To accelerate the rate at which beneficial technologies are safely and efficiently utilized by the railway industry.

To be the worldwide provider of choice for high-value rail transportation technology development, testing, standards, and training.

TTCI participated with BNSF in the Intermodal Train Fuel Consumption Test using the AAR 112 test car.
Dear customers, partners and colleagues,

In 2006, TTCI had a very successful year. While the commercial work was steady, seven accelerated projects were completed under the AAR’s Strategic Research Initiatives Program. The results at the end of the year were very rewarding and demonstrated what can be done with talented people and appropriate funding.

But the highlight of the year, for me, was the culmination of an outstanding R&D program to improve the crashworthiness of passenger railcars. The program was conducted by the FRA and Volpe Center, with assistance from TTCI.

It all started in 1999 with a single baseline car being run into a massive concrete wall that TTCI had constructed. What followed was a classical R&D program involving a combination of careful laboratory tests, full-scale testing, and sophisticated computer modeling. The program led the Volpe Center to design a crash energy management system that TTCI personnel retrofitted to the ends of existing passenger cars.

The final test was unspectacularly successful, just as the designers predicted. A five-car consist impacted a stationary freight car/locomotive consist at 50.7 miles per hour without derailing. And, by distributing the energy of the crash down the length of the consist, there was no life-threatening crushing of the passenger compartments on any of the five cars.

For the AAR’s accelerated research program, the highlight was clearly the development of an automated cracked wheel detection system. A prototype system was developed and installed at TTC by Dapco Industries through a partnership with TTCI. It uses conventional ultrasonic technology and demonstrated that it can accurately inspect the wheels on one side of a full freight car consist operating at 5 mph. The inspection took 13 minutes. This compares to about 15 to 20 minutes per wheel (and about 3 weeks for a full consist) for conventional manual inspection methods; a tremendous leap forward in efficiency and safety.

Another highlight: Through the combined efforts of TTCI researchers, railroads, and suppliers, the industry saw a doubling of the expected life of insulated bonded joints, with expectations of further improvements. Previous designs of insulated joints were found to have significant reliability problems and were very costly, particularly on very high tonnage lines.

Last, but not least, I wish to take this opportunity to wish our colleague and friend Keith Hawthorne a very long and happy retirement. Keith is TTCI’s Vice President of Technology and has made many incredibly impressive technological contributions to the rail industry in his 35 years of service to AAR and TTCI. Good luck, Keith. We will miss you.

Roy A. Allen
President
Transportation Technology Center, Inc.
## Contents

### SOLUTIONS FOR THE INDUSTRY
- Crash Energy Management ................................................................. 9
- TADS® in China .................................................................................. 10
- Kinkisharyo’s Light-Rail Cars ............................................................. 12
- Emergency Response Training Center ............................................... 13
- Electro-Motive Diesel, Inc. ................................................................. 14
- Bombardier ......................................................................................... 15
- Indian Railways .................................................................................. 16
- UK Structure of Charges .................................................................... 18

### ACCELERATED RESEARCH INITIATIVES
- Automated Cracked Wheel Detection System .................................. 20
- Facility for Accelerated Service Testing .......................................... 22
- Insulated Joints .................................................................................. 22
- HAL Axle Design .............................................................................. 23
- Predictive Car Maintenance ............................................................... 23
- U-Rail System ................................................................................... 24

### MORE R&D
- Flange Bearing Crossing Diamond ................................................. 24
- Field Evaluation of a New Rail Profile ............................................. 24
- Strategies to Prevent HAL Wheel Failure ........................................ 24
- Bridge Research ................................................................................. 25

### IMPROVING SAFETY & SECURITY
- Equipment Health Management ..................................................... 25
- Technology Driven Train Inspection ............................................... 25
- Safe and Secure Rail Transportation .............................................. 26
- Positive Train Control ..................................................................... 26

### IMPROVING EFFICIENCY & CUSTOMER SATISFACTION
- NUCARS® ......................................................................................... 26
- Communication & Train Control ..................................................... 27
- FactIS ................................................................................................. 27
- Safety Resource Team ....................................................................... 27
- Quality Resource Teams ................................................................... 27
- Investments ....................................................................................... 28
Several VIPs including 2006 U.S. Secretary of Transportation Norman Mineta clapped and cheered as they witnessed the successful head-on impact test of a train equipped with the newly developed Crash Energy Management system at the Federal Railroad Administration’s (FRA) Transportation Technology Center (TTC).

