

TRACK INSPECTION INTO THE 21ST CENTURY

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ABSTRACT

Since 1974, the Federal Railroad Administration (FRA) Automated Track Inspection Program (ATIP) has been collecting track geometry, ride quality and other track related data on the nation's rail transportation network. FRA is continuing the study of improving the collection and dissemination of geometry data for the benefit of its shareholders. In 1999, to improve data proficiently for monitoring track conditions and assessing track safety compliance, FRA developed a state-of-the-art geometry car, FRA T17 (aka T2000) with the necessary track geometry and ride quality measurement systems. Recently, FRA awarded a contract to construct two new geometry cars and upgrade an integrated Track Data Management System (TDMS) to provide functionality of track data manipulation, data viewing, recordkeeping, and route scheduling. Built within TDMS (due to the integrated nature), queries will enable systematic evaluation of overall track conditions, including a Track Quality Index (TQI) tool. More importantly, TQI provides the functionality to project future track conditions so that FRA shareholders can better schedule the frequency for track inspection or plan track maintenance activities.

This paper will provide an overview and will show the capabilities, scheduling, and reporting functionality according to the Department's National Rail Safety Action Plan of

the geometry car owned by FRA Office of Safety and the two Geometry cars owned by Research and Development.

BACKGROUND

Automated Track Inspection Program

For more than 30 years the FRA's *Automated Track Inspection Program* (ATIP) has provided accurate, objective measurements of loaded track geometry data to assess compliance with the *Federal Track Safety Standards*. Priorities for ATIP inspections include passenger, major Hazardous Material (HAZMAT) and Strategic Rail Corridor (STRACNET) routes, and other track, which present a safety concern to the FRA.

Currently, FRA geometry cars survey (inspect) approximately 27,000 miles of track on average each year. With the addition of two new geometry cars T19 and T20, the agency goal is to survey 100,000 miles of track each year. Figure 1 shows the Office of Safety's track geometry car, FRA T17. FRA expects two new cars, FRA T19 and FRA T20, to be built and in service by the fall of 2006. Figure 2 shows the FRA Office of R&D's research cars, FRA T16 and FRA T18 (GRMS) which will be utilized as part of the Office of Safety National Safety Program Plan.



Figure 1. Office of Safety's FRA T17



Figure 2. Office of Research and Development's FRA T16 and FRA T18 (GRMS)

How is the track data utilized? The track data collected by ATIP is used by FRA, railroad inspectors and railroads to assist and assure track safety is being maintained by setting priorities for their respective compliance activities. Also, the data is used by FRA to assess track safety trends within the industry. Immediately following ATIP track surveys, the railroads use the data to help locate and correct exceptions found. Often

railroads use the ATIP data as a Quality Assurance check on their track inspection and maintenance programs.

Continuous Improvement

FRA is committed to the continuous improvement of ATIP technology in order to assure the track condition data collected is the best available and to facilitate the dissemination and use of the data. ATIP makes every effort to achieve precision, accuracy, repeatability, and reproducibility, or the acronym PARR. The ATIP inspection systems are indeed “mobile measurement laboratories.” In order to better assure the quality and integrity of the ATIP data, ATIP achieved certification under the International Organization for Standardization (ISO) 17025 on March 16, 2006 by developing necessary quality procedures. Figure 3 shows a copy of the official ISO 17025 certificate.



Figure 3. Copy of ISO 17025 Certification

Advancements in Track Inspection

Most of the advancements in ATIP technology come from the application of technologies that have been developed and refined by other industries. Advancements in sensors, instrumentation, computers, data communications and data management currently come at a rapid pace. ATIP is continually evaluating these new and emerging technologies to assess their potential benefits for track inspection. At the same time ATIP is assessing the needs of its data users and shareholders to determine what new measurement or data management capabilities would best enhance the program's safety assurance mission. The following is a brief review of some of the more recent technology enhancements that have been introduced to the program.

