US Department
of Transportation
**Federal Railroad
Administration**

Research Results

RR01-01
MARCH 2001

T-16: FRA's High Speed Research Car

SUMMARY

In November, 2000, the Federal Railroad Administration (FRA) began operating high speed research car T-16 (Figure 1) to investigate methods for providing a safer and smoother ride for passenger and freight trains traveling at higher speeds. FRA's Office of Research and Development uses T-16 to study the dynamics of wheel-rail behavior, to investigate methods for improving track inspection, and to assess potential high speed rail corridors. T-16 also assists Amtrak, local and regional commuter authorities, and individual railroads in assessing their routes.

T-16 is a former Amtrak Metroliner passenger car which was refurbished and instrumented with advanced technology, with capabilities for measurement and data collection at speeds up to 160 mph. Measurement capabilities include track geometry, rail head profile, ride quality, and wheel-rail forces.

Figure 1. FRA's High Speed Research Car.

BACKGROUND

In September 1998, FRA issued its first track safety standards for operation at speeds above 110 mph. Three new classes of track were created (classes 7, 8, and 9), covering track requirements for operating speeds up to 200 mph. These standards were produced in anticipation of emerging high speed operations in the U. S., particularly Amtrak's Acela service in the Northeast Corridor from Washington to Boston, where top speed reaches 150 mph.

To better assess the speed potential for planned high speed corridors, to learn from Amtrak's faster operations in the Northeast Corridor, and to improve understanding of the requirements for operating at speeds above 110 mph, FRA needed a research car with high speed and advanced technological capabilities. Through arrangements with Amtrak, the FRA obtained a surplus passenger car which was rebuilt and instrumented to serve as its mobile high speed research laboratory: car T-16.

T-16's MISSION

T-16 provides a research platform to investigate methods for providing a safer and smoother ride for passenger and freight trains traveling at higher speeds. Its primary uses include:

- *Studying the Dynamics of Wheel-Rail Behavior*: The contour (or profile) of the running surfaces of wheels and rails, and the manner in which they contact, have a significant effect on the wheel to rail forces generated as a train travels along the track. These forces affect wear on wheels and rail, and further, the stability of trains, especially when running at higher speeds. As wheels and rail wear, their profiles change, resulting in different wheel-rail riding characteristics - or wheel-rail behavior. With a better understanding of this behavior, and how it is affected by changes in wheel and rail profiles, more optimal wheel and rail profiles can be achieved, resulting in smoother and safer operation at higher speeds and longer life for wheels and rail.

- *Assessing Potential High Speed Rail Corridors:* T-16's instrumentation and software help engineers to determine the speed potential for various track segments and to develop alternative track modifications for achieving higher speeds. This information is then used to assess the benefits and costs of higher speed operation in potential high speed rail corridors.

- *Investigating Methods for Improving Track Inspection:* T-16 provides two different ways to support the development of improved track inspection techniques. First, the data collected by T-16, and subsequent analysis, provide a better understanding of track conditions required to support higher speed operation. This knowledge is used in developing methods that can more effectively measure and monitor those conditions. Then, as experimental techniques are developed, T-16 provides a means for testing these techniques and for refining them into practical and reliable inspection tools.

- *Assessing the Performance of Different Rolling Stock:* The riding behavior of railroad rolling stock (freight cars, passenger cars, and locomotives) varies with size, weight, structural design, and suspension design - and for freight cars, with the amount of load carried. Software is being developed for T-16 to allow prediction of riding characteristics for various rolling stock. The software takes data representing T-16's riding behavior, and using design characteristics of other rolling stock, produces a prediction of how that rolling stock would react over the same section of track. This capability to simulate ride behavior will help in selecting the best rolling stock designs and track maintenance practices for various operating speeds and routes. It will also assist in determining how to improve the riding characteristics of existing rolling stock.

T-16's ORIGIN

T-16 was built in 1968 as Penn Central no. 803, one of the original self-propelled Metroliner cars, which entered service between Washington and New York in January 1969. During 1987-88, Amtrak removed the propulsion equipment and rebuilt it as cab car coach 9642. It remained in this configuration until withdrawn from service in 1996. FRA obtained the car from Amtrak in June 1999.

CONVERSION TO A RESEARCH CAR

In September 1999, the FRA contracted with ENSCO, Inc. to convert 9642 into a high speed research car, subcontracting the structural, mechanical, and electrical work to the Delaware Car Company, with KLD Laboratories, Inc. suppling part of the instrumentation. The car emerged from the shop as T-16 (officially DOTX 216) and began research service in November, 2000.