A dramatic improvement in safety for passenger rail transportation was demonstrated at TTC in 2006. The capstone test of the FRA-sponsored passenger train impact safety program confirmed the practicality of crash energy management for the passenger railroads. This demonstration test was the culmination of a 7-year program designed to improve passenger survivability in train collisions. By working cooperatively, the FRA, American Public Transportation Association, Transportation Technology Center, Inc., and Volpe National Transportation Systems Research Center showed that railcars need not crush and derail upon impact at moderate impact speeds.

The Volpe-led design team redesigned the cars to stay on track, preserve the passenger cabin, and protect the occupants in a collision. Modifications to the carbodies included adding crushable energy absorbers and anticlimbers to the car ends. Interior modifications placed safer, passenger-friendly surfaces around the occupants, such as compartmentalized seating and work station tables that “give” on impact. TTCI’s team of engineers, skilled tradesmen, and technicians pulled together to retrofit a five-car passenger train with the new hardware.

The timeliness of this successful test made it possible to include a crash energy management requirement on an upcoming commuter train purchase. Ultimate replacement of the existing fleet of commuter train cars with newly designed crash energy managed cars will further improve the safety of passenger trains.
In 2006, the Asian Development Bank approved a multi-million dollar purchase of 20 more of TTCI’s Trackside Acoustic Detection Systems for the Chinese railroads.

The Ministry of Railways of China issued another international tender seeking 20 more wayside monitoring systems for roller bearings. TTCI, through its local partnering company Harbin VEIC Technology, won all 20 units in the tender with TADS® technology. The units are assembled and tested in Beijing with TTCI providing key hardware components and software as well as quality monitoring for the production.

These unique bearing-monitoring devices report data in real time to a national database, and timely actions are taken to ensure that the railways are operated safely and smoothly.

Six major trunk lines, the busiest lines in China, are presently monitored by TADS®. Approximately 30 more units will be installed in the Shanghai, Wuhan, Zhengzhou, and Xian railway administrations in 2007. TTCI continues to support the China TADS® market with improved software, data quality monitoring, and operations and maintenance training.

Full-scale testing was completed on Kinkisharyo's new three-car train in 2006. It was the first full-scale test of the vehicles that are being produced for Sound Transit, Seattle, Washington.

TTCI modified the DC substations of the transit test track to provide multiple voltage levels. A level tangent test track was also upgraded to accommodate Kinkisharyo test requirements. TTCI provided the resources needed for Kinkisharyo to successfully accomplish baseline performance testing of its light-rail vehicle.

A major initiative and accomplishment in 2006 was the rapid development and presentation of six classes of a new course in railroad technology for the Transportation Security Administration. The new course was designed to provide a basic understanding of safety, rail networks, organizations, equipment, policies, procedures, and terminology related to the rail industry. It included emergency management and communication protocols as well.

The Emergency Response Training Center, in 2006, embarked on the goal of achieving and being fully recognized as world class in all aspects of surface transportation first response training within a two-year period. Stakeholder attendance increased 51 percent over 2005, with significant increases coming from railroad attendees (up 84%), municipalities (up 46%), federal and state agencies (up 128%) and industrial participants (up 57%).
Another established TTCI customer, Bombardier Transportation, brought New Jersey Transit’s new stainless steel multilevel vehicles to TTC for verification testing in 2006.

Bombardier Transportation received an order from NJ Transit to deliver 100 more stainless steel multi-level vehicles to increase train capacity on its commuter rail lines. In turn, Bombardier commissioned TTCI to assist in the testing and verification of these vehicles prior to delivery.

