

Transportation Technology Center Rail Engineering Services



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For over 50 years, ENSCO's team of engineers has been at the forefront of the rail industry, setting standards in safety, reliability, and efficiency through our engineering services and innovative technologies. ENSCO's services and technology enable customers to enhance the quality of their operations while ensuring safer travel.



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Transportation Technology Center (TTC)

ENSCO, Inc. proudly supports the Federal Railroad Administration's (FRA) Transportation Technology Center (TTC) as the prime contractor, conducting research, engineering, testing, and training while also operating and maintaining this vital U.S. Department of Transportation (USDOT) facility. The TTC is the largest railway test and training center in the world, spanning 52 square miles (135 sq km) with over 50 miles (80 km) of test track, 13 miles (20 km) of catenary wire track, and nine miles (14 km) of third rail track. The current maximum test speed at the TTC is 165 mph (265 kph).

On October 1, 2023, ENSCO commenced operations of the TTC under the Total Care, Custody, and Control contract with a total duration of 20 years. This momentous partnership between ENSCO and the FRA will ensure the TTC delivers research, testing, and workforce development to meet the safety, security, and sustainability needs.

Supporting Federal and Commercial Partners

The TTC serves the U.S. Federal Government (including FRA, FTA, DHS/TSA, DOE, PHMSA), passenger and freight railways, and suppliers, fostering innovation and safety in the rail and surface transportation sectors.

TTC History

1971 – 1974: High-Speed Ground Test Center (HSGTC)

December 1974: Renamed to Transportation Test Center (TTC)

1982 – 2022: Operated by AAR/TTCI as a Care, Custody, and Control Contract

October 1, 2022: ENSCO commenced the Care, Custody, and Control Contract

Community Engagement

ENSCO is dedicated to supporting the Pueblo, Colorado, economy by partnering with local leadership, universities, and businesses. We collaborate with Colorado State University – Pueblo, a Hispanic Serving Institution (HSI), Pueblo Community College, Pueblo Economic Development Corp (PEDCO), and the Pueblo Chamber of Commerce to support local development and attract top technical talent to the area.

Looking Ahead

ENSCO aims to collaborate with government, commercial, and educational entities interested in conducting work at the TTC in support of rail and surface transportation innovation. We are committed to creating a dynamic, forward-looking environment that fosters innovation, encourages positive change, and generates opportunities.





TTC Rail Engineering Services

ENSCO's globally acclaimed experts offer engineering services to railways worldwide aimed at increasing safety, reliability, and efficiency. Our efforts are bolstered by a focus on automation, connectivity, cybersecurity, and resilience. Equipped with state-of-the-art facilities, cutting-edge equipment, and a dedicated team of engineers, data scientists, and field personnel, ENSCO empowers clients to expand their in-house capabilities. This approach mitigates risk, enhances network safety, and optimizes maintenance planning. At ENSCO, we prioritize problem solving, and provide comprehensive training to your in-house staff throughout the project, fostering their professional growth and expertise.

Customer Needs

- Increase Safety
- Decrease Derailment Risks
- Reduce Trespasser and Grade Crossing Casualties
- HAZMAT & Energetic Material Training and Management Requirement Development
- Evaluate Rolling Stock and Components
- Accelerated Component Testing
- Industry Standard Development Support
- Cybersecurity
- Asset Mapping, Inventory, and Management
- Operations Optimization and Evaluation of Available Alternatives
- Increase Asset Availability
- Increase Asset Life
- Optimize Maintenance Planning
- Decrease Maintenance Costs
- Technology Transfer and Work-Force Development
- Develop and Implement Greenhouse Gas Reduction Technology

ENSCO's Specialties

- World Leading Track Infrastructure & Rolling Stock Subject Matter Experts
- Vehicle/Track Interaction
- Wheel/Rail Surface Condition
- Track/Train Dynamics
- Instrumentation & Testing
- Data Analytics & Trending
- Artificial Intelligence and Machine Learning
- Data Driven Track & Rolling Stock Maintenance Planning
- Component Failure Analysis, Laboratory Testing, and Field Testing
- Partnership with Ambipar International Leader and Hazmat and Environmental Solutions
- Cyber and Physical Security Experts at the Center for Critical Infrastructure Protection (CCIP)
- Full-Scale Crash, Blast, and Fire Testing
- Full-Scale vehicle laboratory testing
- On-track testing at the TTC

Why ENSCO?

TTC: Since October 2022, ENSCO has been overseeing research, testing, and training operations at the FRA's TTC in Pueblo, Colorado, USA. As the the largest railway test center globally, the TTC offers premier facilities for test track loops, whole vehicle testing, and accelerated track and rolling stock component testing under real-life conditions.

Industry Recognition: With over 50 years of dedicated service, ENSCO stands as the foremost provider of track research, engineering, and track inspection services. Renowned for data-driven safety enhancement and track analysis, ENSCO's expertise in establishing research and test programs globally can bolster your initiatives.

Expert Team: ENSCO boasts a team comprised of highly acclaimed experts in diverse fields. Our engineers and data scientists collaborate closely with customers and

partners to deliver tailored solutions.

VAMPIRE Source Code Access: ENSCO holds the source code for VAMPIRE, an industry leading vehicle/track interaction modeling software originally developed by British Rail Research. This source code enables ENSCO to pioneer new applications in vehicle dynamics modeling and simulation, including automated predictive simulations utilizing track measurement vehicle data. Additionally, VAMPIRE is used to create simulations to accompany on-track testing occurring at the TTC.

Training Collaboration: ENSCO addresses challenges but also prioritizes knowledge transfer through training programs for railway staff. This collaborative approach empowers clients to enhance their internal capabilities, with all engineering services inclusive of staff training opportunities.

Rail Partnerships and Affiliated Labs

ENSCO is bolstered by a consortium of premier surface transportation research, training, technology, and facilities management organizations dedicated to advancing next generation technology that underpins and elevates transportation infrastructure.



Railroad research and test capabilities with expertise in rolling stock design and train operations.



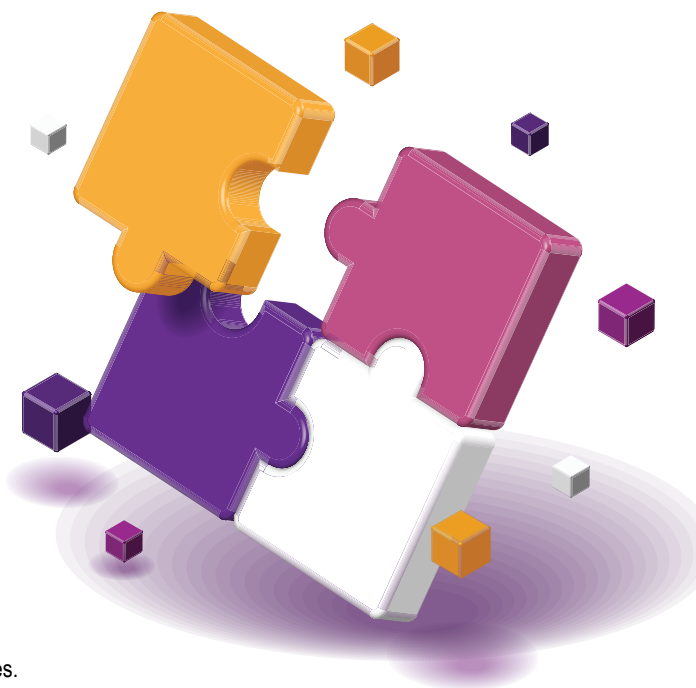
Train control expertise including implementing train control systems and providing safety consulting services complemented by world-recognized experience in transit, environmental, and construction engineering services.



Hosts the Ambipar Response Training Center (ARTC) located at the TTC providing industry leading hands-on, live-fire railway **emergency response training**.



Affiliated Lab: Materials and failure analysis experts with fully equipped metallurgy lab and material testing capabilities.



