THE FAST TRACK TO POSITIVE TRAIN CONTROL COMPLIANCE

THE GROWING ROLE OF CELLULAR IN MEETING THE PTC MANDATE

Whether it's for passenger or freight, automated train control has become a requirement for U.S. railroad infrastructure, both in vehicles and waysides along the thousands of miles of track that crisscross the country. It's the United States Congressional Positive Train Control mandate, and it's calling for operators to deploy a range of onboard computers and navigation equipment as well as systems to connect and control rail traffic.

While there are exceptions, PTC is required for Class I railroad main lines (lines that handle more than 5 million gross tons annually) over which any toxic or hazardous materials are transported, or railroad lines that carry intercity commuters. Experts believe this will involve 60,000 miles of track and 20,000 locomotives.

PTC uses communication-based, processor-based train control technology to automatically control train speeds and movement if the operator does not or cannot take appropriate action given the circumstances. PTC can reliably and functionally prevent train-to-train collisions, derailments caused by excessive speed, incursions into a work zone, and switching errors. For example, PTC can enforce a train to a stop before it passes a signal displaying a stop indication, or before diverging on a switch improperly lined, thereby averting a potential collision.

Digi routers are rugged and rail-ready for a full range of positive train control, wayside and in-transit connectivity solutions.

RAIL-CERTIFIED PERFORMANCE

Digi WR44 RR routers are the industry choice for on-the-move PTC deployments.

SIMPLE AND SECURE CONTROL

Configure and monitor moving or multi-location PTC connectivity with Digi Remote Manager®

RIGHT-SIZE CONNECTIVITY

Digi WR31 routers deliver reliable, purpose-built wayside connectivity.

RAIL COMMUNICATIONS AND CELLULAR TECHNOLOGY

For decades, safe and efficient rail operations have relied on cellular technology for voice and data communications. It started with the GSM-R standard, adopted in 1997, that replaced dozens of incompatible analog systems across Europe. But in the U.S., interoperable communications only recently started with the 220 MHz band. However, this has fallen short due to incompatible radio protocols.[1] What's more, Canada and Mexico do not use the 220 MHz band for rail communications.

PTC communication networks must be secure, fault tolerant and have no single point of failure. For this reason, cellular technology is widely used throughout North America as a backup to terrestrial/fiber networks at fixed sites. Its other principle use is for remote management of onboard systems. It also provides a secondary path for train control messages routed to/from the train control center, which are transmitted primarily over the 220 MHz radios. The broadband cellular link enables standards-based IP communications, providing high speed and secure connections for an expanding list of applications.

A worldwide effort is underway to standardize rail communications based on emerging 5G cellular specifications. There is a convergence of IT and radio, a result of demand for mission-critical communications that can deliver economies of scale similar to the explosive growth seen in smartphones. The sections below introduce rail communication systems, describe cellular use in the U.S. today and how a new 5G system might be deployed.

RAIL COMMUNICATION SYSTEM REQUIREMENTS

Voice and data communications are critical to the operation of a passenger-rail or freight network. For train control, the key wireless performance requirements are fundamentally low latency and dependable data. In certain situations, control messages must be delivered intact and in time, else the locomotive automatically applies its brakes. Other more functional requirements are derived from the structure of rail systems and operations, and include:

- Cybersecurity
- Emergency group communications
- Video transmission
- Prioritized safety-critical applications

In the rail industry, dedicated frequency bands are traditionally considered mandatory for low latency and reliable data. Dedicated frequency is central to the dominant Global System for Mobile Communications - Railway (GSM-R) Standard deployed throughout Europe, Asia, Australia and North Africa, which operates without contention predominately in the 900 MHz band. Similarly, in the U.S., 220 MHz has been the common channel to enable PTC interoperability for passenger rail and freight on shared tracks.

RECENT DEVELOPMENTS IN RAIL COMMUNICATIONS STANDARDS

The evolution of wireless communications technology is enabling mission-critical services on shared spectrum. The driving force behind these advances in global mobile cellular standards including LTE and the next generation 5G is the Third Generation Partnership Project (3GPP). This is a consortium of standards organizations from Asia, Europe and North America, with participation from industry associations around the world that create a consensus of market-specific requirements.

1. Requirements for Positive Train Control 220 MHz Locomotive Radio Filter, Transportation Technology Center, Revision 4, Nov. 17, 2015.