On-site testing was successfully completed in early 2006 and included high-speed verification of the vehicles using TTCI’s patented Instrumented Wheelset technology. The top in-service speed of these multi-level vehicles will be 100 mph.

Electro-Motive Diesel (EMD), Inc., a large builder of diesel-electric locomotives for commercial operation, continued its long-standing working relationship with TTCI in 2006.

TTCI and EMD concluded performance and reliability testing of EMD’s SD70ACe locomotive bound for BHP Billiton in Australia. Simultaneously, retrofit and validation testing was successfully performed on EMD’s China Mainline Locomotive. Modifications that include the installation of Chinese specification traction motors and bogie frames are scheduled to be completed and tested by mid-2007.

Late in 2006, EMD’s Algerian Locomotive program was under way. Verification testing on an Algerian freight locomotive will continue into 2007 and will be closely followed by similar testing on an Algerian passenger locomotive.

EMD Chief Engineer Dave Semple & TTCI Marketing Director Ed Groves, met with Chinese railway officials in 2006 to tour TTCI’s facilities. China’s Ministry of Railways is upgrading its fleet and has signed a contract with EMD for 300 4.47 MV locomotives.
Two full-scale crashworthiness tests performed by TTCI for Indian Railways made front page news in India.

TTCI and its partners RITES and Applied Research Associates carried out crash tests on two coach designs in Lucknow, India, in 2006. The tests performed on revenue service lines near Alamnagar Station, attracted a large crowd of observers and made national news in India.

The tests were performed as part of a program to improve the crashworthiness of passenger coaches. TTCI will finish this portion of the program in early 2007 and is working with Indian Railways and RITES to take up development of crashworthy locomotives and diesel multiple units, as well as interior crashworthiness features for passenger coaches.
TTCI(UK) Ltd. conducted work in 2006 for the Office of Rail Regulation (ORR) in the United Kingdom (UK) for its review of variable usage and electrification asset usage charges.

The ORR is responsible for determining the charges paid by train operating companies to Network Rail, the rail infrastructure owner in the UK.

TTCI(UK) Ltd. took the lead in the review of cost causation issues, reviewing the existing cost causation models for the associated work types, and relevant issues. A new model was required to predict the costs associated with rolling contact fatigue and rail wear.

The ORR also asked TTCI(UK) Ltd. to perform a scoping study on rail surface damage caused by freight vehicles.
Transportation Technology Center in February 2006, the system has been exposed to and operated in a number of environmental conditions such as strong winds, snow, rain, hail, tumbleweeds, sand, and wildlife. It is designed to operate in a temperature range from \(-10^\circ\)F to \(+140^\circ\)F.

This ultrasonic inspection system is fully automated and provides dynamic inspection of each wheel while a train is operating over the track. Previous approaches required manual inspection, using handheld portable ultrasonic flaw detectors that would require approximately 15 to 20 minutes to inspect each wheel and approximately 3 weeks to inspect a full-unit train. The ACWD system, operating at approximately 5 mph, provides complete inspection for one side of a 105-car train in about 15 minutes.

Four test trains were inspected by the ACWD system in 2006. The qualification test train contained 13 cars, some with 36-inch wheels and others with 38-inch wheels. Wheels identified by the inspection system as containing possible flaws were characterized using a portable handheld ultrasonic inspection technique to verify wheel condition. Eleven identified wheels were evaluated using this approach. The results showed that the four wheels containing artificial defects and wheels containing shattered rim cracks were repeatedly detected by the system. Industry demonstrations of the ACWD system in 2006 have resulted in at least two major U.S. railroads considering installation of these systems in 2007.
Major milestones were reached at the Facility for Accelerated Service Testing (FAST) in 2006 due to increased funding, premium rail, and upgraded locomotives. One hundred and sixty one million gross tons (MGT) were accumulated under the FAST Heavy Axle Load (HAL) Program in 2006. This is more than for any other year since the beginning of HAL operations in 1988.