This team receives additional reinforcement from the Center for Surface Transportation Testing and Academic Research (C-STTAR) consortium, established by ENSCO and spearheaded by the University of South Florida Center for Urban Transportation Research (CUTR) expertise in research focus areas across all modes of surface transportation, including intermodal transportation, thereby fortifying the TTC's ability to serve rail transportation's intersections with other transportation modes.



TTC at a Glance

On-Track Vehicle Testing

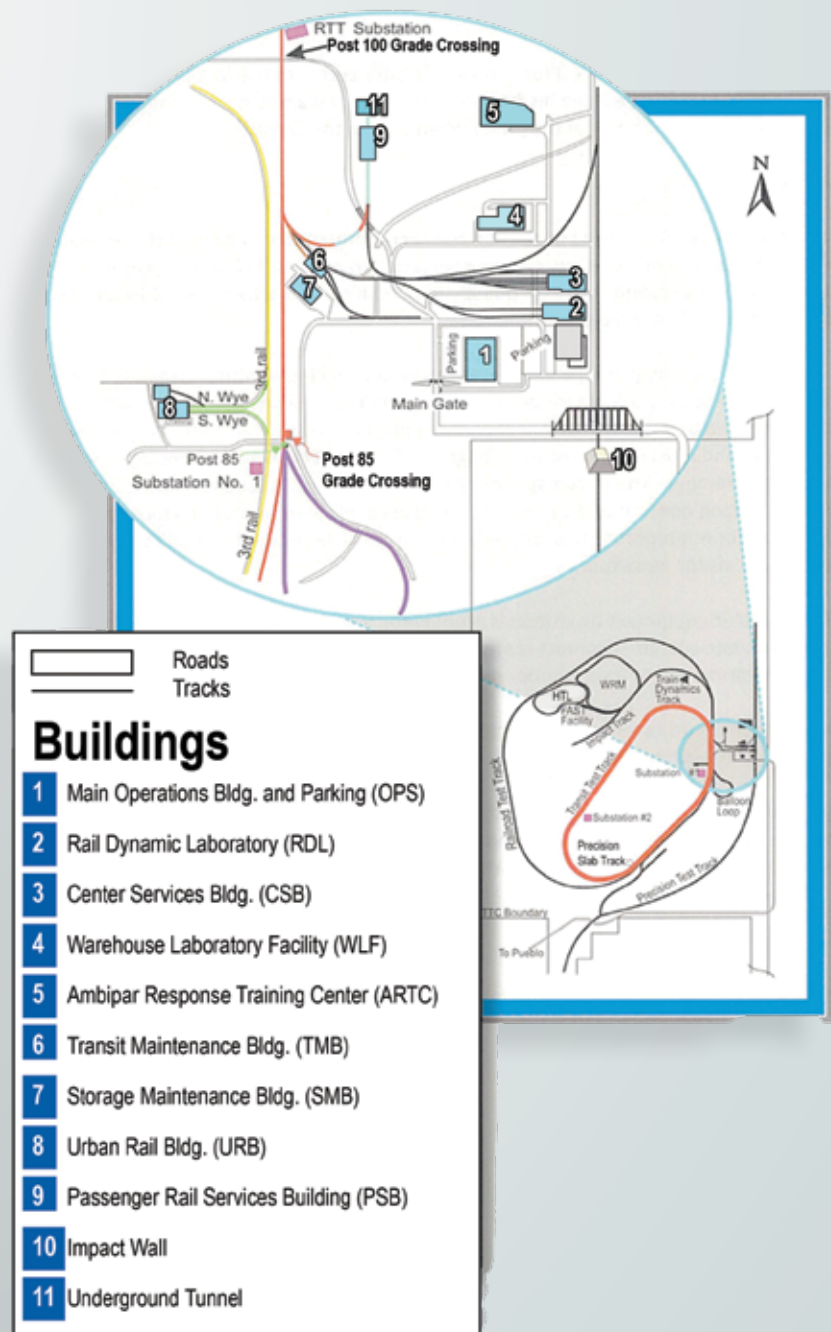
- High Tonnage Loop
- Rail Transit Track Loop
- Transit Test Track
- Wheel Rail Mechanism Loop
- Tight Turn Loop
- Precision Geometry Slab Track
- Vertical Wall for Impact Testing
- Underground Test Tunnel

Support Infrastructure

- Passenger-Rail Services Building
- Transit Maintenance Building
- Urban Rail Building
- Center Services Building
- Wheel Truing Machine
- Drop Table
- Cranes, Jacks, Floor Pits, etc.
- Overhead Wire and Third Rail with Adjustable Voltage

Facility Leasing and Support

- Office space, shop space, and tracks available for long term lease to support onsite testing
- Provide services to support long term rail vehicle storage including rolling stock maintenance support and car movement services
- Support staff to aid in rolling stock maintenance and testing



Applications:

- New locomotive, freight car, and passenger car testing (homologation)
- Accelerated service testing of rolling stock and track components
- Impact testing of railway vehicles including tank cars and passenger cars
- Testing of new products in accessible and controlled railway environment.

Test Tracks

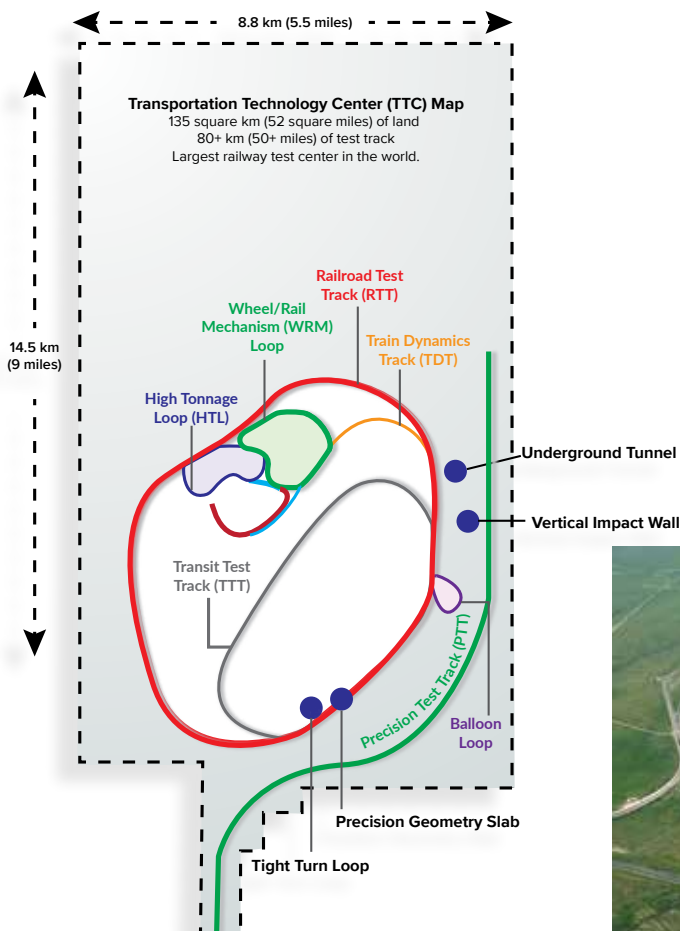
The TTC has over 50 miles (80 km) of railroad testing track, the largest in the world. The two largest test tracks are the Railroad Test Track (RTT) and Transit Test Track (TTT). The RTT extends over 13.5 miles (21.7 km) and supports high-speed testing up to 165 mph (265 kph). It features an overhead catenary wire system with adjustable voltage and a Precision Geometry Slab Track, allowing for vertical and lateral precision adjustment to create track geometry perturbations. The TTT, spanning 9.1 miles (14.6 km) with a top contact third rail, accommodates speeds up to 89 mph (142 kph) and is ideal for assessing heavy and light rail vehicles. Both tracks enable thorough evaluation of vehicle and track components, ensuring optimal performance and safety.