ATIP Track Data Management System

FRA has developed and implemented a new *Track Data Management System* (TDMS) to improve access to and dissemination of the ATIP data. TDMS enables FRA shareholders to log on to a central server over the Internet and access both current and historical ATIP track condition data. Figure 4 is a screen shot of FRA's TDMS. The system provides both a map based Geographical Information System (GIS) and a database query system to access and display the data. Railroads are able to access ATIP data collected over their track and generate statistical summaries such as the following:

- Exceptions per 100 miles

- Exceptions by class and type of exception
- Foot-by-Foot graphical data
- National Average
- Safety Trends

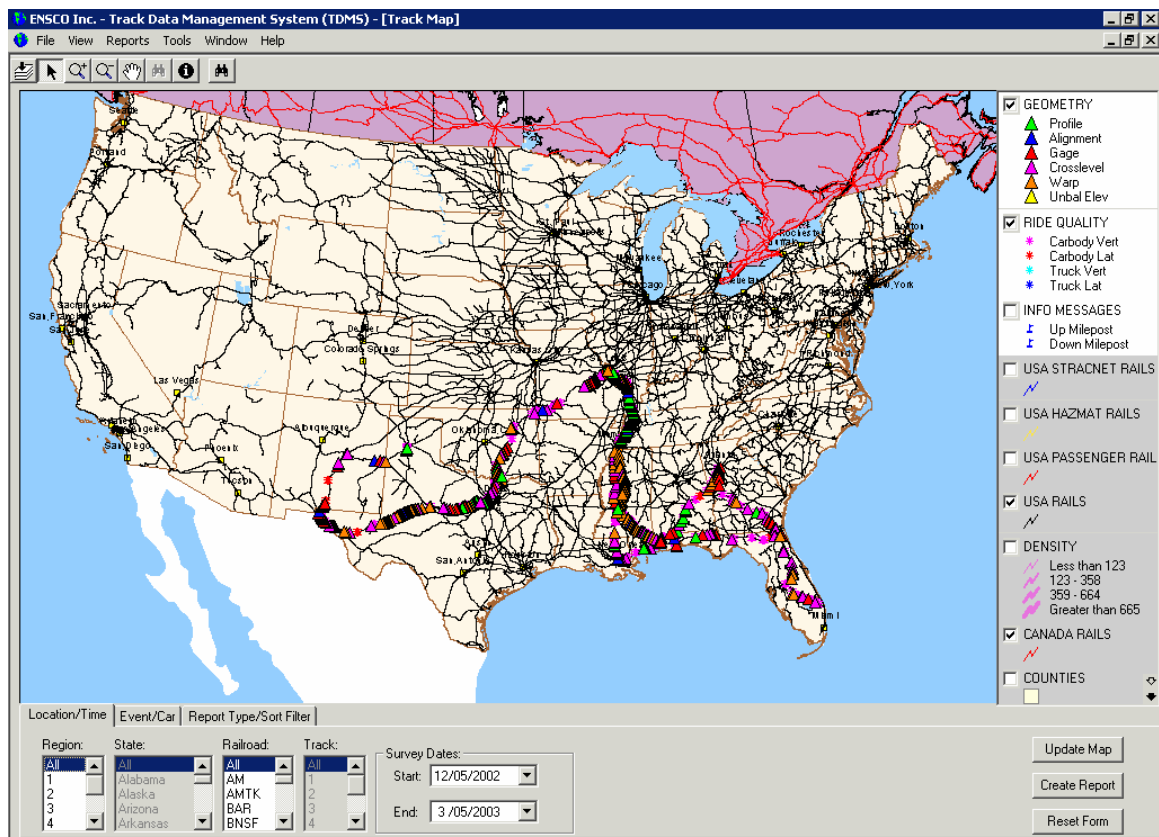


Figure 4. Track Data Management System (TDMS)

Digital Track Notebook

Since 1974, track inspections have traditionally been recording in a paper-based system. In 1994, the FRA Inspectors were equipped with MS Windows on a laptop running the *Railroad Inspection System for PC* (RISPC) application that provided a means for entering the data that they collected on paper, in the field and later transferred into local MS Access database. This information is subsequently uploaded to a centralized Railroad Inspection System at FRA headquarters.

In the late 1990's, with the mainstream introduction of handheld computers and Personal Digital Assistants (PDA's), the next logical step in the inspection reporting process was to provide the Track Inspectors with a tool to electronically enter inspection data while they were actually at the track location.

In 2001, design and development of the *Digital Track Notebook* (DTN) was initiated by the FRA Office of Safety and ENSCO, Inc. The project was driven by the inspectors' limited track time and the high level of risk associated with today's fast-paced railroad industry. Most times an inspector must judiciously gather vital inspection information quickly and effectively to determine compliance with the standards. The goals were to reduce the hardware equipment, paperwork carried into the field, and minimize any nonproductive time in redundant or repetitive note taking when transferring data into RISPC. What was needed was an electronic recording system that could encompass a

rules reference library and simplify note taking and record keeping in one seamless and rapid operation. This would permit inspectors to allocate more on-track time to determine whether the nation's railroads are compliant with federal regulations.

