the answer to this conundrum. However Lochman believes too much regulation can diminish rail's advantages over other modes, while in areas where more stringent rules are required, "The key must be suitable regulation, finding the right balance and not stifling companies by over-regulating, whilst providing neither established nor new companies with an advantage," he says.

The advantages of these new technologies certainly outweigh their cost implications. With GPS measured distance supporting predictive maintenance, the advance of M2M technology and IP telephony networks which offer more exchanges supporting a larger number of subscribers, including potentially operations crew and passenger communications, the building blocks are in place for improved efficiency. And as technology continues to advance, Lochman says that CER will work with its members to optimize their activities to help rail become more attractive.

"We are aiming to achieve higher efficiency in both services for the customer and in better performance of our assets. The European White Paper for Transport up to 2050 shows that rolling stock operators need to adapt in order to fulfill these demands, and we will encourage them to do so."

THE NEXT REVOLUTION IN GROUND-TO-TRAIN COMMUNICATIONS

GSM-R has been the global standard-bearer for mainline ground-to-train communications for the past 15 years. Based on the public GSM standard with additional features built in to meet specific needs of railway operations, GSM-R features a high-level of reliability when compared with conventional GSM networks, allowing it to support ETCS. In many countries national GSM-R rollout programs are underway, and in some cases, deployment will continue for another 10 to 15 years. However, GSM-R is about to be superseded. Recent advances in telecommunications mean that standard communications systems can now support safety-critical applications, with an additional protocol layer on top of the open telecom network guaranteeing network integrity. As a result, wireless networks will soon move to IP-based LTE (4G Long Term Evolution) networks which are optimized to deliver speeds of up to 100Mb/s downlink and up to 50Mb/s uplink, supporting channel bandwidths of 1.25MHz to 20 MHz. Commercial mobile operators are already looking to phase out their GSM-based services in a progressive migration to LTE, which can offer new functions such as enhanced telecommunications services for passengers, while still operating on 2G and 3G frequencies. While the rail industry might not be ready to replace their GSM-R infrastructure with LTE until well into the 2020s following hefty investment, the industry needs to seriously consider how to cater for bandwidth heavier applications that are now appearing and will need to be rolled out within the next five years. GSM-R may remain the backbone of safety-critical applications for a few years yet, while the operational and maintenance costs are below the costs of a complete upgrade. However the coexistence of GSM-R and LTE is a much more immediate prospect, and one that will take ground-to-train communications to another level.

INTEGRATED IP INFRASTRUCTURE BRINGS **NETWORK BENEFITS TO TRAFIKVERKET**

ANDERS WAHLBERG
Deputy Head of the Technical Department - Trafikverket

>>> Integration is a key concept for Sweden's national transport administration Trafikverket. Formed in April 2010, Trafikverket brought together the country's rail, road, air and maritime authorities in a single integrated institution overseeing the entire transport infrastructure. The primary motive in uniting these agencies was integration – with all modes part of the same organization, Trafikverket can see all of the connections between them, and make them work together more effectively.

This integrated approach applies equally to Sweden's rail communications. Since 1990, Trafikverket and its predecessor Banverket have maintained a secure national transmission network which supports all safety-critical operations. In 2007, Banverket selected Alcatel-Lucent to lead the transformation of its communications infrastructure, and today Trafikverket manages critical data and services communications through a single, integrated next-generation IP/MPLS network.

By 2007, much of Sweden's rail telecommunications infrastructure was approaching life-expiry, with many SDH and TDM products becoming difficult to source, or discontinued by suppliers. The network was made up of various technologies from different suppliers, making operations and maintenance difficult to manage. Furthermore, the growth in demanding IP-based applications such as Closed Circuit Television (CCTV) meant the needs of the operator were changing in ways the older technology was unable to support.

Banverket therefore decided to consolidate IT, telecoms and signaling into a single carrier-grade, national IP/MPLS network. Beyond the core safety-critical train control and signaling data functions, IP/MPLS supports a variety of communications traffic on the same network that can optimize operation efficiency and improve customer service. The introduction of IP/MPLS has also had a significant impact on skills availability. "MPLS replaced our older system, called X Protocol, and there were only a few specialists with the expertise to make changes within that system," says Anders Wahlberg, deputy head of the technical department of Trafikverket. "With IP/MPLS it's much easier to find specialists on the open market, both for employment or for assignments from consulting firms."

IP/MPLS can facilitate freight consignment tracking using RFID, and trials of these systems have taken place on a number of long-distance rail freight flows within Sweden. These tests proved a success, and a full network of up to 700 RFID readers is planned, which will allow freight customers to monitor the progress of their consignments across Sweden.
Trafikverket recently carried out a pilot project with Stockholm airport train operator Arlanda Express to rollout a high-capacity onboard wireless communication system. This provides an entertainment-quality (more than 10mbps) Internet connection for passenger use and staff intranet, as well as remote rolling stock asset monitoring, which is allowing the development of a predictive maintenance regime.