Railroad Test Track (RTT)

- Passenger and Freight vehicle testing at high speeds
- Higher speeds vehicle/track interaction assessments
- Pantograph/overhead wire interaction assessments
- High-speed vehicle/track interaction assessments

Transit Test Track (TTT)

- Heavy rail and light rail vehicle testing
- Vehicle/track interaction assessments
- Third rail interaction assessments



Impact Testing

At the TTC, ENSCO conducts full-scale, head-on collision testing using the specially engineered impact wall, rated for a three million-pound impact load. The facilities support a variety of crash tests, including side impact evaluations, and is equipped with high-speed data and video acquisition systems for detailed analysis.

With a ram car guidance track offering variable impact speeds, the TTC supports comprehensive testing scenarios for tank car and vehicle component impact evaluations. Designed to withstand immense impacts, the impact wall is instrumental in advancing crashworthiness for passenger vehicles and other rolling stock. Beyond freight and passenger, it has been pivotal in testing various vehicle components, including diesel fuel tanks, in real-life scenarios such as locomotive derailments and impacts from semi-trucks. Looking forward, the facility remains critical for testing crashworthiness designs and specifications for alternative energy methods, such as hydrogen, renewable natural gas, and battery energy storage systems, crucial for meeting safety expectations and reducing greenhouse gas emissions in the transportation sector.

Applications:

- Tank car impact testing
- Fuel tank impact testing
- Vehicle crashworthiness testing



Lab Rig Testing Laboratory

The TTC is outfitted with one-of-a-kind lab rig equipment to evaluate rail vehicles to their full extent.

Vibration Test Unit (VTU)

Whole body vibration testing of rail vehicles

Applications:

- Structural vibration testing
- Identify flexible modes
- Ride quality assessments

Simulader (SMU)

Full rail vehicle stress testing

Applications:

- Structural stress and deflection
- Structural fatigue testing

Squeeze Test Fixture

Compression testing of whole rail vehicles

Applications:

- Crush compliance testing
- Structural stress testing
- Corner post testing

Mini-Shaker Unit (MSU)

Truck (bogie) suspension vibration testing

Applications:

- Assess truck (bogie) vertical, lateral, roll, yaw performance
- Bogie yaw resistance testing
- Bogie component testing
- Component fatigue testing

Major Component Testing Laboratory

Partnered with laboratories and with capabilities at the TTC, ENSCO can provide track and rolling stock component testing capabilities in accordance with AAR and AREMA standards and guidelines.



Component Testing at a Glance

Facilities

- Large lab space and material handling ability to handle large components such as bolsters, side frames, passenger truck frames, and crossties (sleepers)
- State-of-the-art servo-hydraulic testing equipment

Capabilities

- Static and fatigue testing of bolsters and side frames
- Friction wedge testing
- Polymer, composite, steel, wood, and concrete crosstie (sleeper) testing
- Rail, weld, and joint bend testing

Component Failure Analysis and Materials Laboratory Testing

In partnership with ESI Inc., ENSCO provides rail component failure analysis and laboratory testing. The ESI staff is a leader in railway industry component failure analysis, serving prominent railways including Union Pacific Railroad and CSX.



ESI Laboratory at a Glance

Facilities

- Large lab space, material handling and sample preparation capabilities to handle large components such as wheelsets and bogies
- Hydraulic presses for tensile and compression testing
- Metallurgy evaluation equipment
- Visual and Scanning Electron Microscopy (SEM)

Capabilities

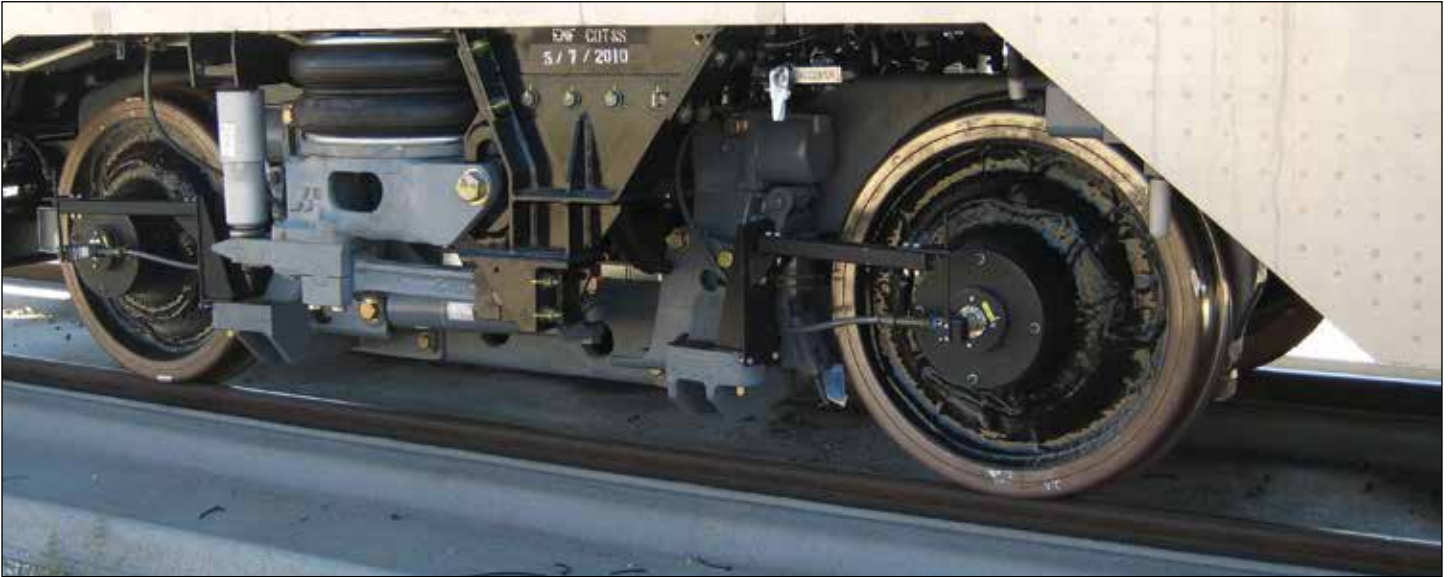
- Component performance deficiency identification
- Railway component failure analysis
- Sleeper laboratory testing
- Industry standard component evaluation
- Chemical composition testing

Instrumentation

Identifying the root cause of a problem such as premature rail wear or evaluating the performance of rolling stock, often requires vehicle or track instrumentation.

ENSCO specializes in the following instrumentation methods (onsite at your facility or at the TTC):

- Sensors—Strain gauges, accelerometers, LVDTs, etc.
- Data Acquisition—High-speed and large channel count data acquisition
- Other Specialties
 - Instrumented wheelsets to measure wheel/rail forces
 - Instrumented couplers to measure in-train forces
 - Autonomous data collection without human intervention



ENSCO's wide breadth of instrumentation capabilities includes Instrumented Wheelsets (top), new vehicle acceptance testing (left), and static lean testing (right).

Case Studies: Instrumentation

Project: Instrumented Track

The Challenge: Collect data to assist in ballast investigation effort.

The ENSCO Approach: ENSCO implemented six, long-term wayside autonomous monitoring sites, which required the design of a multifaceted data collection system integrating a multitude of sensors and instrumentation including accelerometers, high speed cameras, strain gages, subsurface moisture content probes, and weather stations.

Result: Actionable data that allowed customer and industry to arrive at objective means to characterize ballast performance.



Case Studies: Instrumentation

Project: In-Train Force and Train Makeup Study

The Challenge: Study in-train forces, train makeups, and train handling over an extended period.

The ENSCO Approach: ENSCO designed a fully autonomous reporting data acquisition system onboard a ballasted freight vehicle. The system integrated instrumented couplers, accelerometers, brake pipe pressure gauges, and brake cylinder pressure gauges with a remotely reporting rugged data acquisition system. Data was recorded onboard the test vehicle and transmitted remotely via cellular communication to a cloud-based data repository where the data was processed and presented to the client.

