U.S. Department
Of Transportation

Federal Railroad Administration

Research Results

RR06-17
October 2006

An Integrated Track Stability Assessment and Monitoring System Using Site-Specific Geo-Technical/Spatial Parameters and Remote Sensing Technologies

SUMMARY

The Federal Railroad Administration's (FRA) Office of Research and Development sponsored a project to develop a mobile rail track surface and sub-surface surveying system capable of collecting data from a variety of remote sensing instrumentation and integrate this data with other site-specific data to assist in monitoring rail track behavior over time. The mobile surveying system was developed to be modular and adaptable to a variety of platforms and successfully integrated with High Accuracy Differential Global Positioning System (HADGPS) technology, resulting in the capability of measuring top of the track coordinates with centimeter precision at a variety of speeds. The mobile surveying systems were used to collect data from several geo-technically vulnerable sites located on active rail corridors in the State of West Virginia, and a statewide Web-based Geographical Information System (GIS) was developed to store and display the data collected from the field experimentation program, in addition to facilitating the integration of other geo-spatial information. It is complimented by a state-of-the-art information technology system constructed with multi-terabyte storage capacity in order to perform comparative studies over time of selected rail corridors in West Virginia (see Figure 1). The mobile surface surveying system has also been used in other states to evaluate its application for measuring track shift at curves, derailment analyses, and rail yard surveying.

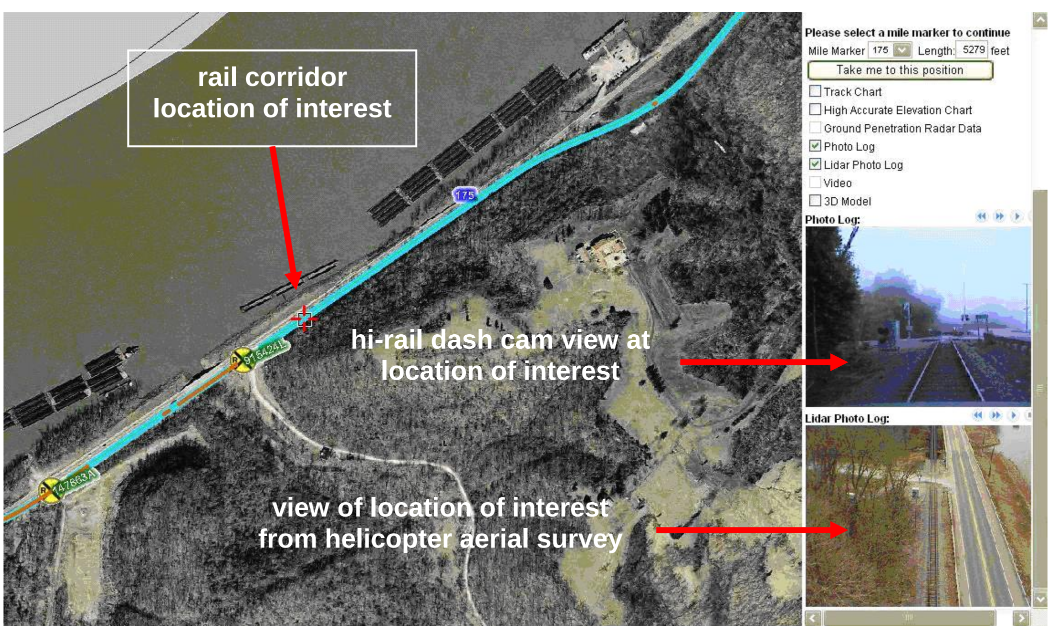

Figure 1. Example screen shot from the user interface for the Web-based GIS system developed to integrate rail surface and sub-surface data with other site-specific data along active rail corridors in West Virginia.

BACKGROUND

Track and structure defects are principal causes of reported railroad accidents and incidents in the United States. Based on FRA's statistics for the period 1988-1999, an average of 1,065 incidents was attributed specifically to track-related causes, which accounted for 34 percent of the total incidents. As reported by FRA for the year 2000, track defects accounted for 36 percent of the total reported railroad incidents.

Recent newspaper stories citing FRA reports reported that railroad accidents in West Virginia during 1996-1998 increased 56 percent when compared to the previous years 1993-95, and the leading culprit or cause was the track. This increase in track-related train accidents can be attributed to several sources. Site-specific factors include increased ton mileage, difficult terrain, and geologic conditions. Additionally, these sites are vulnerable to climatic events. This is particularly prevalent in locations in close proximity to drainage systems.

Parts of West Virginia experienced major floods in 2001 and 2002, which inflicted significant damages to the transportation systems. Geo-technical related potential safety hazards for the rail lines in West Virginia are now more prevalent as a result of these recent floods.

