Integration of PTC and Ride Quality Data

Presented by:

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and

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The FRA mandate to implement Positive Train Control (PTC) in the United States on Class I rail carriers will result in new onboard computing capabilities, including high accuracy track location systems and robust wireless communications. These new capabilities offer the potential of integrating additional real-time services that leverage the PTC architecture to provide rail carriers with added situational awareness. The integration of ride quality monitoring with PTC will provide rail carriers the ability to detect track and vehicle defects encountered during in-service operations in real-time, leading to proactive maintenance activities and improved safety.

I-ETMS PTC Overview

All U.S. Class 1 railroads, and many commuter railroads operating on Class 1 tracks are implementing the Wabtec "Interoperable Electronic Train Management System" (I-ETMS) on-board systems as the basis for meeting FRA PTC requirements. I-ETMS on-board systems provide the following capabilities which support integration of ride quality data:

- Train Management Computer (TMC): This provides the heart of the I-ETMS system, with multiple computer and I/O boards, with Ethernet networking to other system components.
- Computer Display Unit (CDU): Provides a graphical screen interface to the Engineer, with an optional CDU for the Conductor.
- Train Location Sub-system: Current train location and speed is monitored using GPS, axle generator inputs, and other information, with references to the on-board track database.
- PTC Recorder: PTC data is added to FRA locomotive event recorder data, with crash hard memory protection. This provides information to support operating analysis and accident investigations.
- Video Recorder (Option): The latest Wabtec LDRS-V product combines recording of PTC and locomotive data, together with digital video into the same package.
- Data Radio Communications – Wide Area: The Class 1 railroads are implementing a wide area 220 MHz narrow band data radio network to provide full coverage over tracks planned for PTC. In addition, commercial cellular data radios are being deployed to provide back-up capabilities.
- Wi-Fi Wireless Networks: In yards and other selected areas, Wi-Fi "hot spots" are being deployed to provide broadband wireless networking capabilities. These are used to download PTC recorder files, and upload new on-board software and track database files.

I-ETMS on-board systems communicate with wayside signal systems as well as back office systems. The back office communications is generally divided into two types of data:

- Real time data which is communicated over the wide area narrow band networks (220 MHz and cellular).
- Broadband data with lower time sensitivity which is communicated over Wi-Fi networks with spot coverage, as well as cellular.

I-ETMS integration with ride quality monitoring is discussed later in this paper.

Ride Quality Overview

Ride quality is the correlation of a vehicle's vibration to the vehicle/track interaction (V/TI) forces for detecting issues on the track or of the vehicle. While modern day track inspection is typically performed at routine intervals using dedicated geometry measurement cars, hi-rail vehicles and/or manual inspections, these methods are expensive and performed infrequently due to cost. Ride quality data, however, can be gathered at a significantly lower cost point, much more frequently and greater areas may be covered (i.e., every time a train is in service). Augmenting traditional track inspection technologies with day-to-day ride quality data provides rail carriers with more up-to-date situational awareness of their tracks and their vehicles and may improve overall operational safety.

Ride quality standards, such as the United States' 49CFR213.333, UIC 518, EN 14363, etc. all define a set of acceptable vibration signatures that indicate normal operating conditions. While mostly targeted towards passenger vehicles, these standards can establish a baseline of safety and maintenance thresholds for Class I railroads. Indeed, some Class I railroads have already integrated ride quality monitoring systems with their track maintenance process.

rMetrix Overview

Since 2006, the Federal Railroad Administration (FRA) has invested significant time and resources in developing cutting-edge ride quality technology and algorithms that provide rail carriers access to real-time ride quality data for performing maintenance and safety inspections. Under FRA guidance, dFuzion, Inc. has commercialized this technology into the rMetrix Ride Performance Assessment System.

rMetrix revolutionizes the way ride quality data is collected, stored, analyzed and displayed. Incorporating cutting edge GPS and accelerometer sensors with an intuitive easy-to-use control software interface and cellular communications, rMetrix delivers real-time, geo-spatially correlated ride quality data to the rail carrier. Using rMetrix for continuous track inspection activities leads to the rapid identification and prioritization of locations for corrective and preventive maintenance, as well as the detection of vehicle and track abnormalities that may impact passenger comfort, cargo integrity, equipment reliability and operational safety.