Increased funding from the AAR, replacement of about 11,000 feet of old rail with premium rail donated by the Union Pacific, replacement of one locomotive, and major work on another were major factors in the increased tonnage accumulation. Tonnage on premium rails from five suppliers reached 198 MGT. Track and laboratory tests have identified differences in rail metallurgical properties that may contribute to the enhanced performance.

Tonnage on the steel bridge and concrete bridges reached 1,170 MGT and 415 MGT, respectively. The bridges serve as test beds for evaluations including effects of tie/deck type, manufacturing tolerances, and high-impact wheels, as well as techniques for crack growth detection and crack repair.

Gas pressure welds were installed and have accumulated 161 MGT. There have been no failures of these welds, though four have required maintenance. The FAST program, funded by the Federal Railroad Administration and AAR and supported by donations from the industry, focuses on investigating the effects of heavy axle loads on structures, track components, and mechanical components.

### Insulated Joints

Research sponsored by AAR has assisted the industry in identifying the root causes of insulated joint failures and in developing solutions that promise to double the lives of these joints.

Significant progress in 2006 has improved the service life and reliability of installed insulated joints for HAL service. Insulated joints serve the purpose of segmenting the track for traffic control (i.e., signal system) and detecting some broken rails. Improvements in foundation designs, joint bar design, rail quality, and joint insulator configurations have contributed to significantly longer service lives in HAL coal routes. In fact, the life of the new designs has doubled compared to old designs.

Changes in foundation designs and installation practices are already being implemented. The "supported" foundation, where the end post of the insulated joint is supported, lowers deflections and extends service life.

Results on improved joint configurations, materials, and assembly processes are planned for implementation in 2007. Work conducted by Virginia Tech and TTCI shows that current materials are subject to significant environmental degradation. An improved surface preparation and stronger epoxies are being prepared for prototype tests.

Revenue-service prototype tests of the taper cut IJ design proceeded in 2006, with promising preliminary results. The taper cut design is a more mechanically efficient design than the traditional butt joint used for rail joints. The taper cut should reduce the occurrence of epoxy shear failure, the leading cause of IJ failures.

### HAL Axle Design

Revenue service data from coal operations from the Powder River Basin to both New York and Georgia in 2006, showed that current 286,000-pound axles are capable of surviving high stress and high utilization environments. It also pointed out the need to consider technologies for repairing surface damage and potential modifications to the present handling and re-qualification practices for axles.

As part of the AAR's Strategic Research Initiatives (SRI) Program, the Heavy Axle Load Design Program began in 2005 as an accelerated SRI program. The industry wanted to determine if the current axle design was capable of long-term survival under the current load environment. Full-scale laboratory testing was done to verify material properties of the axles and material durability. Finite element modeling, using the measured material properties and stress environment input, was conducted to determine the life expectation of the axle design.

### Predictive Car Maintenance

Working through the Advanced Technology Safety Initiative, TTCI advanced in its task of improving railroad safety and efficiency by interpreting data from innovative trackside technology to provide freight car owners with advanced warning of degraded car performance.

During 2006, TTCI completed the analysis of the results of teardowns of cars identified as poor performers at hunting detectors and truck performance detectors. Cars identified above a Salient System's truck hunting index of 0.2 were found to have either low truck warp restraint, low truck to carbody rotation, or both. Low truck warp restraint is replacement of wedges and column wear liners and/or fitting of CCSBs or replacement of CCSB elements or components.

Cars identified at truck performance detectors as having either high warp indices, high gage spread forces, or both were found to have either low warp restraints as found with hunting cars, high rotational resistances, or both. High rotational restraint was found to result from excessive side bearing resistance and/or from a high degree of carbody twist as measured across side bearings and center plates. In addition, poor center plate geometry/condition (concave center plates and bowls, rough center plate and bowl geometry as well as a lack of center plate lubrication).
The laser based rail inspection system is being evaluated at TTCI over the Rail Defect Test Facility (RDTF). The prototype system has been designed to ultrasonically inspect a full rail section (head, web, and base) on one side of the track. This is accomplished using four lasers to generate ultrasonic energy into the rail and 12 air-coupled ultrasonic transducers to monitor the ultrasound exiting the rail. Two of the lasers are used to inspect the head and web of the rail, and two are used to inspect both the flange and gage sides of the base. All four lasers are installed in a donated hi-rail vehicle. Software enhancements are nearly complete and system evaluations are continuing over the RDTF and in revenue service during 2007.