Result: The system ran continuously, autonomously, and maintenance free for over two years on a Class I railroad to aid in practices to reduce in-train forces.

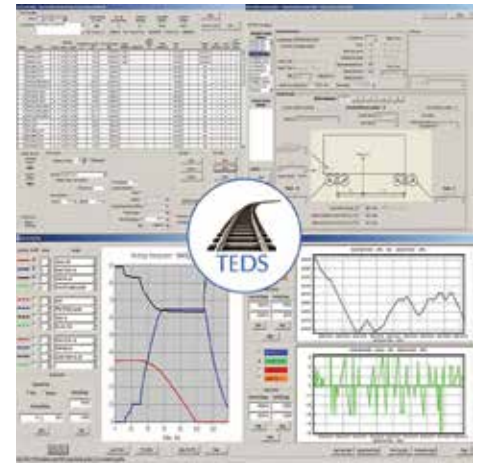


Simulation

ENSCO understands how to complement instrumentation with simulation tools to quickly and cost-effectively evaluate hypothetical scenarios. This helps identify problems before they occur, prevent downtime, and optimize your operations. Areas of expertise include simulations in track/train dynamics, vehicle/train interaction, and finite element analysis.

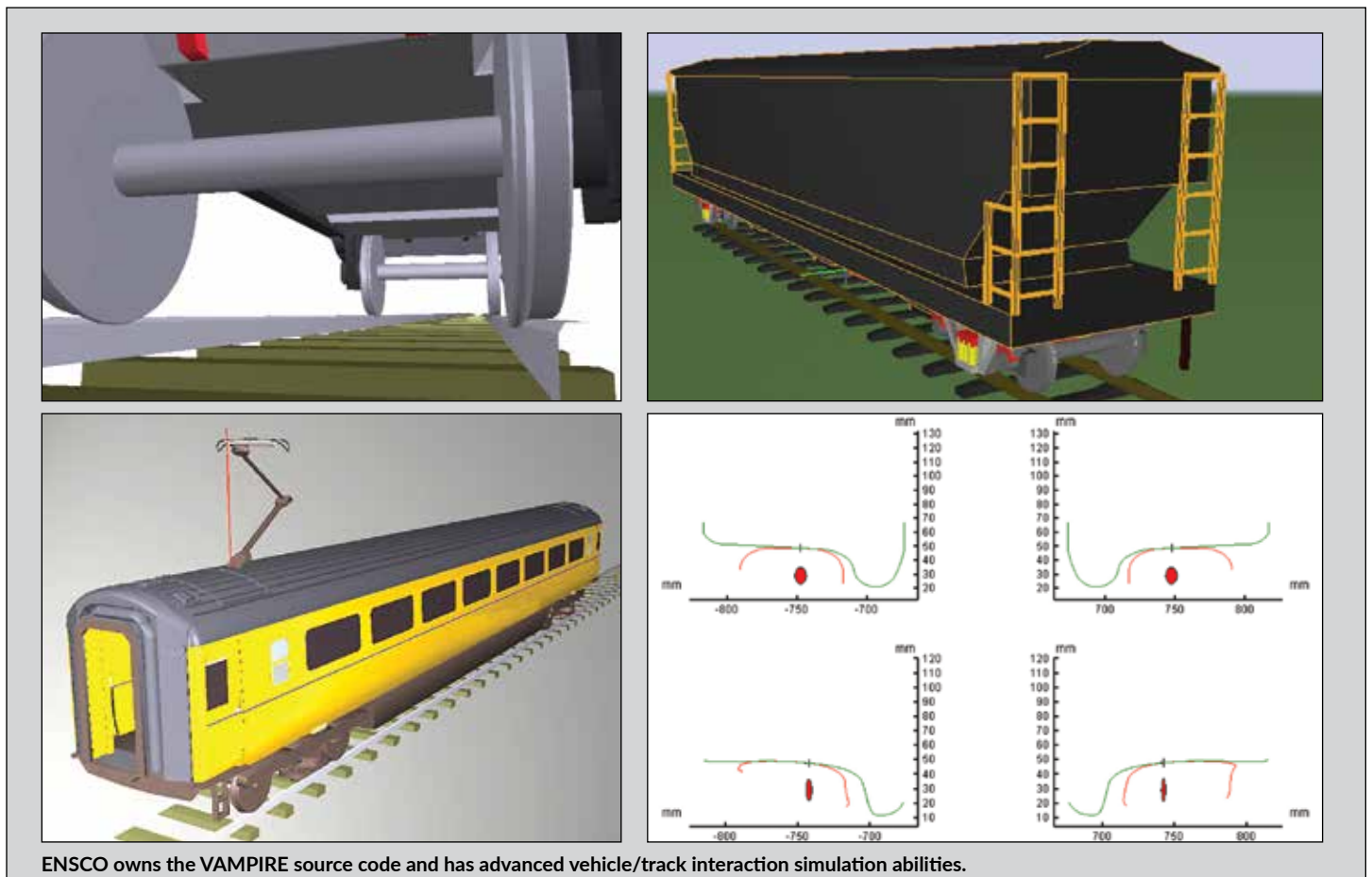
Track/Train Dynamics: Used to simulate an entire train over long stretches of track that includes elevation changes and curves. This type of simulation is often used to assess freight train make-up and train handling. ENSCO uses the software program Train Energy and Dynamics Simulator (TEDS) provided by our partner Sharma and Associates. Results of simulations can be used to assess problems such as:

- Building operational rules for train make-up and train handling
- Evaluating larger freight train sizes for safety
- Assessing proposed designs of new track, industrial leads, and balloon loops for safety and expected use deterioration
- Investigating and predicting derailment risk and identifying mitigating strategies



Vehicle/Track Interaction: ENSCO uses VAMPIRE for vehicle/train interaction simulation for the purpose of predicting vehicle motions and wheel/rail interaction forces when interacting with measured track conditions. Results of simulations can be used for:

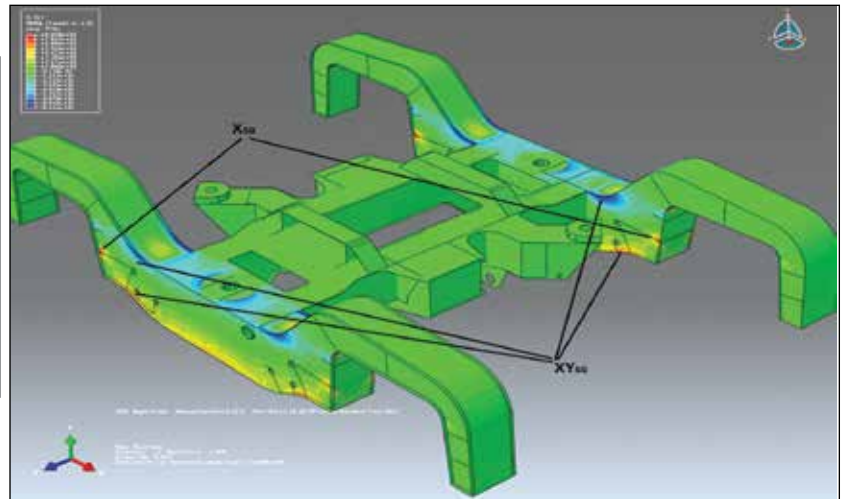
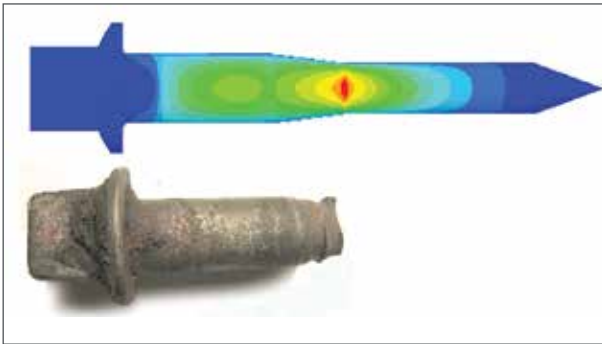
- Understanding premature wheel and rail wear or RCF generation
- Investigating and predicting derailment risk and identifying mitigating strategies
- Identifying root causes of rapid track deterioration conditions
- Evaluating new vehicle or suspension types



ENSCO owns the VAMPIRE source code and has advanced vehicle/train interaction simulation abilities.