To improve the safety of railroad operations in the United States, this project focused on: advancements in the detection of track and subsurface stability and analysis of the most appropriate remote sensing technologies for site-specific geo-technical/spatial data collection and monitoring.

METHODS

Field Work with Remote Sensing Instrumentation

Researchers developed and deployed several different modular and adaptable platforms to survey track subsurface conditions at several locations along active rail lines adjacent to river embankments in West Virginia. They collected, analyzed, and compared seismic, gravity, resistivity, geophysical, Ground Penetrating Radar (GPR), and terrain conductivity data at these locations. Figures 2, 3, and 4 show examples of the mobile platforms.

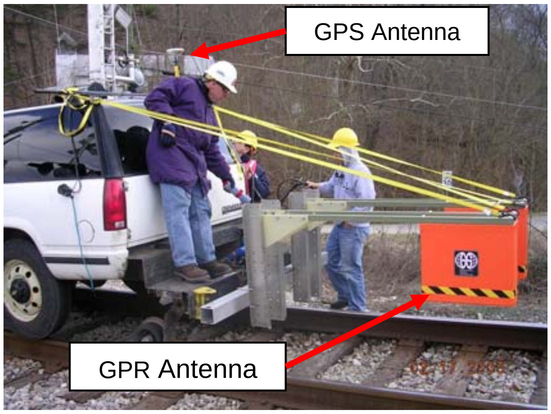

Figure 2. GPR antenna adapted to a hi-rail.

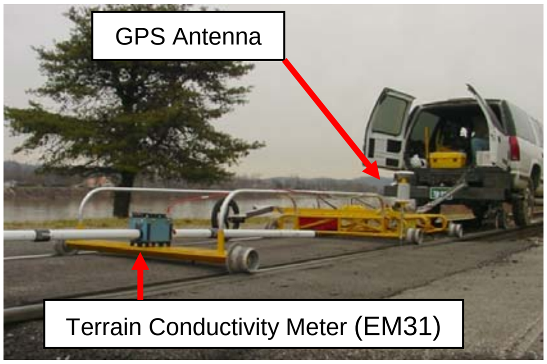

Figure 3. Terrain conductivity meter (EM31) adapted to a rail cart.

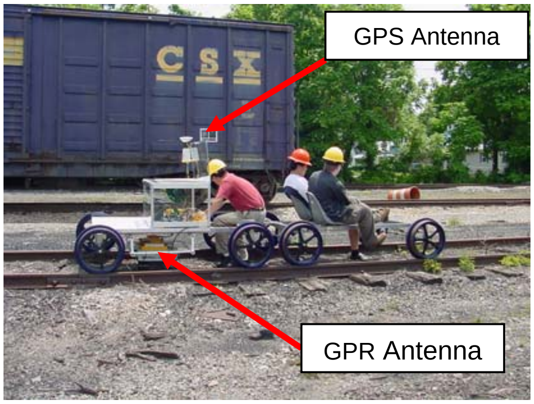

Figure 4. GPR antenna adapted to a rail bike.

Integration of HADGPS Technology

A HADGPS that requires a temporary base station or adequate access to a permanent base station and a roving unit as shown in figure 5 was employed to conduct surface track surveys at different speeds over several rail segments and corridors of track in West Virginia and for single corridors or rail yards in New Mexico, Alabama, Missouri, and Illinois.

Figure 5. Left: GPS antenna being adapted to a locomotive. Right: Temporary GPS base station needed to achieve centimeter precision from the roving GPS unit.

In some cases, multiple surveys of the same rail corridor were performed, while in some cases only one survey was conducted at a particular location. In West Virginia, the HADGPS was integrated with GPR for one 20-mile rail corridor survey. The HADGPS antenna units were adapted to hi-rails and locomotives .

Comparison of HADGPS Surveying Technology with Other Surveying Technologies

A 40-mile rail corridor in West Virginia was surveyed using a helicopter equipped with Light Detection and Ranging (LIDAR) technology for comparison purposes with HADGPS technology. The LIDAR data was processed and integrated into the Web-based GIS platform to allow for effective comparisons with the HADGPS data. Traditional surveying technology was used to compare with the HADGPS technique for several 3000-foot rail lines for a rail yard located in Alabama.

Integration of the Mobile Surveying Data with Other Geo-Spatial Data using a GIS platform for the State of West Virginia

Web-based GIS technology was employed to establish the capability to integrate, display, and compare all data collected with a variety of other data, including but not limited to aerial photography from two different sources and photo logs taken from a hi-rail based dash cam for one of the rail corridors surveyed previously.