During refurbishment, the car was stripped nearly down to its shell and thoroughly rebuilt. The interior was then reconfigured into four areas, from front to rear:

- Workshop
- Conference Area
- Instrumentation Area
- Observation Area

The workshop supports maintenance on the instrumentation and equipment throughout the car. The conference area (Figure 2) provides general seating, a conference table with built-in light table for analyzing graphical data, and facing seats with a work table in between. Sliding doors enclose this section.

Figure 2. Conference area, with light table .

The instrumentation area (Figure 3) contains instrumentation control equipment, computers for analyzing and displaying data, a small kitchen area, and the electrical cabinets. The observation area at the end of the car provides a view of the track during data collection or during backward moves. Data collection can also be monitored from this area.

Figure 3. Instrumentation area.

Electric power can be provided by any of three sources: 480-volt train line, from wayside when the car is parked, or from an onboard auxiliary power system. The car is also equipped with train radio, telephone line, fax, a differential global positioning system (DGPS), and a security system.

INSTRUMENTATION AND MEASUREMENT CAPABILITIES

T-16 is equipped to measure track geometry, rail head profile, ride quality, and wheel-rail forces at speeds up to 160 mph. Its measurement systems and data analysis techniques incorporate the results from FRA-sponsored research as well as work conducted by the Volpe National Transportation Systems Center in Cambridge, MA. Capabilities and instrumentation include:

- Inertial systems for measuring track gage, profile, alignment, and crosslevel over a range of defect wavelengths.
- Gage-face optical rail profile system (supplied by KLD Laboratories, Inc.) for measuring rail wear and wear patterns. At 150 mph, rail

profiles are measured every 15 feet, with smaller increments at lower speeds.

- Automated Track Data Alignment System (ATDAS) to highlight changes in track condition between surveys. This system provides a real time comparison between measurements made as the car is running and those from selected past test runs made over the same track.

- 32-channel general purpose data acquisition system for time or position-based measurements, which allows the car to be used for a variety of special tests.

- Integrated computer network system to provide a high speed real-time interface for data viewing, storage, and analysis.

- Full truck of instrumented wheels (two wheelsets) for measuring wheel to rail contact forces (Figure 4). These are installed when needed for special testing.

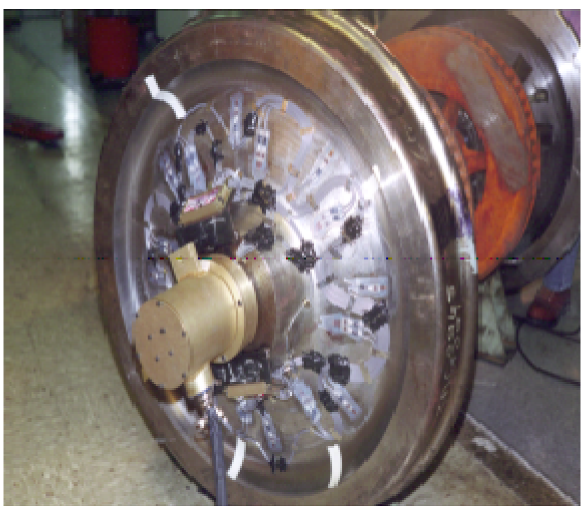

Figure 4. Instrumented wheels for measuring wheel/rail contact forces.

- Neural network to determine track geometry limits based on vehicle design parameters.

- Video system to observe and record testing and track conditions.

- Differential Global Positioning System (DGPS) to tag all data with track position information; inertial dead reckoning in tunnels; automated mapping of vehicle path.

The neural network installed on T-16 is a typical artificial intelligence (AI) recurrent network. It is trained to predict wheel-rail interaction forces generated from T-16 as it travels over track with known geometry. Vehicle characteristics and track geometry data were used to train the network to predict the vertical and lateral forces of T-16 on other known sections of track.

ACKNOWLEDGMENTS

T-16 results from the work of many people and several organizations, including ENSCO for the overall design and instrumentation and the Chief Engineer for Delaware Car, who supervised the structural and mechanical work. Appreciation is also extended to Amtrak for providing 9642.

CONTACT

Ali Tajaddini
Federal Railroad Administration
Office of Research & Development
1120 Vermont Avenue NW - Mail Stop 20
Washington, DC 20590

TEL (202) 493-6438
FAX (202) 493-6333
E-mail: Ali.Tajaddini@fra.dot.gov

KEYWORDS: track/train dynamics, track geometry, high speed rail, track measuring systems, instrumented wheels