The first revenue service flange bearing frog crossing diamond testing under the Federal Railroad Administration (FRA) waiver was installed in 2006 by CSX. Flange bearing frogs (FBF) eliminate impacts seen on conventional frogs when wheels have to “jump” flangeways. In FBF, the wheels are supported on their flanges when going across the flangeway gap. Although used in many applications for years, the CSX diamond is the first one installed in U.S. freight lines with speeds above 10 mph.

TTCCI has designed a new wheel profile for improving vehicle curving performance and reducing the wear-in period. Limited tests were conducted in revenue service in 2006. The new wheel profile led to lower gage spreading forces and lower wheel L/V ratios (lateral force over vertical force ratio) compared to the current standard wheel profile. Limited results also indicated that the new wheel profile resulted in lower wheel wear and better wear patterns.

TTCCI bridge researchers continued to develop and test methods in 2006 to reduce the stress state and extend the service life of railroad bridges. They tested an innovative new crack growth detection system on the steel bridge at the Facility for Accelerated Service Testing, and also conducted a first annual inspection of an extensive weld treatment test on a revenue service bridge.

TTCCI further developed new models for managing continuous welded rail on bridges and quantified costs of increased train speeds on bridges. TTCCI and partner Railinc continued their support of the AAR’s Advanced Technology Safety Initiative (ATSI) in 2006. The partners better integrated a production version of TTCCI’s detector database, InteRRIS® with Railinc’s Equipment Health Management System to provide railroads and other car owners with seamless access for managing railcar maintenance alerts.

A new steering committee was established in 2006 to oversee the ATSI initiative. The committee’s work focused on the development of performance-based metrics for the assessment of railcar condition. Testing of truck performance and hunting causes excessive wear of car and truck components and can create potentially unsafe operating conditions. Data generated by this work was used to develop recommended alert levels that were incorporated into the AAR Interchange Rules in 2006. Another major accomplishment in 2006 was the development of a Technology Roadmap to be used as a guide for the incorporation of new detector technologies over the next 5 years. The focus of this work will be to develop performance-based metrics that can be used to convert data from the various detectors into actionable information that will result in safer and more efficient train operations.

TTCCI and AAR, in cooperation with member railroads, paved the way in 2006 to start the Technology Driven Train Inspection initiative. This initiative is designed to improve the safety and efficiency of railroad operations by integrating the various wayside detector technologies into a unified system that can validate car health in real time. The ultimate goal is to automatically generate a “certificate to operate” based solely on data from the industry’s array of wayside detectors.
TTCI continued growing its Communications and Train Control (C&TC) business in 2006 aimed at improving the safety, capacity, and productivity of railroad operations by providing experienced program management, system engineering, demonstration, testing, and consulting services. As well, TTCI has been working closely with the Department of Energy’s Office of Civilian Radioactive Waste Management and U.S. Navy Transport in their efforts and developments of railcars that will meet performance specifications for trains used to carry high-level radioactive material (AAR S-2045).

Production units of TTCI’s FactIS wheel profile measurement systems are performing at six sigma gage repeatability levels for flange height, flange thickness, and rim thickness as verified by a 99.9997% accuracy.

OSHA recordable injuries in 2006 compared to 2005. The employee-led SRT implemented a pre-meeting safety checklist and job-briefing checklist, resulting in a higher level of safety awareness in TTCI activities. Corrections of 210 safety hazards were successfully completed throughout the site.

A 90 percent reduction of hazardous waste inventories was also completed in 2006.