A data warehouse was developed using a Storage Area Network (SAN) for reliable storage, backups, and dissemination of the GIS data. The data warehouse hardware and software was installed in a state-of-the-art library facility on the Marshall University campus complete with back-up power, 24-7 environmental management, cyber security, and physical security systems.

RESULTS

Figures 6 and 7 provide typical results from two of the subsurface survey instruments that were utilized in West Virginia.

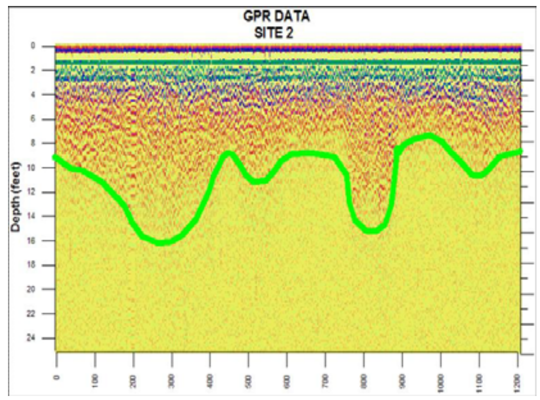

Figure 6. GPR results for a 1200-foot rail track survey with interface between track ballast and track sub-grade shown in green.

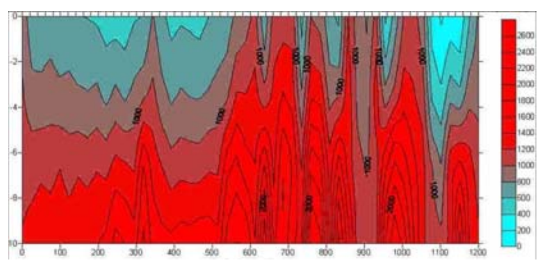

Figure 7. Terrain conductivity results for a 1200-foot rail track survey. Blue color reflects wet conditions while red indicates dryer conditions.

Figures 8 and 9 illustrate typical survey results from multiple surveys conducted at the same locations using the HADPGS technique. The data was collected from a hi-rail moving approximately 20 miles per hour.

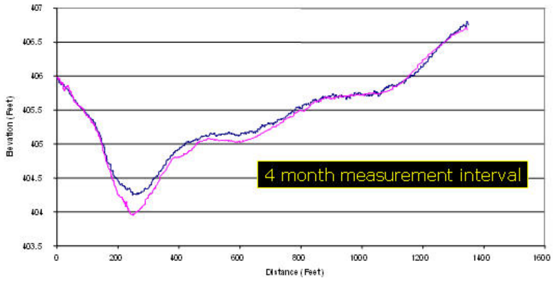

Figure 8. Compares two vertical elevation profiles obtained using the HADGPS technique conducted at 4-month intervals for a 1600-foot segment of rail track in West Virginia.

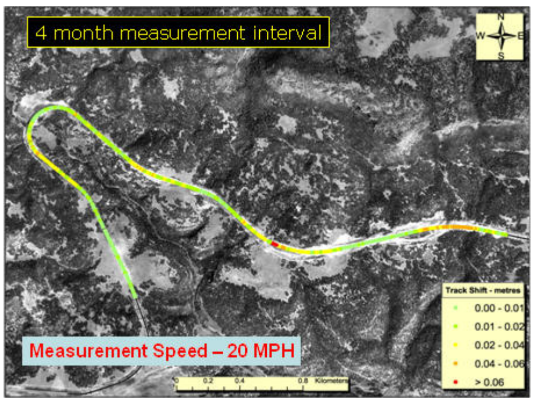

Figure 9. Track shift measured from HADGPS surveys conducted at four month intervals for a 2- mile (+) track segment in New Mexico.

CONCLUSIONS

The project's field work illustrated the usefulness of HADGPS in surveying and monitoring of railway track superstructure. Improvements in worker safety and general railroad operations can be realized through minimizing workers exposed to hazards around active rail lines required with the traditional surveying techniques. HADGPS precision can be adequate for certain construction specifications and does offer more precise measurements capability than the LIDAR technique for establishing baseline information for subsequent comparative purposes.

Integration with non-invasive remote sensing technologies and other data sets in a GIS platform provides a very effective means for surface and subsurface data comparative and interpretive analyses.

ACKNOWLEDGEMENTS

This study was conducted by Marshall University at Huntington, WV researchers led by Dr. Richard Begley and Dr. Tonly Szwilski. Mahmood Fateh and Dr. Magdy El-Sibaie of the FRA's Track Research Division provided technical support and direction. The study would not have been possible without the excellent support of CSXT, NS and BNSF Railroads, including access to active rail lines during the course of field work.

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