Finite Element Analysis (FEA): This modeling technique simulates the stress and deformations that individual components undergo during railway operations. ENSCO uses various FEA simulation packages including Ansys, ABAQUS, and LS-DYNA. Results of simulations can be used for:

- Investigation of rolling stock and track components failing from fatigue
- Evaluation of design changes to components
- Life-extension studies of rolling stock



ENSCO uses Finite Element Analysis (FEA) to aid in investigating premature component failure, such as screw spikes.

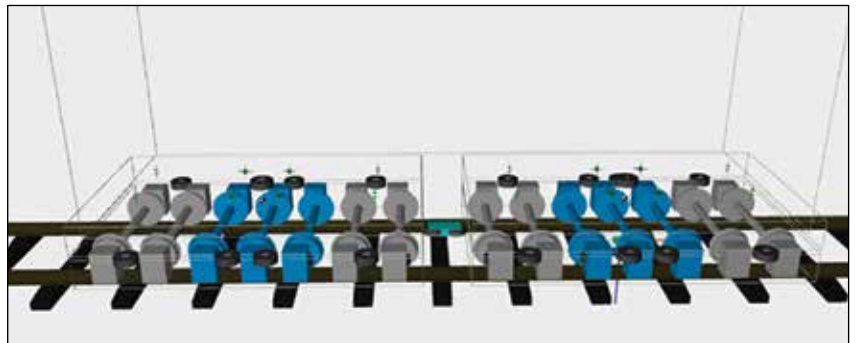
Case Studies: Simulation

Project: Transformer Transport Vehicle

The Challenge: Determine the risk of derailment of a specialized transport vehicle.

The ENSCO Approach: Evaluate derailment risk against speed of operation, to include evaluating track data, clearances, suspension, masses and wheel/rail geometry.

Result: The design and operation were optimized via simulation and successfully implemented.



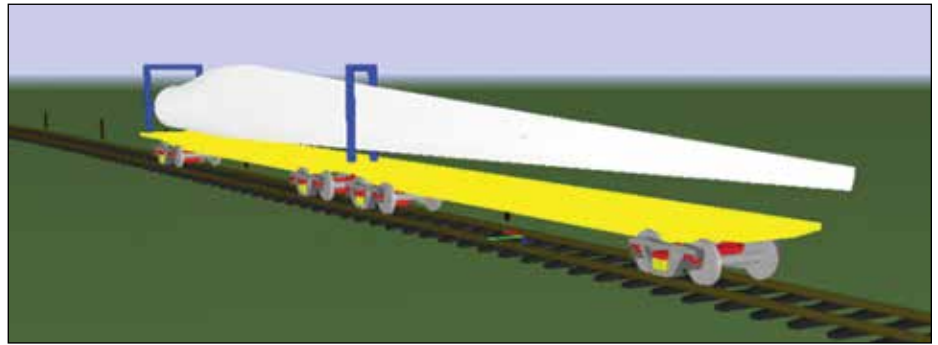
Case Studies: Simulation

Project: Wind Turbine Blade Transport

The Challenge: Determine clearance and derailment risk associated with transporting wind turbine blades by rail.

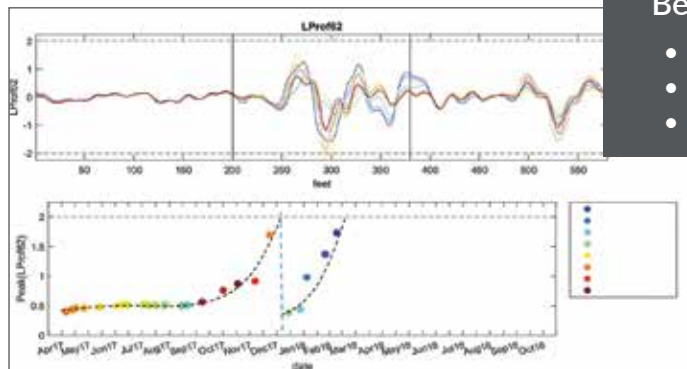
The ENSCO Approach: Evaluate derailment risk based on vehicle dynamics simulation predictions.

Result: Implementation of proposed operations.



Analytics

ENSCO employs subject matter expert-driven data analysis of track measurement train, instrumentation, and simulation data. ENSCO uses small and large data analytics tools and methodologies including statistical, artificial intelligence, and machine learning.



ENSCO applies the latest tools in machine learning/artificial intelligence.

Benefits of ENSCO Data Analytics

- Root Cause Identification
- Prediction
- Optimization

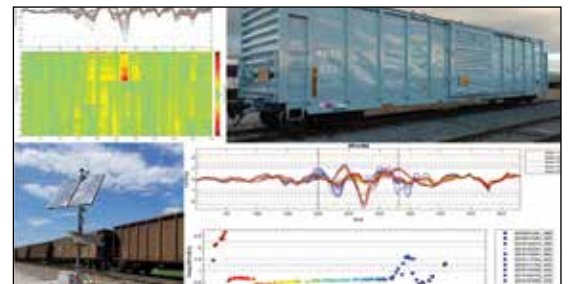
Case Studies: Data Analytics

Project: Ballast Fouling and Trending Study

The Challenge: Determine criteria for class-based approach to fouled ballast safety enforcement.

The ENSCO Approach: Collect and analyze pertinent information via track inspection vehicles, long-term wayside instrumentation and ground-penetrating radar.

Result: Objective criteria for more consistent enforcement of fouled ballast safety.



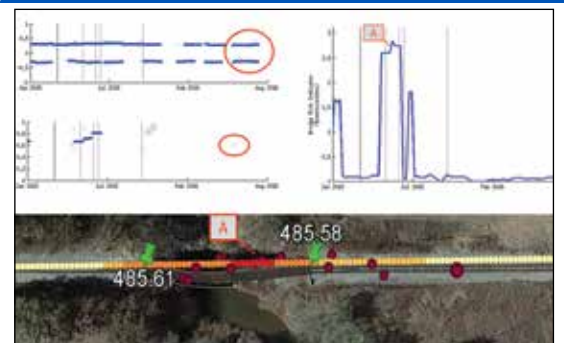
Case Studies: Data Analytics

Project: Track Feature Risk Assessment Using V/TI Data

The Challenge: Assess track feature health/risk using Vehicle/Track Interaction monitors and determine if the approach can scale to fleet size and offers greater coverage than traditional systems.

The ENSCO Approach: Use analytical models that can be trained and applied to a variety of track features to develop a risk assessment index algorithm to rank features and conditions, and identify/prioritize high-risk sites.

Result: Track feature-specific Bridge Risk Index that provided health and derailment risk assessments for bridges to prioritize maintenance.



HAZMAT and Energetic Material Management

In collaboration with Ambipar Response/Ambipar USA, ENSCO delivers comprehensive Training and Energetic management support to the USDOT at the TTC. Ambipar Response stands as the world's largest commercial response organization, boasting over 70 years of expertise in managing environmental incidents and responding to major hazard events globally, including oil spills and chemical incidents.

Additionally, our partnership encompasses training modules tailored to simulated emergency response scenarios, such as train derailments and highway accidents. Participants undergo rigorous training in live fire conditions under the guidance of qualified instructors and safety personnel. The program also includes simulated HAZMAT response and handling exercises, along with specialized training in emergency response for hydrogen and battery-powered vehicles.



ENSCO's partner Ambipar providing HAZMAT training at the TTC in Pueblo, Colorado.