One such association, the International Union of Railways (IUC), developed a specification for its Future Railway Mobile Communications System (FRMCS)[2] that will replace GSM-R. The 3GPP Technical Study Group (TSG) SA1 is working to identify gaps between the FRMCS requirements and existing 3GPP functionality and expected 5G mission critical services.[3] Ideally, the FRMCS user requirements will be covered within LTE standards. Where gaps exist, functional architecture enhancements, new procedures and information flows are to be suggested as candidates for normative specifications. The FRMCS plan is to begin trials of the new system by 2020 and deploy by 2022.[4]

RAIL APPLICATIONS OVER CELLULAR

A migration by forward-thinking rail operations to broadband cellular networks is already underway.[5] Early applications included wireless backup to terrestrial networks at wayside facilities, a service traditionally provided by point-to-point radio links. More recently, cellular is enabling central office access to onboard train control systems and as backup to primary 220 MHz communications.

Other applications support passenger convenience, safety and information. Onboard mobile access routers equipped with Wi-Fi hotspot technology enable laptop and tablet access to the internet. Security personnel can also remotely access video surveillance systems when ongoing incident assessment is warranted. And passenger information systems provide entertainment, news and commuter information such as availability of scheduled transfers.

TRAIN CONTROL OVER CELLULAR TOMORROW

FRMCS would leverage the 3GPP transport and mission-critical services expected of 5G for rail communications, enabling higher data rates, lower data latencies, multimedia communication and improved communication reliability.[6] When complete, the system would deliver the following capabilities:

- Prioritized emergency group communication, train control data and video service
- Seamless cellular connectivity in high-speed railway moving environments
- Low latency and high reliable data and video service
- Real-time train monitoring and management for safe train operation
- Reliable location tracking including tunnel conditions
- Legacy railway communication interworking to GSM-R system

The higher data rates of 5G are largely a result of the increase in utilized spectrum. Unfortunately, current GSM-R and PTC 220 MHz band allocations are inadequate. In any case, those bands support mission-critical systems and it is impractical to consider any reauthorization. Therefore, either new dedicated spectrum must be allocated or railroads must identify suitable spectrum to share with other users. The latter is now possible due to advances in mobile cellular standards and related service offerings:

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2. Future Railway Mobile Communication System User Requirements Specification, International Union of Railways, Version 3.0, Jan. 24, 2018. 3. GPP TR 23.790 - Study on application architecture for the Future Railway Mobile Communication System (FRMCS).

4. 3GPP news/events, “3GPP drives GSM-R to a new track” August 5, 2016.

5. http://www.progressiverailroading.com/csx_transportation/article/Railroad-communications-technology-from-cellular-to-radio-to-satellite-to-Wi-Fi--30947

6. 3GPP TR 22.889 - Study on Future Railway Mobile Communication System (FRMCS).

- **Network Slicing** – An emerging 5G capability allows multiple logical networks to be created on top of a common shared physical infrastructure.[7]

- **Priority and Pre-emption** – First introduced in 3GPP Release 8 in 2008, it has become a top priority for nationwide deployment on the major U.S. networks.

- **Public Safety Broadband Network** – Commuter rail operators could be authorized to use the FirstNet service and obtain access to the 20 MHz PSBN band.

FIVE THINGS TO CONSIDER FOR PTC COMMUNICATIONS

- **Network Performance and Resilience** - In modern PTC deployments broadband cellular can provide and backup primary two-way connectivity among trains, wayside stations and rail operations. This supports far more sophisticated controls and information feeds than narrowband 220 MHz. As cell networks continue to advance, rail operators will benefit from priority and pre-emption to ensure their urgent messages are not delayed.