The first generation DTN mobile field inspection platform was introduced to FRA track inspectors in January 2001 as a proactive means of utilizing the most advanced technology on the market to increase field inspector productivity. The DTN has allowed the FRA to demonstrate leadership capability to the industry by providing the mobile field inspector with modern technology to increase efficiency in performing job duties.

Since 2001, the track inspection tools built for the DTN have been designed around the most cutting edge technologies available on the market. The product is currently in the second generation and has received several major technology updates such as global positioning systems (GPS), digital cameras, and infrared data beaming and printing.

The foundation of the second generation DTN is the Microsoft PocketPC and SQLServer CE platforms. Figure 5 depicts the second generation handheld that is presently being used. The third generation DTN will allow for web access of data, automated downloads from geometry cars and other advancements being studied which include heads-up display and voice recognition technology.



Figure 5. Digital Track Notebook

New Track Parameter Reported by ATIP

After testing and follow-up verifications over the past three years, three new parameters of track condition data have been added to the ATIP inspection process: (1) Runoff31 at the end of a raise, (2) Twist31 in spirals, and (3) Ride Quality in terms of Track Quality Indices. These parameters are currently being presented as “Advisory” data in reports generated on the inspection cars. Runoff31 and Twist31 are presented as advisory because the detected conditions it may, at times, be unrelated to a mechanical track raise or caused by physical conditions at a spiral location, respectively. The Runoff31 detection algorithm applies three criteria to the left and right profile space curves:

- Change in elevation criteria change in elevation within 31 feet exceeds the FRA runoff limit set for the posted class of track.

- Length criteria the peak and the valley adjacent to the change in elevation are at least 62 feet long. Absolute value of the peak and the valley exceed 25% of the FRA runoff limit for the posted class of track for at least 62-feet.
- Flatness criteria the top of the peak is reasonably flat.

A runoff exception is reported if all three conditions are satisfied. Exceptions for left and right rail are processed separately.

Performance-based Ride Quality is only included in the Part G (High-Speed) section of the Federal *Track Safety Standards*; however, it is useful in helping track inspectors locate areas where repeated or cyclical track anomalies produce significant vehicle/track interaction. These locations are often found to be the result of sub grade failures for vertical accelerations (typically at road crossings and bridge approaches) and contributing to poor alignment at bridges, turnouts, and spiral curve transition points when lateral accelerations are excessive.

Advancements in Track Inspection beyond ATIP

High-Speed Gage Restraint Measurement System

FRA Office of Research and Development developed a new high-speed Gage Restraint Measurement car FRA T18, which is presently being used in service. The system includes a lightweight independent retractable load axle to enable better control of applied forces at high speed. FRA T18 is shown in Figure 6.



Figure 6. FRA T18 – Gage Restraint Measurement Car (GRMS)

Automated Track Data Alignment System (ATDAS)

FRA Office of Research and Development (R&D) have developed an *Automated Track Data Alignment System* (ATDAS) to enable precise alignment of track geometry data from survey to survey as shown in Figure 7. This system, which is currently installed on the FRA T16 high-speed track geometry car, is used to detect changes in track condition on a foot-by-foot basis for detailed assessment and early warning of track degradation.