<https://ambipar.com/artc/>

Knowledge Transfer and Work Force Development

ENSCO goes beyond merely offering solutions; we strive to enhance customer comprehension. Through knowledge transfer and workforce development initiatives, ENSCO equips its clients with expertise in all areas of railway technical workforce development, derailment investigation, track and rolling stock data analysis, and vehicle/track interaction dynamics.

ENSCO and its partners offer unique and tailored hands-on training that can be hosted at the TTC. Additionally training can be provided at our customers' locations or online. Contact us today to see how we can meet your workforce development needs



ENSCO experts take the opportunity to provide training and knowledge sharing with our customers.



Center for Critical Infrastructure Protection (CCIP)

ENSCO is proud to host the Center for Critical Infrastructure Protection (CCIP), located at the TTC in Pueblo, Colorado. CCIP's mission is to aid critical infrastructure government and industry organizations in meeting their Cyber and Physical Security protection requirements.

Mission and Focus Areas

CCIP focuses on four key areas to support Critical Infrastructure organizations:

- **Training:** Cyber and physical security training courses for all skill sets, including executives.
- **Assessment:** Cyber Vulnerability Assessments, Compliance Assessments, Threat and Vulnerability Assessments (TVAs), Systems Security Plan (SSP).
- **Testing & Modeling:** Penetration Testing, Large-Scale Incident Testing & Modeling.
- **Protection:** Cyber and physical security consulting,

Cyber Lab

CCIP features a Cyber Lab at the TTC to test Operational Technology (OT), enhancing our capability to address the evolving cyber and physical security landscape.

Certified Workforce

CCIP's highly skilled personnel deliver innovative, value-driven solutions to complex cyber and physical requirements. Specializing in Information Technology (IT) and OT environments, the CCIP team holds over 20 certifications and has extensive experience with the Department of Defense (DoD), federal organizations, and the commercial sector.

Academic Partnerships

CCIP collaborates with respected academic partners, including The Center for Urban Transportation Research (CUTR) at the University of South Florida and the Mineta Transportation Institute at San Jose State University, providing proven physical security training.

Sector-Specific Services

The center offers tailored services to address the unique security challenges faced by various industries:

- **Transportation Systems Sector:** Mass Transit and Passenger Rail, Freight Rail, Pipeline, Highway and Motor Carrier, Aviation, Maritime
- **Critical Manufacturing Sector:** Locomotive Suppliers, Railroad and Transit Car Suppliers, Rail Track Equipment Suppliers, Nuclear Sector Critical Suppliers, Energy Sector Critical Suppliers, Water and Wastewater Critical Suppliers
- **Nuclear Reactors, Materials, and Waste Sector:** Nuclear Reactors, Storage, Medical Use Facilities, Transportation
- **Energy Sector:** Electrical Power Plants, Oil and Gas Facilities, Solar and Wind Energy Facilities, Hydrogen Production and Storage Facilities
- **Water and Wastewater Systems Sector:** Public Drinking Water, Treatment Facilities



Visit ccip-ensco.com
to learn more

TTC Conference & Tour



The Annual TTC Conference and Tour is a premier annual event that bridges government, industry, and academia, providing a unique platform to discuss and showcase the latest advancements in rail transportation. Held over two days in Pueblo, Colorado, the conference offers a comprehensive program designed to foster collaboration, innovation, and networking all set against the backdrop of the world's largest rail testing and training facility.

Conference Overview

• Day One:

- **Location:** Pueblo Convention Center
- **Activities:** A rich lineup of technical presentations, exclusive networking opportunities, and the chance to connect with government and industry leaders. Attendees can expect diverse sessions covering the most pressing issues and trends in the rail industry.
- **Networking:** Extended networking sessions ensure meaningful connections and engagement, especially for our sponsors who have the opportunity to showcase their products and services.

• Day Two:

- **Location:** TTC
- **Activities:** An immersive experience featuring on-track equipment displays, extended tours of the world's largest rail testing facility, and enhanced networking opportunities. Attendees will benefit from live demonstrations, exclusive access, and the chance to see cutting-edge rail research and technology in action.

Key Features

- **Exclusive Tours:** Attendees have the rare opportunity to explore the TTC, witnessing firsthand the innovative testing and training facilities.
- **Live Demonstrations:** On-track equipment displays provide a unique experience not available at most industry conferences.
- **Networking Opportunities:** The event fosters connections among attendees from government, industry, and academia, creating a collaborative environment to discuss and address the most prevalent issues in the rail sector.
- **Sponsorship Opportunities:** The conference offers various sponsorship levels, providing exposure and engagement opportunities for businesses looking to connect with industry leaders and stakeholders..



For more information and to learn more, please visit ttc-conference.com.



ENSCO Inc. holds the distinguished role of operating the Transportation Technology Center (TTC) located in Pueblo, Colorado on behalf of the U.S. Department of Transportation (DOT) Federal Railroad Administration. Spanning a vast 52 square-miles, the TTC is more than just a facility: it's the accelerator of innovation in surface transportation. This pivotal center is dedicated to the relentless pursuit of advancements in research, development, testing, and training, all converging to fortify the pillars of safety, security, and sustainability in transportation. With ENSCO's expert stewardship, the TTC stands as an inclusive institution, catering to every mode of surface transportation, empowering them to realize their objectives. Further elevating its stature, the TTC is also home to the Center for Critical Infrastructure Protection (CCIP). The CCIP's mission is singular: to fortify critical infrastructure entities against cyber and physical threats through comprehensive training, rigorous assessments, meticulous testing, and robust protection measures.

Visit Our Website



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- Decrease Maintenance Costs
- Technology Transfer and Work-Force Development
- Develop and Implement Greenhouse Gas Reduction Technology

ENSCO's Specialties

- World Leading Track Infrastructure & Rolling Stock Subject Matter Experts
- Vehicle/Track Interaction
- Wheel/Rail Surface Condition
- Track/Train Dynamics
- Instrumentation & Testing
- Data Analytics & Trending
- Artificial Intelligence and Machine Learning
- Data Driven Track & Rolling Stock Maintenance Planning
- Component Failure Analysis, Laboratory Testing, and Field Testing
- Partnership with Ambipar International Leader and Hazmat and Environmental Solutions
- Cyber and Physical Security Experts at the Center for Critical Infrastructure Protection (CCIP)
- Full-Scale Crash, Blast, and Fire Testing
- Full-Scale vehicle laboratory testing
- On-track testing at the TTC

Why ENSCO?

TTC: Since October 2022, ENSCO has been overseeing research, testing, and training operations at the FRA's TTC in Pueblo, Colorado, USA. As the the largest railway test center globally, the TTC offers premier facilities for test track loops, whole vehicle testing, and accelerated track and rolling stock component testing under real-life conditions.

Industry Recognition: With over 50 years of dedicated service, ENSCO stands as the foremost provider of track research, engineering, and track inspection services. Renowned for data-driven safety enhancement and track analysis, ENSCO's expertise in establishing research and test programs globally can bolster your initiatives.

Expert Team: ENSCO boasts a team comprised of highly acclaimed experts in diverse fields. Our engineers and data scientists collaborate closely with customers and

partners to deliver tailored solutions.

VAMPIRE Source Code Access: ENSCO holds the source code for VAMPIRE, an industry leading vehicle/track interaction modeling software originally developed by British Rail Research. This source code enables ENSCO to pioneer new applications in vehicle dynamics modeling and simulation, including automated predictive simulations utilizing track measurement vehicle data. Additionally, VAMPIRE is used to create simulations to accompany on-track testing occurring at the TTC.

Training Collaboration: ENSCO addresses challenges but also prioritizes knowledge transfer through training programs for railway staff. This collaborative approach empowers clients to enhance their internal capabilities, with all engineering services inclusive of staff training opportunities.

Rail Partnerships and Affiliated Labs

ENSCO is bolstered by a consortium of premier surface transportation research, training, technology, and facilities management organizations dedicated to advancing next generation technology that underpins and elevates transportation infrastructure.



Railroad research and test capabilities with expertise in rolling stock design and train operations.