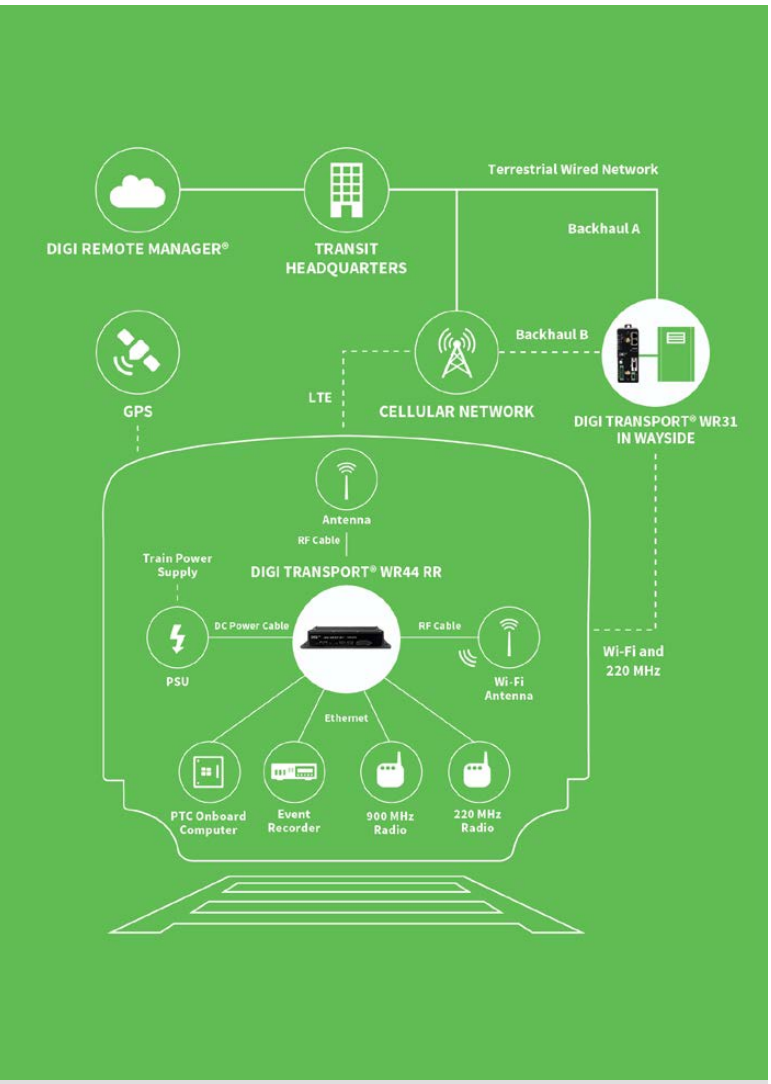
- **Rugged Devices** – Trains and rail yards present challenging environments for deploying communications devices. It is essential for the cell modem to have ruggedized housing and withstand shock, vibration, temperature and humidity extremes.

- **Long Life** – Rail operators don't have the time or money to spend on repairs, replacements or upgrades. The connectivity solution must offer power-efficient, low-cost operation. What's more, the solution should offer a long product lifecycle to minimize disruptions and changes to operations and infrastructure.

- **Security** – The device must have built-in-protocols and methods to support:

    - Encryption – Prevent unauthorized snooping
    - Message Integrity – Ensure packets aren't tampered with in transit
    - Authentication – Verify the message is from the proper, valid source

7. https://www.gsma.com/futurenetworks/wp-content/uploads/2017/11/GSMA-An-Introduction-to-Network-Slicing.pdf



THE DIGI TRANSPORT CELLULAR ROUTER FOR RAIL SYSTEMS

When you're looking for the connectivity infrastructure for Positive Train Control, the Digi TransPort® WR44 RR is an ideal choice. This rugged enterprise-class cellular router offers rail industry certification, versatility, security features and performance.

Digi TransPort WR44 RR provides a reliable high-speed cellular network connection. It features a flexible communications design with 3G/4G multi-carrier cellular, plus integrated Wi-Fi ac/b/g/n; a/c access point or client; serial and four-port Ethernet switch. It also features full on-board train certifications, including AAR S-9401 and EN50155. Communications interfaces include hardened connectors, specifically M12 for Ethernet and serial, as well as TNC connectors for antennas.

Digi management solutions provide easy setup, configuration and maintenance of large installations of remote Digi TransPort devices. Digi Remote Manager® offers web-based device management for remote Digi cellular routers, gateways and third-party devices. With the Digi TransPort WR44 RR cellular router, you benefit from:

- **Security** to ensure data integrity and protect against misuse and attack
- **Management** of the router that's reliable, flexible, intuitive and scalable to support even the largest fleets
- **Performance** to maintain the fastest connections with the highest availability
- **Versatility** to accommodate the complexities of today's many types of IP systems and devices
- **Agility** to support multiple carrier networks and future wireless standards

CONCLUSION

As the PTC mandate takes hold, cellular communications can play a central role in enabling an effective connectivity infrastructure. For more information, visit www.digi.com/PTC.

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