US Department
of Transportation
**Federal Railroad
Administration**

Research Results

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Developed Wheel and Axle Assembly Monitoring System to Improve Passenger Train Safety

SUMMARY

To encourage the expansion of safe high-speed passenger rail service nationwide, the FRA sponsored the development and testing of two autonomous systems to monitor passenger trains to help ensure safety and ride quality. This monitoring is essential for high-speed trains where the consequences of derailment are potentially greater than for trains traveling at lower speeds. The first system is a rugged unit that can function reliably in extreme environments. This system was tested on a Talgo train with tilting technology traveling between Portland and Vancouver during the summer and fall of 1998. The unit was installed to monitor Talgo's compliance with an FRA waiver allowing the train to travel through certain curves at speeds higher than those of a non-tilting train.

The second system is a lighter less rugged system designed for passenger cars where the operating environment is typically less harsh than that of locomotives. The system was installed on Amtrak passenger cars traveling from Bakersfield to Sacramento California and from Washington, DC to New York City. This unit was designed to measure and monitor the vibration of wheel and axle assemblies using standard accelerometers. The measurements were then processed using a neural net computer that "learns" in a manner similar to a human. The data can be used to identify track and vehicle maintenance and repair needs and potentially unsafe conditions.

The tests successfully demonstrated that the remote monitoring systems (see Figure 1) could provide a reliable means for detecting potentially unsafe track and vehicle conditions in near-real time. In addition it can be easily modified to meet various users' monitoring requirements.

Figure 1. A light onboard platform with cellular/CDPD modem and accelerometers designed for passenger cars.

BACKGROUND

Real time safety monitoring is essential for high-speed passenger trains the consequences of a derailment are much greater than for trains operating at lower speeds. Recognizing this fact, the FRA in 1995-1996 initiated two projects to develop sensor systems to detect various hazardous conditions in high-speed rail (HSR) operations. Two versions of a remote monitoring system were developed: one was designed more ruggedly for installation on locomotives and the other designed for passenger car applications.

SYSTEM DESIGN

Each remote monitoring system consists of two major components as follows:

1. Onboard platforms installed on each monitored vehicle.

2. A central station located in an office, displaying location and status of each vehicle, as well as detected events on a map or other graphical display.

Each system provides two-way wireless communication between the mobile onboard platform and the central station. This communication can be provided through circuit-switch cellular or digital wireless communication links. The onboard platform can be configured for installation on any rail vehicle and is scalable, allowing for expansion of its capabilities to fit the needs of the user.

The onboard platform continuously monitors the motion of car body and truck, wheel and axle assemblies, mounted accelerometers and GPS-based geographical position and analyzes their outputs. When an abnormal condition is detected, the onboard platform sends either an "ALERT" or "ALARM" message to the central station with the location of the exception and parameters describing this exception. The onboard system also sends at regular intervals a "STATUS" report that includes the vehicle's location and a "snapshot" of all measured data.

The central station computer stores all received messages in a database and displays icons corresponding to each message on the Geographical Information System (GIS) based operator interface. These icons represent vehicle locations and detected track exceptions.

When the operator clicks on a particular icon, specifics about the detected exception are displayed, including the status of the vehicle at the time of the event detection and a time series of measured parameters before and during the event.

The operator can also display waveforms associated with any particular alarm or alert message, thus facilitating data analysis (See Figure 3). Additionally, the operator can create daily, weekly and monthly reports for maintenance personnel.

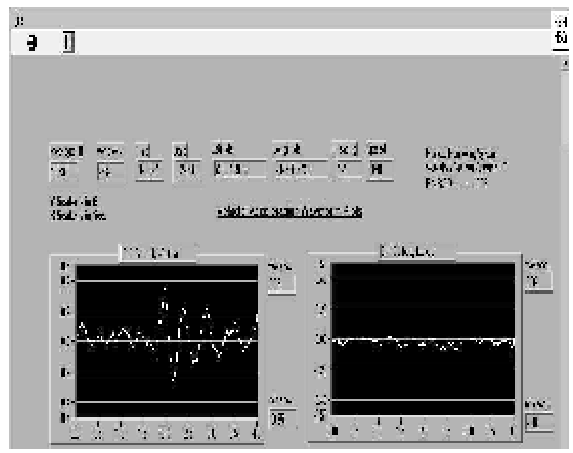

Figure 3. Car body vertical and lateral acceleration waveforms.

TEST RESULTS

In field testing over a seven month period beginning in July 1998, the three remote monitoring systems were installed; one on a locomotive in the Pacific Northwest, one on an on Amtrak passenger car in the California San Joaquin corridor, and one on an Amtrak passenger car in the Northeast corridor. The system tested in the Pacific Northwest was also used to monitor compliance with an FRA waiver allowing TALGO, a Spanish high-speed tilting train, to travel through certain curves at higher speeds[1]. These monitoring systems demonstrated their functionality, position accuracy and repeatability of results. All systems detected multiple maintenance exceptions. (See Figure 3.) Approximately 84% of all exceptions were repeatable, which means they were detected in the same locations multiple times. Neural net, computer software installed on one of the systems was developed using experimental data related to the shimmy of trucks available from a series of tests on the Amtrak Road Railer, track inspection car.

The neural net was successfully trained to distinguish between steady truck motion and hunting motion. During official testing, the trained neural net detected several instances of excessive truck lateral acceleration. Analysis revealed that none of these exceptions were indicative of hunting but rather were caused by transient impacts from the rail. Most of these impacts could be attributed to switches.

CONCLUSIONS

The completed projects demonstrated that the remote monitoring system can satisfy the requirements of the new Federal Track Safety Standards (49 CFR Part 213) [2] in car body and truck acceleration monitoring and can be used on high speed trains to improve safety of operation and increase efficiency of maintenance. The system provides sufficient data for the analyst to determine unsafe conditions and predict maintenance needs. It can be modified to meet various users' requirements. Thus, the remote monitoring system is a valuable tool in ensuring the timely detection and correction of rail defects and vehicle safety and maintenance problems.

ACKNOWLEDGMENTS

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REFERENCES

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[2] Department of Transportation, Federal Railroad Administration, "Track Safety Standards," Final Rule, 49 CFR Part 213, June 22, 1998.

CONTACT

Dr. Tom Tsai
Federal Railroad Administration
Office of Research & Development
1120 Vermont Avenue, NW - Mail Stop 20
Washington, DC 20590
TEL (202) 493-6354
FAX (202) 493-6333
e-mail: tom.tsai@fra.dot.gov

Steven Sill
Federal Railroad Administration
Office of Research & Development
1120 Vermont Avenue, NW - Mail Stop 20
Washington, DC 20590
TEL (202) 493-6348
FAX (202) 493-6333
e-mail: steven.sill@fra.dot.gov

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