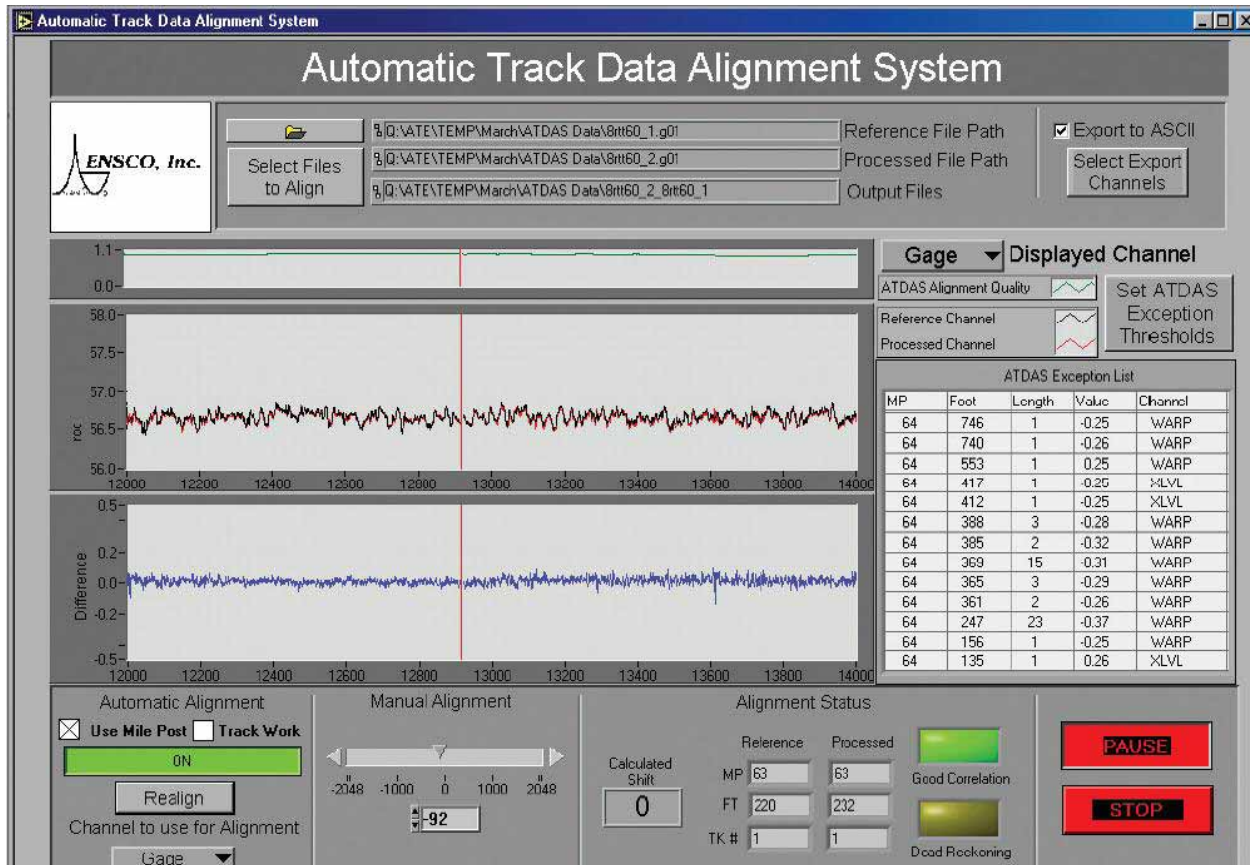


Figure 7. Automated Track Data Alignment System (ATDAS)

Derailment Analyzer

This system was developed by FRA R&D to run on a track geometry car and identify track locations which may produce unacceptable vehicle dynamics in real-time. A simplified vehicle simulation is used to process track geometry data in real-time and provide exception reports of locations, which may require speed restriction to avoid unacceptable car response.

Portable Track Loading Fixture

The *Portable Track Loading Fixture* (PTLF) and previously known as the Lightweight Track Loading Fixture was originally developed as a supplement to the Gage Restraint Measurement System to verify exceptions and repairs. It has since found broad acceptance by the industry as a tool to confirm the strength of track. Figure 8 shows the Portable Track Loading Fixture.



Figure 8. Portable Track Loading Fixture

Vertical Track Interaction Inspections

There are over 70 VTI monitors operating in passenger and freight service. Figure 9 illustrates some of the outputs using the VTI Monitoring system. The VTI monitors provide an excellent *low cost* supplement to traditional track inspections because of the following capabilities:

- Provides more frequent coverage of territory than track geometry cars
- Detects deviations not detected by track geometry standards
- Registers vehicle/track interaction responses of fleet cars
- Provides objective view of territory
- Provides access to track and vehicle health for management review

The VTI monitoring system will integrate with existing maintenance planning systems.

Using this technology to plan and qualify vehicle or track maintenance will significantly help to reduce the overall risk to railroad assets.