© Trafikverket Photography

Trafikverket now possesses Sweden's second-largest IP network, and the scope of the system both in terms of its geographical reach and its technical capability has also opened a host of supplementary revenue streams for the railway. Such is the capacity of the network that it offers sufficient redundancy to meet all railway demands while also providing the same level of service and flexibility to other commercial users. Trafikverket is selling unused network capacity to an increasing variety of non-rail customers, including Internet service providers, private industries, and cable operators. Harnessing such capabilities can be a powerful proposition for railway infrastructure managers, enhancing the business case for investing in IP technology.

"A KEY CAPABILITY OF THE IP BACKBONE IS THE ABILITY TO REMOTELY MONITOR INFRASTRUCTURE, PROMOTING A SHIFT TOWARDS CONDITION-BASED PREDICTIVE MAINTENANCE."

Trafikverket recognizes that good quality asset information is vital both to support effective decision making, and to optimize operational efficiency. Infrastructure data is fed into a central asset register, which is used to ensure consistent output both within the organization and by contractors. Data input currently comes from standalone software tools, all linked to the central tool, and field data is generally collected and downloaded via handheld devices, although the system can support remote asset monitoring and equipment telemetry.

Trafikverket is moving towards advanced tools which allow condition-based renewal of infrastructure assets. These include Optram, a web-based data-analysis system for planning of grinding, tamping, and electrification maintenance activities, which is part of the company's ongoing eMainteance program.

"One of the main objectives of eMaintenance is to align maintenance processes with business and operational processes to achieve our organizational aims," explains Wahlberg. "This is being realized through enhanced utilization of our ICT infrastructure and making the most of the technology we have available. eMainteance also supports the different interconnected levels of the organization, providing an effective infrastructure for decision-making. We feel that the benefits of eMaintenance are reflected in an organization's overall performance and effectiveness."

The drive to optimize operational efficiency and enhance infrastructure availability means Trafikverket will continue to explore new ways of exploiting its advanced ICT capabilities. "In the next few years we would like to see the introduction of dynamic train and maintenance tools to support and speed-up the decision making process," concludes Wahlberg. "This will allow daily flexible maintenance activities such as opportunity-based maintenance which will minimize disruption to traffic. We want to achieve 24/7 real-time monitoring, control and alerts that are relevant to the effective management of maintenance processes. This will give us increased availability of production capacity, a greater return on investment, and enhanced competitiveness."

FLEXIBLE MOBILE NETWORKS OPTIMIZE OPERATIONAL EFFICIENCY

Rail applications are rapidly becoming IP-based. Even radio systems are moving away from slower technology to an IP foundation which will deliver more bandwidth, more flexibility and more innovative applications such as real-time video. This means today's rail communications networks must migrate from traditional circuit switched technology such as SDH to packet based networks supporting IP. The challenge is to safely move critical services to the new environment. Alcatel-Lucent's IP/MPLS platform, which can run over fiber, copper and microwave, ensures older applications will continue to function while providing the capability to introduce IP-based services. Our IP platform also complements our new LTE infrastructure and makes it easier to prepare for the evolution to high-bandwidth mission critical radio networks. Alcatel-Lucent is also dramatically changing the way these radio networks are built with the introduction of our lightRadio™ platform. This breakthrough technology simplifies mobile radio access networks. It eliminates the need for cumbersome masts and towers and greatly reduces power requirements making it ideal for tunnels and rail pathways. Future wireless networks will be greener, use less equipment and deliver high bandwidth enabling next generation rail applications and services.
The capability of networks can be further enhanced with Alcatel-Lucent's FP3 400G processor, which can quadruple the speed of the most advanced networks while reducing power consumption by up to 50%.

INNOVATIVE COMMUNICATION AIDS EFFICIENCY
ON DELHI AIRPORT METRO EXPRESS

NATWAR SHEKHAWAT
Project Head and Head of Operation and Maintenance Delhi Airport Metro Express (DAME)

>>> Since opening in February 2011, the Delhi Airport Metro Express (DAME) service has greatly improved transit to and from India's busiest airport. While the journey by road from the center of the city can take over an hour on a bad day, the 22.7 km train trip from Delhi's Central Station takes just 18 minutes. And with trains departing every 20 minutes from 5.00 am to 11.00 pm seven days a week, passengers now have an efficient and easy to use service at their disposal. The frequency will soon be increased to a 15-minute, and ultimately 10-minute, interval to further improve availability.

With 15.7 km of the six station line underground, and 6.5 km on viaducts, construction of the line was certainly a challenge, but one that has produced a line that is comparable with any air-rail link currently operable in the world. The attention to detail evident in the engineering and building phase is replicated in efforts to provide a distinct and comfortable journey experience for passengers, as Natwar Shekhawat , project head and head of operation and maintenance at DAME explains.
"We are trying to be distinct from other rail services in Delhi," Shekhawat says.

"WE HAVE PUT A LOT OF THOUGHT INTO SEEING WHAT PASSENGERS WANT BECAUSE WE NEED TO PROVIDE THE BEST POSSIBLE ENVIRONMENT FOR TRAVEL."

A major part of this is trying to cater to the needs of the range of people that will use this service through offering everything they need, both on board the train and at the stations."