Train control expertise including implementing train control systems and providing safety consulting services complemented by world-recognized experience in transit, environmental, and construction engineering services.



Hosts the Ambipar Response Training Center (ARTC) located at the TTC providing industry leading hands-on, live-fire railway **emergency response training**.



Affiliated Lab: Materials and failure analysis experts with fully equipped metallurgy lab and material testing capabilities.



This team receives additional reinforcement from the Center for Surface Transportation Testing and Academic Research (C-STTAR) consortium, established by ENSCO and spearheaded by the University of South Florida Center for Urban Transportation Research (CUTR) expertise in research focus areas across all modes of surface transportation, including intermodal transportation, thereby fortifying the TTC's ability to serve rail transportation's intersections with other transportation modes.



TTC at a Glance

On-Track Vehicle Testing

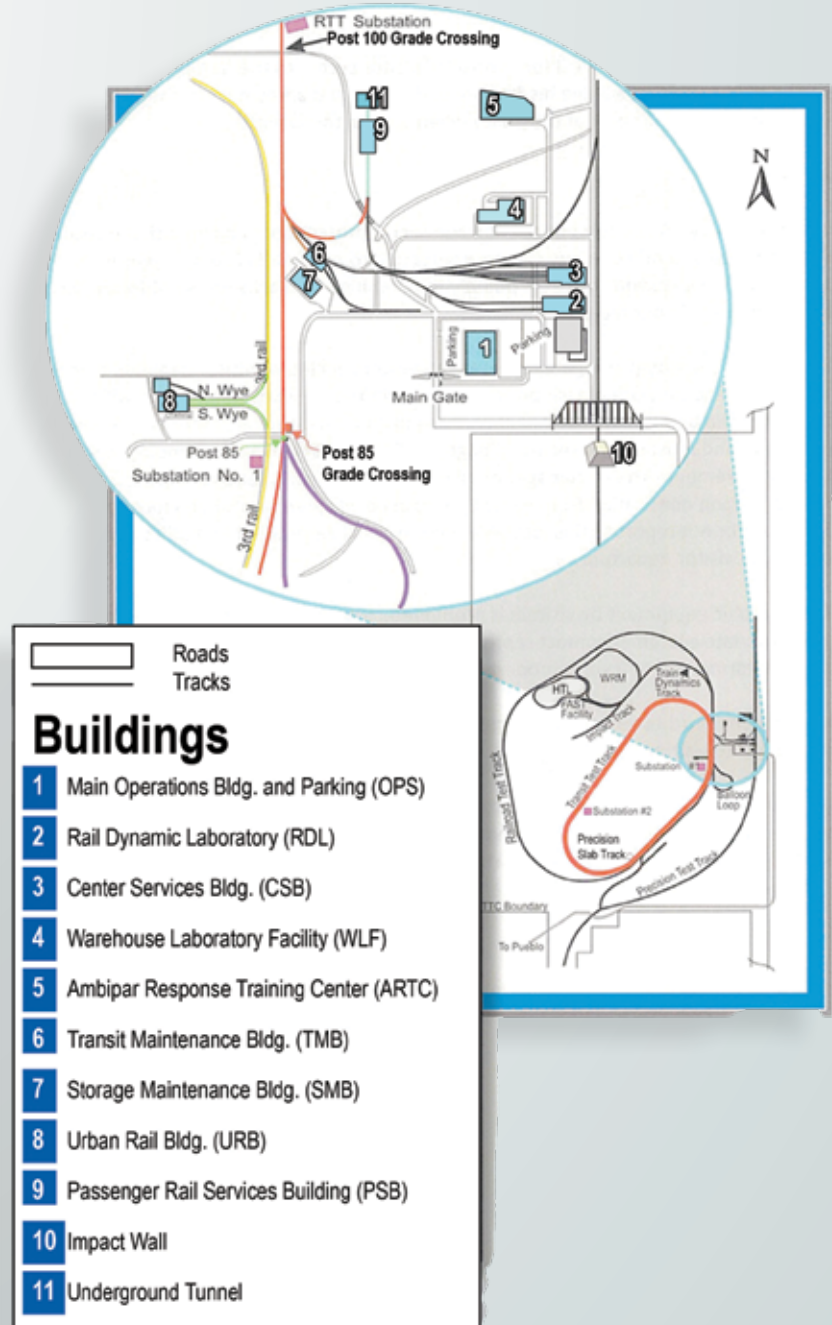
- High Tonnage Loop
- Rail Transit Track Loop
- Transit Test Track
- Wheel Rail Mechanism Loop
- Tight Turn Loop
- Precision Geometry Slab Track
- Vertical Wall for Impact Testing
- Underground Test Tunnel

Support Infrastructure

- Passenger-Rail Services Building
- Transit Maintenance Building
- Urban Rail Building
- Center Services Building
- Wheel Truing Machine
- Drop Table
- Cranes, Jacks, Floor Pits, etc.
- Overhead Wire and Third Rail with Adjustable Voltage

Facility Leasing and Support

- Office space, shop space, and tracks available for long term lease to support onsite testing
- Provide services to support long term rail vehicle storage including rolling stock maintenance support and car movement services
- Support staff to aid in rolling stock maintenance and testing



Applications:

- New locomotive, freight car, and passenger car testing (homologation)
- Accelerated service testing of rolling stock and track components
- Impact testing of railway vehicles including tank cars and passenger cars
- Testing of new products in accessible and controlled railway environment.

Test Tracks

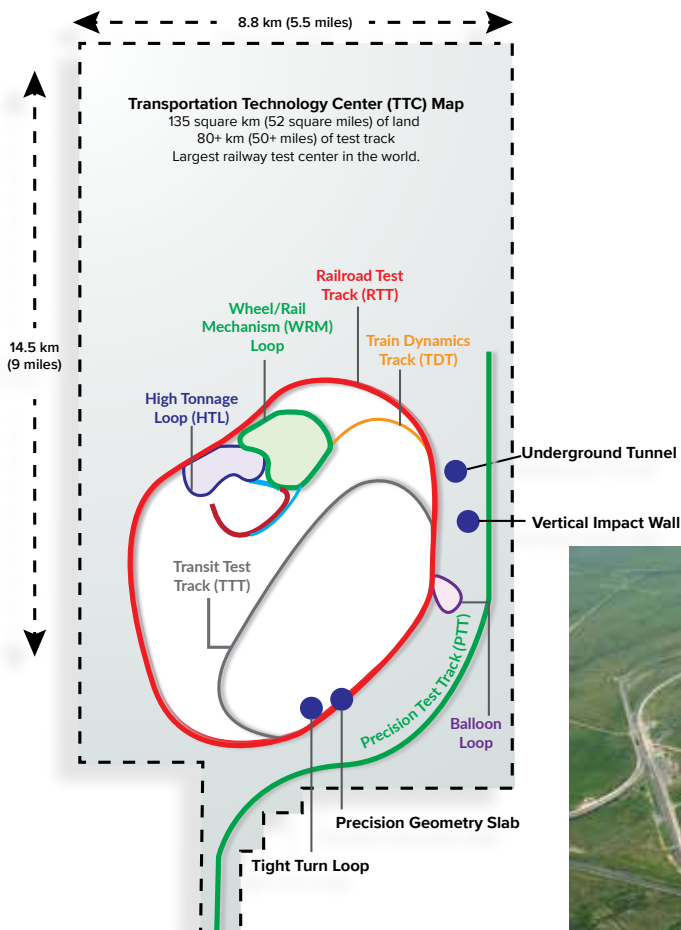
The TTC has over 50 miles (80 km) of railroad testing track, the largest in the world. The two largest test tracks are the Railroad Test Track (RTT) and Transit Test Track (TTT). The RTT extends over 13.5 miles (21.7 km) and supports high-speed testing up to 165 mph (265 kph). It features an overhead catenary wire system with adjustable voltage and a Precision Geometry Slab Track, allowing for vertical and lateral precision adjustment to create track geometry perturbations. The TTT, spanning 9.1 miles (14.6 km) with a top contact third rail, accommodates speeds up to 89 mph (142 kph) and is ideal for assessing heavy and light rail vehicles. Both tracks enable thorough evaluation of vehicle and track components, ensuring optimal performance and safety.