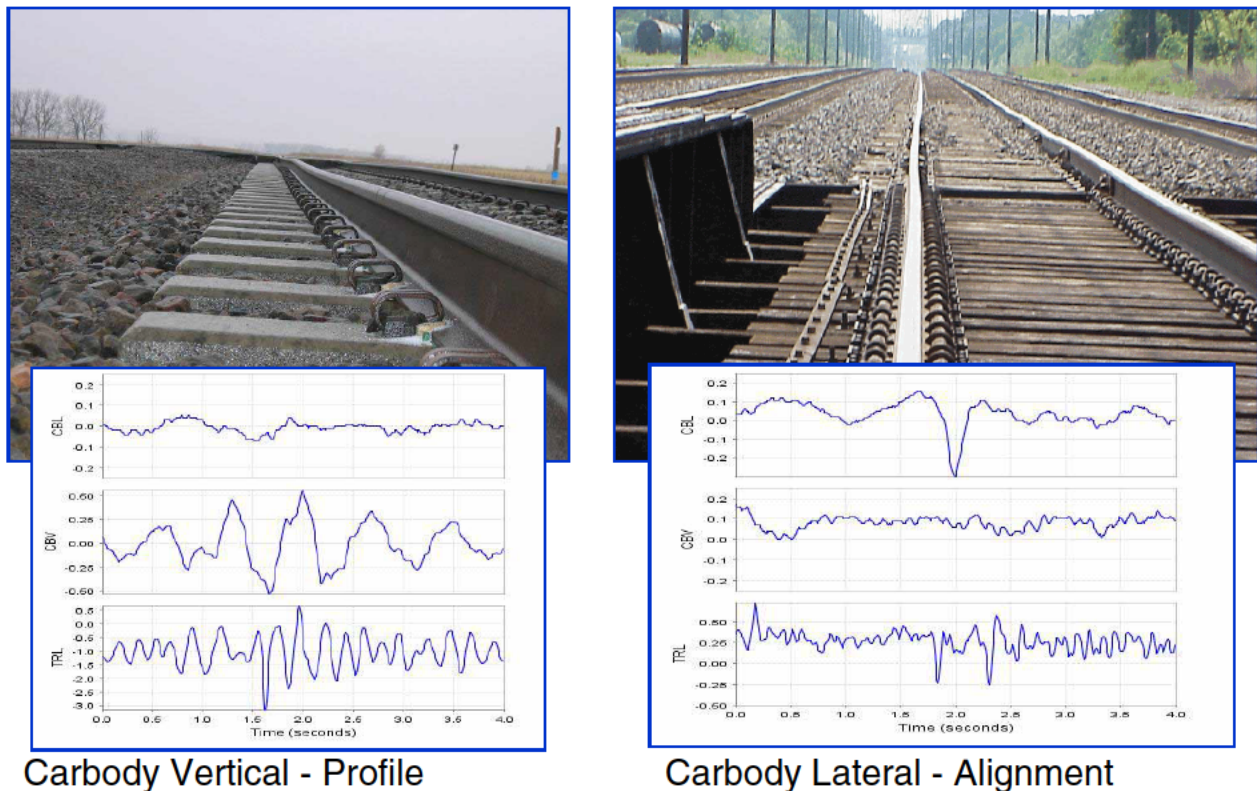


Figure 9. Samples of VTI Monitors Outputs

Autonomous Ride Meters

In response to FRA requirements for routine monitoring of vehicle/track interaction for high-speed trains, freight and passenger railroads have equipped their trainsets with autonomous ride meters (see Figure 10) which continuously monitor both carbody and bogie accelerations in revenue service. The system uses GPS to pinpoint the location of each event and wireless communication to send data to central servers. Pager notification of events can be sent to track inspectors in the field for follow-up.



Figure 10. Autonomous Ride Meter

In mid 2003, accelerometers were installed on the journal boxes of the FRA T17 geometry car. Data from these sensors is processed to measure the vertical impact associated with significant anomalies on the running surface of the rail. The system, in

terms of force, has been found to reliably detect excessive impact locations, which may lead to component failure at rail joints, switches and crossing diamonds.

Advancements under Study

Automated High Speed Joint Bar Inspection

Broken joint bars resulted in a significant number of track-caused derailments. Figure 11 shows the mounting of a joint bar system. Early detection by manual inspection of cracked joint bars is difficult, if not impossible; by a typical on track Hi-Rail based visual track inspection system. Developed by FRA R&D, the system uses high-speed line scan video cameras to collect a high resolution image of each joint bar at speeds up to 80 mph. These images can be reviewed by an operator and will ultimately be evaluated by a computer to detect the presence of small cracks and missing bolts, etc.