Every level of detail at every stage of the journey is covered - from the artwork used in stations to distinguish the airport express network from other metro lines in the city and to promote a comfortable and convenient ambience, to a host of retail facilities at stations and real-time information systems for passengers. There are airline check-in facilities at three city stations, a first for India, while at two of these stations, New Delhi Station, and Shivaji and Stadium, passengers can not only check in but also drop off their luggage. These are all features that are improving journey experience and making the trip to the airport as stress-free as possible.

Inevitably at the heart of many of the technological provisions that are improving passenger experience is an effective telecommunication system, which in Delhi, is entirely provided by Alcatel-Lucent.

© Delhi Airport Metro Express Line (DAMEL) Photography

More than 160 km of fiber with seven STM nodes and an underlying data network of 50 OmniSwitch IP switches together with an IP telephony system of seven exchanges and more than 1,000 subscribers support the project requirement of communication for train operation and passenger convenience. An extensive Tetra radio communications system which utilizes five base stations and more than 250 handheld terminals is utilized to provide a reliable and secure communication network among operators, maintenance personnel, and emergency services.

Shekhawat says that the communications systems are proving to be extremely successful, with only very minor teething troubles reported since the line entered service.
"We had some problems in the early stages where we didn't have good enough coverage, particularly in some patches in the tunnels," he says. "We overcame this by putting up some extra antennas and now the coverage is very good. Since then there have been no reports of poor coverage."

A very extensive CCTV network, with video analytic features in some cameras, is another prominent and important feature of the network, and with around 700 cameras, Shekhawat says that the system is the "most extensive" that he has ever seen."

© Delhi Airport Metro Express Line (DAMEL) Photography

Most of the staff-only areas and 100% of the public space are viewable through the CCTV system. This means that every stage of an individual passenger's journey is viewable – from the moment they enter the station, check baggage, board and exit the train, and leave the station – providing the safety assurances that modern day passengers expect.

Another safety feature that is enabled through the use of efficient telecommunications systems is an emergency phone network. Passengers can speak directly to an operator about any enquiries they might have or to report any problems at 110 emergency phones and 178 help points that are available on every platform at every station.

They shouldn't though need to use the system to enquire about when the next Airport Express train might be, or to obtain details of connections on both the rail network and at the airport. Real-time information is displayed on 125 screens that are easy to read and identify are located in prominent areas throughout the stations. For example, flight information is displayed six hours before scheduled departure. A public address system is also in place with more than 4,000 speakers providing up to date service and safety information to passengers in all areas of the stations.

Shekhawat says that passengers have voiced satisfaction of the level of service that they are receiving on the airport express link since it opened. However, he does foresee further improvements in the ticketing system.

"The potential exists for a seamless interchange between the different networks, speeding up journey times and providing a more efficient service," Shekhawat says. "Passengers will be able to buy a ticket on a chargeable card and then use that card to continue their journey on different services through a seamless interchange."
While DAMEL ticketing cards are configured for interoperability, existing cards in use by others may have to be reconfigured, which Shekhawat believes will happen in the next few years.

"The potential is there for this to improve journeys across New Delhi," he says.

Certainly the new DAMEL service is showing others in the city the way forward in both the facilities offered to passengers and the effectiveness of its operations. And with proposals to extend the line to provide a connection with the city's Blue metro line, in the future more and more passengers are likely to think to use the train when traveling to the airport.

MULTIMEDIA INNOVATIONS FOR AN ENHANCED PASSENGER EXPERIENCE

For rail operators seeking an advanced multimedia solution capable of managing and delivering all types of digital media content, Alcatel-Lucent offers a flexible easy-to-use *common platform for multimedia applications*. The Enterprise Media Suite (EMS) integrates live and recorded content from TV providers, third parties, the Internet and the transport operator, delivering them to a wide range of devices – from a passenger's individual device or a screen on the back of a seat to a full-blown touch screen media kiosk onboard the train. This solution allows rail operators to merge different multimedia services and different uses – live and on-demand content, advertising, information, and corporate communications – for a customized mix of content that is relevant to their business. Content is managed in the back end, and delivered to the different sites (trains and stations) using the network (fixed for the stations and mobile for trains).

Augmented reality applications enable passengers to access contextual maps and searches, image recognition, barcode scanning, localized promotion, and social networking, using nothing more than their smartphone. By delivering this information directly to passengers' devices, rail operators can transform their customer experience, differentiate their services from other modes, and generate new sources of revenue.

"HOW FAST WILL TRAINS RUN IN THE FUTURE? IN GIGABITS/S PLEASE."

DYNAMIC COMMUNICATIONS FOR DYNAMIC SERVICES

Fast travel is a good start, but without high speed communications, we are only halfway there. Passengers today expect always-on anywhere multimedia services. With dynamic communication solutions from Alcatel-Lucent, a single smart network enables a connected travel experience while managing operational excellence and safety. With solutions running effectively in more than 80 mission-critical railway networks, Alcatel-Lucent provides deep expertise in building, integrating and managing networks - to optimise operational efficiency and ensure safety and security for an enhanced customer experience. To learn more about how Alcatel-Lucent can help you provide your customers with an on-time, safe and connected journey, please visit us at www.alcatel-lucent.com/railways

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