QRT team members, Stephanie Abeyta, Ron Lang, and Sam Chapman presented “Communication: What it is and how to make it work for you” to all TTCI employees in 2006. The program was designed to help employees identify and use the various methods of verbal and nonverbal communication.

TTCI stepped up its initiative in 2006 rallying support from local and national politicians, to expand its programs in the areas of safety and security. With the threat of terrorism to the railroad infrastructure, TTCI is looking beyond its traditional arenas of research, test, and training and is adapting to meet the security needs of railroads, THI tank car initiatives, and the safe rail transportation of highly radioactive waste material.

The Next Generation Rail Tank Car Group (Dow, UP, UTLX) chose TTCI in 2006 as a supporting partner in the critical development of tank cars which will exceed the current AAR and FRA requirements in terms of safety, security, and probability of release.

As well, TTCI has been working closely with the Department of Energy’s Office of Civilian Radioactive Waste Management and U.S. Navy Transport in their efforts and developments of railcars that will meet performance specifications for trains used to carry high-level radioactive material (AAR S-2045).

The new Wheel/Rail Contact Penetration Model increases accuracy and realism by using multiple overlapping contact patches and penetration algorithms. It also offers users realistic representation of conditions leading to rolling contact fatigue and wear. The penetration model includes the capability of varying rail profile along the track.

Animation makes it possible to visualize individual wheel/rail contact patches and observe changes in contact patch sizes and position along the track.

The Multibody Track Model provides a powerful tool for many applications including various representations of the track and vehicle as a multi-body system that shows details of rails, ties, fasteners, and ballast.

Other technical advances include wheel/rail animation, improved friction wedge models, a new track geometry preprocessor, and improvements to TTCI’s powerful data analysis package MULTIVU.

Safety & Secure Rail Transportation

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A 90 percent reduction of hazardous waste inventories was also completed in 2006.

Safety training in 2006 included fall protection, equipment inspection certification, and training in fire suppression of flammable liquids. Mutual aid response agreements were signed by local county safety response organizations including TTCI to enhance emergency response within Pueblo County. Eagle Eye awards were presented to John Mitchell, Bob Vigil, Richard Reiff, Tom Roderick and Mike Marecovich in 2006 for identifying and eliminating safety hazards that could have led to serious property damage or injury.

Quality Resource Team

QRT members, Stephanie Abeyta, Ron Lang, and Sam Chapman presented “Communication: What it is and how to make it work for you” to all TTCI employees in 2006. The program was designed to help employees identify and use the various methods of verbal and nonverbal communication.

QRT team members are responsible for training process improvements, customer satisfaction, and quality celebrations, keeping all employees focused on improving quality and customer satisfaction.
Jian Sun headed up TTCI's marketing and sales efforts in China, handling all translation work and negotiating contracts and agreements in TTCI's effort to win a first tender to supply a total of 29 TADS® units to the Chinese railways. Mr. Sun's continuing negotiations have also been successful in that TTCI won a second tender for 20 more systems in 2007. The superior performance of previously installed TADS® in China was an important factor for winning the latest tender.

R. B. Wiley also received an Eagle Award in 2006 for his extraordinary effort in positioning Interris® as the database of choice to fulfill the Advanced Technology Safety Initiative and Equipment Health Management System's vision of providing the railway industry with information required to support preventive maintenance on rolling stock.

**Investments**

TTCI invested nearly 1.9 million dollars in capital equipment and leasehold improvements in 2006. Major investments included:

- Computing Systems and Local Area Network Improvements
- Instrumentation and Data Collection Equipment
- Trolley Wire and Track Power Supply Enhancements
- Installation of a Cracked Axle Detection System
- Environmental and Safety Related Investments
- Cafeteria Improvements including a New Outdoor Lunch Deck
- Radio Communications and Fiber Optic Network Improvements
- Three Cargo Tanks for the Emergency Response Training Facility
- Rail Dynamics Building Lighting and HVAC Upgrades
- Vibration Test Unit Control System Upgrade
- Fire Prevention Systems Upgrades