Figure 1 – dFuzion rMetrix-A Ride Quality Measurement System and Custom Tri-Axial Accelerometer

rMetrix utilizes a ride quality analysis processor with a custom-designed tri-axial accelerometer designed specifically for measuring vibrations in the rail environment. The embedded software compares the longitudinal, lateral, or vertical acceleration signal strength against pre-defined safety thresholds to detect abnormal conditions ("exceptions") that may be indicative of track geometry, track structure, or vehicle performance issues. For example, excessive vertical acceleration may indicate profile or cross-level track geometry deviations; excessive lateral acceleration may indicate alignment or gage geometry defects or potential truck/bogie related problems. rMetrix also has the capability of detecting track structure defects such as mud spots, fouled ballast, pumping joints, loose ties, crushed heads, broken heel blocks, broken switch points, engine burn, corrugation. In terms of vehicle performance issues, abnormal vibration data may point to problems with worn wheels or the primary or secondary suspension components such as springs or dampers.

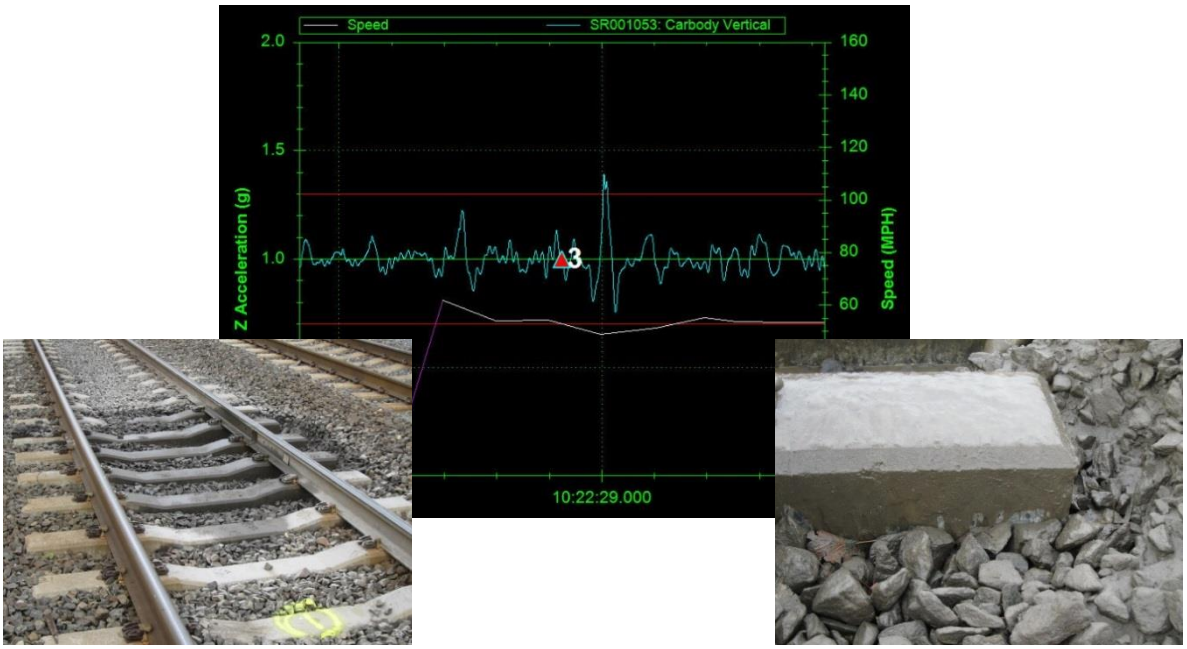

Figure 2 – rMetrix Ride Quality Results

I-ETMS and rMetrix Integration Plan

The hardware integration of ride quality monitoring with I-ETMS is based upon addition of an rMetrix intelligent 3-axis accelerometer, with Ethernet interface to the I-ETMS Train Management Computer (TMC). The accelerometer unit will be mounted near the center of the locomotive, typically in the short hood. The base configuration combines the accelerometer and ride quality analysis processor into a single package. Options can be provided to support mounting the smaller accelerometer package separately from the processor package or to provide multiple accelerometer streaming.

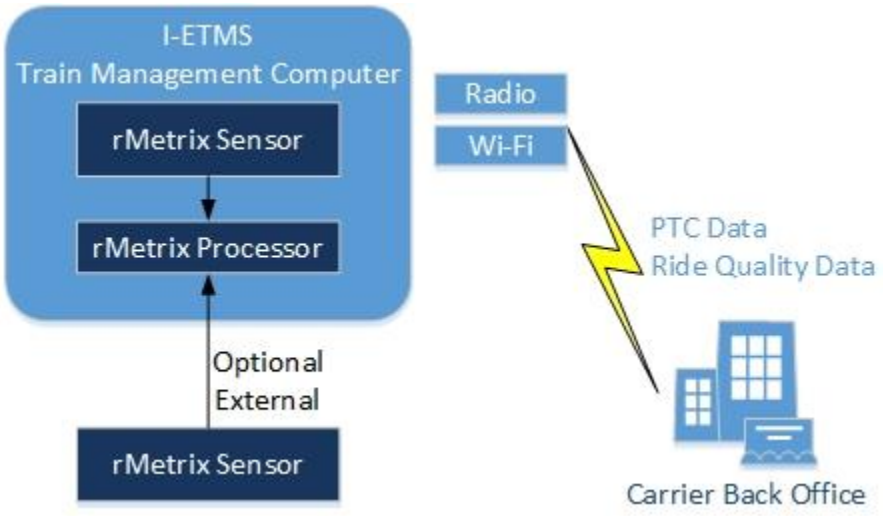

Figure 3 – I-ETMS PTC System and rMetrix Ride Quality Integration

The rMetrix ride quality sensor package will continuously monitor 3-axis acceleration. When acceleration parameters exceed pre-defined alarm thresholds, the signals are analyzed in real time to determine the type and severity of the defect, with the following actions:

- Severe alarms are reported to the engineer, via messages to the I-ETMS display (CDU).
- Summary alarm data is tagged with the locomotive ID, track location, and speed, and sent to the Ride Quality Analysis back office server over available PTC data radio links (220 MHz or cellular).
- Both alarm and detailed data is stored in the PTC Recorder.
- As an option with the Wabtec LDRS-V data and video recorder, video from the forward facing track camera can be saved as a clip, to also be stored with a tag to link the event data.
- Detailed event data (with optional video clips) can be downloaded from the locomotive when within Wi-Fi coverage to the Ride Quality Analysis back office server.
- Users can select data for detailed downloading over cellular as soon as available on a request basis.
- Ride quality events are reported to personnel responsible for control, equipment and track maintenance through the back office server.

Ride quality alarms (sent to the engineer and the back office), as well as ride quality alerts or baseline conditions (sent only to the back office) may be correlated to specific track conditions based on the direction of excessive acceleration and the optional video clips, and confirmed with field follow-up. These exceptions events may relate directly to track conditions including changes in track geometry and/or structure. Excessive vertical acceleration, for example, may be indicative of engine burn, fouled ballasts, joint defects, rail corrugation, profile or cross-level deviation. Excessive lateral acceleration may be indicative of alignment or gage deviation, or rail bends or warps. Excessive lateral acceleration may also indicate truck hunting. Excessive acceleration in either the vertical or lateral directions may be indicative of pumping or loose ties, broken ties, or broken or cracked rail. Significant and/or repeat events should be followed up by inspection and maintenance personnel unless correlated with known track structures (i.e., switches, turnouts, grade crossings, bridges, etc.).