Camera and laser mounting



Figure 11. Automated High Speed Joint Bar Inspection System

Rail Cant and Rail Cross Section Advisory

FRA geometry cars will be equipped with a Rail Profile Measurement System (RPMS), similar to that on the FRA T16. With the advent of better laser scanning devices and processing, it is now possible to accurately measure the rail cant and rail profile, and also to determine the type of rail section. Recent events have caused FRA to investigate derailments caused by excessive Rail Seat Abrasion (RSA), see Figure 12, on concrete crossties. FRA seeks to understand the mechanics of rail overturn caused by excessive abrasion of the rail seat area and has enlisted the help of railroads and industry experts. With the use of RPMS, inspectors can identify both detrimental (negative and positive) limits of rail cant angle values along a segment of track.

Extreme rail headwear loss is a concern both in the vertical and horizontal planes. Questions of gage measurement emerge when the rail head is excessively worn, creating a condition whereby the 5/8 inch point below the rail running surface cannot be determined. ATIP will issue 'safety advisories' when rail wear conditions are severe. The system will also provide 'safety advisory' reports of locations where rail wear is such that contact from normal wheels will result in vertical loads being applied to the field corner of the rail. These conditions have been associated with the derailment of freight cars because of rail overturning.



Figure 12. Rail Seat Abrasion Photograph

Grade Measurement UPDATE

A prototype system for grade measurement has been evaluated on the FRA T17 track geometry car and is expected to be introduced into service in 2007. This system is expected to provide more detailed and accurate grade data than is currently included on most railroad track charts.

Wayside Mapping System

The present Wayside Mapping System consists of a suite of affordable tools that can be inventory and map track-related assets and build a track asset management system.

The system provides a portable, low-cost, highly accurate tool for mapping and inventoried track elements and wayside assets. The end user software provides an interactive which attributes to collection of assets to create and maintain a comprehensive track asset management system. Key benefits are:

- Accurate Inspection of Infrastructure Conditions
- Improved Record Keeping
- Cost Efficiency
- Information Management System
- Flexibility
- Seamless Information Flow between Systems
- Easy Access to Primary Information

Autonomous Geometry System

The Autonomous Geometry Evaluation System measures track geometry data. The system detects and pinpoints the locations of exceptions. It tracks and monitors track geometry data including gage, crosslevel, alignment and limiting speed in curves. The Autonomous Geometry System provides the same accurate and dependable

performance as a dedicated Track Geometry Measurement System (TGMS) on high-speed track geometry cars. However, it does so without the onboard crew. This enables the system to run on revenue trains, which greatly improves the efficiency of inspection operations and limits interruption of revenue service.

A rail car equipped with the Autonomous Geometry Evaluation System can measure more than twice as much as a typical dedicated track geometry car at a fraction of the cost per mile. This allows for track inspections, which haven been shown to improve safety and allow for more efficient maintenance planning. When defects are detected, they are transmitted to a notification cent via communication from the cars, making it available to view in real-time.

Closing Remarks

Each year ATIP detects and helps remediate more than 13,000 verifiable track safety defects. FRA believes ATIP provides a beneficial service and helps railroads reduce the number of geometry caused derailments. FRA is committed to the continuous improvement of ATIP so that we meet our track safety goals both now and into the 21st century. One way that will increase the detection of verifiable track safety defects will be accomplished by the onset of the two new geometry cars that are schedule for operation in late 2006.

Our efforts will focus on improving data quality, enhancing data value and facilitating data usage, and will be closely coordinated with FRA shareholders who are the primary consumers of the ATIP data.

Acknowledgements

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LISTS OF FIGURES

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FIGURE 2 Office of Research and Development's FRA T16 and FRA T18 (GRMS)

FIGURE 3 Copy of ISO 17025 Certification

FIGURE 4 Track Data Management System (TDMS

FIGURE 5 Digital Track Notebook

FIGURE 6 FRA T18 – Gage Restrain Measurement Car (GRMS)

FIGURE 7 Automated Track Data Alignment System (ATDAS)

FIGURE 8 Portable Track Loading Fixture

FIGURE 9 Samples of VTI Monitors Outputs

FIGURE 10 Autonomous Ride Meter

FIGURE 11 Automated High Speed Joint Bar Inspection System

FIGURE 12 Rail Seat Abrasion Photograph