The back office stores and analyzes ride quality data across the fleet, which allows it to provide additional situational awareness to the rail carrier by using statistical methods to differentiate between track and vehicle exceptions. Fundamentally, if multiple rMetrix systems exhibit a similar vibration abnormality at the same location, the abnormality is due to an issue with the track; if one system exhibits a different vibration signature than its fleet counterparts, the signature can be used to determine a fault within the vehicle itself. Vehicle conditions identifiable with ride quality data are vehicle spring or damper failure and truck hunting.

rMetrix Repeat Exception Locations

Repeats	Exception Type	Location	Heading	Level	System
2	CBV-Peak	(-77.356963201389 39.040539673611)	192.60	1	DF-VTC1000-001

rMetrix Event Counts

DF-VTC1000-001

Level	# of Events	Event Type
1	2	CBL-Peak
1	34	CBV-Peak
	36	

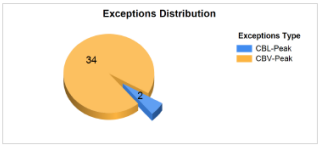

Figure 4 – Back Office Ride Quality Reporting

The back office ride quality data can be communicated to multiple stakeholders within the railroad via electronic email reports, dedicated websites, and direct transfer to railroad back office data management systems. With integrated real-time ride quality information, automatic speed limiting through PTC systems may prevent operations under unsafe conditions that emerge rapidly as track or vehicle conditions deteriorate.

The back office can generate automated reports that allow carriers to:

- Monitor track and vehicle conditions in real-time
- Identify track locations in need of maintenance
- Identify vehicles in need of maintenance
- Identify abnormal equipment operation
- Identify locations for imposing temporary speed restrictions
- Validate effectiveness of track and vehicle maintenance activities

The integration of real-time ride quality monitoring requires the addition of an acceleration sensor and an analysis processor onboard the vehicle, with interface to I-ETMS over the Ethernet network. This approach can significantly reduce the cost of track inspection. The collection and analysis of track performance data from revenue trains can support reduction of the need for scheduling and running separate track inspection vehicles.

Implementation Considerations

The Federal Railroad Administration has recognized the importance of autonomous ride quality data monitoring. Their studies have resulted in implementation guidance (*Autonomous Track Inspection Systems – Today and Tomorrow, AREMA 2009, Gary Carr, FRA, Ali Tajaddini, FRA, Boris Nejikovsky, Ensco Corp.*) presented at AREMA 2009 such as:

1. Pilot applications of autonomous inspection technology on limited routes often serve as an opportunity to identify issues, and validate the approach and results of the system while minimizing railroad investments in time and effort required.
2. Prior to the full implementation of autonomous inspection technology, the railroad should have a clear plan on data usage.
3. As is often done in automated inspection programs, different measurement thresholds are used to identify issues that could grow into defects. With increased reporting frequencies, new thresholds may be warranted to monitor defect growth rates with increased sampling rates and projections of when the defects will become critical.
4. Pilot applications can afford an opportunity for operators to gradually develop response plans, formulate appropriate thresholds where applicable, and grow accustomed to data flow rates.
5. Confidence in the data reported with this technology can often be bolstered by considering the existence of “repeated events” on consecutive surveys as a validation mechanism.

Although this represents a logical approach during the initial stages of autonomous inspection deployment, this is accompanied by risk – the “knowledge” of a potential defect without immediate remedial action. This is an extremely critical issue in that it not only represents increased liability for the railroad but a regulatory issue as well.

Wabtec and dFuzion can work together to provide rail monitoring solutions with integration to I-ETMS PTC implementation plans. Requirements and a phased implementation plan can be developed for individual railroads.