Railroad Test Track (RTT)

- Passenger and Freight vehicle testing at high speeds
- Higher speeds vehicle/track interaction assessments
- Pantograph/overhead wire interaction assessments
- High-speed vehicle/track interaction assessments

Transit Test Track (TTT)

- Heavy rail and light rail vehicle testing
- Vehicle/track interaction assessments
- Third rail interaction assessments



Impact Testing

At the TTC, ENSCO conducts full-scale, head-on collision testing using the specially engineered impact wall, rated for a three million-pound impact load. The facilities support a variety of crash tests, including side impact evaluations, and is equipped with high-speed data and video acquisition systems for detailed analysis.

With a ram car guidance track offering variable impact speeds, the TTC supports comprehensive testing scenarios for tank car and vehicle component impact evaluations. Designed to withstand immense impacts, the impact wall is instrumental in advancing crashworthiness for passenger vehicles and other rolling stock. Beyond freight and passenger, it has been pivotal in testing various vehicle components, including diesel fuel tanks, in real-life scenarios such as locomotive derailments and impacts from semi-trucks. Looking forward, the facility remains critical for testing crashworthiness designs and specifications for alternative energy methods, such as hydrogen, renewable natural gas, and battery energy storages systems, crucial for meeting safety expectations and reducing greenhouse gas emissions in the transportation sector.

Applications:

- Tank car impact testing
- Fuel tank impact testing
- Vehicle crashworthiness testing



Lab Rig Testing Laboratory

The TTC is outfitted with one-of-a-kind lab rig equipment to evaluate rail vehicles to their full extent.

Vibration Test Unit (VTU)

Whole body vibration testing of rail vehicles

Applications:

- Structural vibration testing
- Identify flexible modes
- Ride quality assessments

Simuloader (SMU)

Full rail vehicle stress testing

Applications:

- Structural stress and deflection
- Structural fatigue testing

Squeeze Test Fixture

Compression testing of whole rail vehicles

Applications:

- Crush compliance testing
- Structural stress testing
- Corner post testing

Mini-Shaker Unit (MSU)

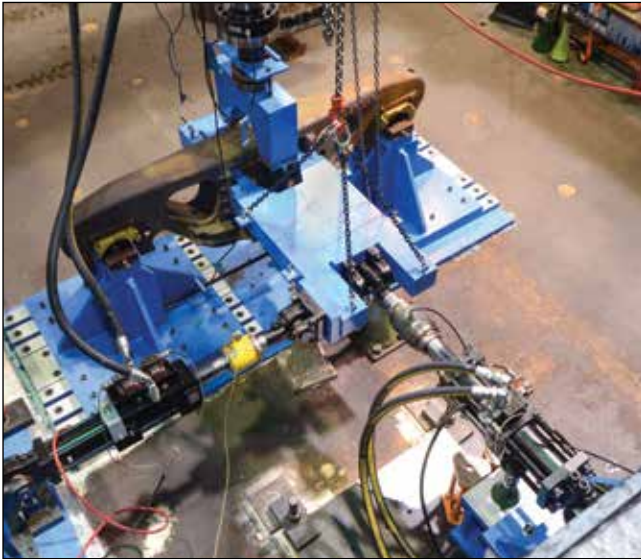
Truck (bogie) suspension vibration testing

Applications:

- Assess truck (bogie) vertical, lateral, roll, yaw performance
- Bogie yaw resistance testing
- Bogie component testing
- Component fatigue testing

Major Component Testing Laboratory

Partnered with laboratories and with capabilities at the TTC, ENSCO can provide track and rolling stock component testing capabilities in accordance with AAR and AREMA standards and guidelines.



Component Testing at a Glance

Facilities

- Large lab space and material handling ability to handle large components such as bolsters, side frames, passenger truck frames, and crossties (sleepers)
- State-of-the-art servo-hydraulic testing equipment

Capabilities

- Static and fatigue testing of bolsters and side frames
- Friction wedge testing
- Polymer, composite, steel, wood, and concrete crosstie (sleeper) testing
- Rail, weld, and joint bend testing

Component Failure Analysis and

Materials Laboratory Testing

In partnership with ESI Inc., ENSCO provides rail component failure analysis and laboratory testing. The ESI staff is a leader in railway industry component failure analysis, serving prominent railways including Union Pacific Railroad and CSX.



ESI Laboratory at a Glance

Facilities

- Large lab space, material handling and sample preparation capabilities to handle large components such as wheelsets and bogies
- Hydraulic presses for tensile and compression testing
- Metallurgy evaluation equipment
- Visual and Scanning Electron Microscopy (SEM)

Capabilities

- Component performance deficiency identification
- Railway component failure analysis
- Sleeper laboratory testing
- Industry standard component evaluation
- Chemical composition testing

Instrumentation

Identifying the root cause of a problem such as premature rail wear or evaluating the performance of rolling stock, often requires vehicle or track instrumentation.

ENSCO specializes in the following instrumentation methods (onsite at your facility or at the TTC):

- Sensors—Strain gauges, accelerometers, LVDTs, etc.
- Data Acquisition—High-speed and large channel count data acquisition
- Other Specialties
 - Instrumented wheelsets to measure wheel/rail forces
 - Instrumented couplers to measure in-train forces
 - Autonomous data collection without human intervention



ENSCO's wide breadth of instrumentation capabilities includes Instrumented Wheelsets (top), new vehicle acceptance testing (left), and static lean testing (right).

Case Studies: Instrumentation

Project: Instrumented Track

The Challenge: Collect data to assist in ballast investigation effort.

The ENSCO Approach: ENSCO implemented six, long-term wayside autonomous monitoring sites, which required the design of a multifaceted data collection system integrating a multitude of sensors and instrumentation including accelerometers, high speed cameras, strain gages, subsurface moisture content probes, and weather stations.

Result: Actionable data that allowed customer and industry to arrive at objective means to characterize ballast performance.



Case Studies: Instrumentation

Project: In-Train Force and Train Makeup Study

The Challenge: Study in-train forces, train makeups, and train handling over an extended period.

The ENSCO Approach: ENSCO designed a fully autonomous reporting data acquisition system onboard a ballasted freight vehicle. The system integrated instrumented couplers, accelerometers, brake pipe pressure gauges, and brake cylinder pressure gauges with a remotely reporting rugged data acquisition system. Data was recorded onboard the test vehicle and transmitted remotely via cellular communication to a cloud-based data repository where the data was processed and presented to the client.

Result: The system ran continuously, autonomously, and maintenance free for over two years on a Class I railroad to aid in practices to reduce in-train forces.

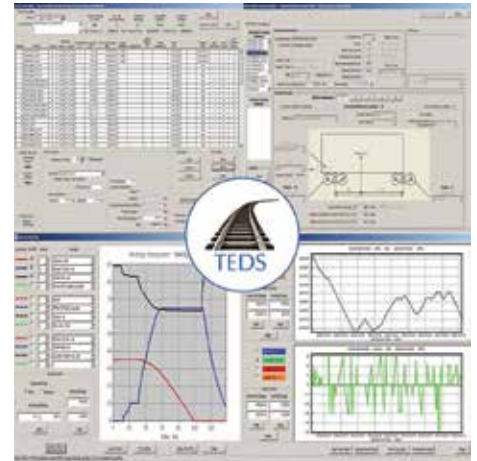


Simulation

ENSCO understands how to complement instrumentation with simulation tools to quickly and cost-effectively evaluate hypothetical scenarios. This helps identify problems before they occur, prevent downtime, and optimize your operations. Areas of expertise include simulations in track/train dynamics, vehicle/train interaction, and finite element analysis.

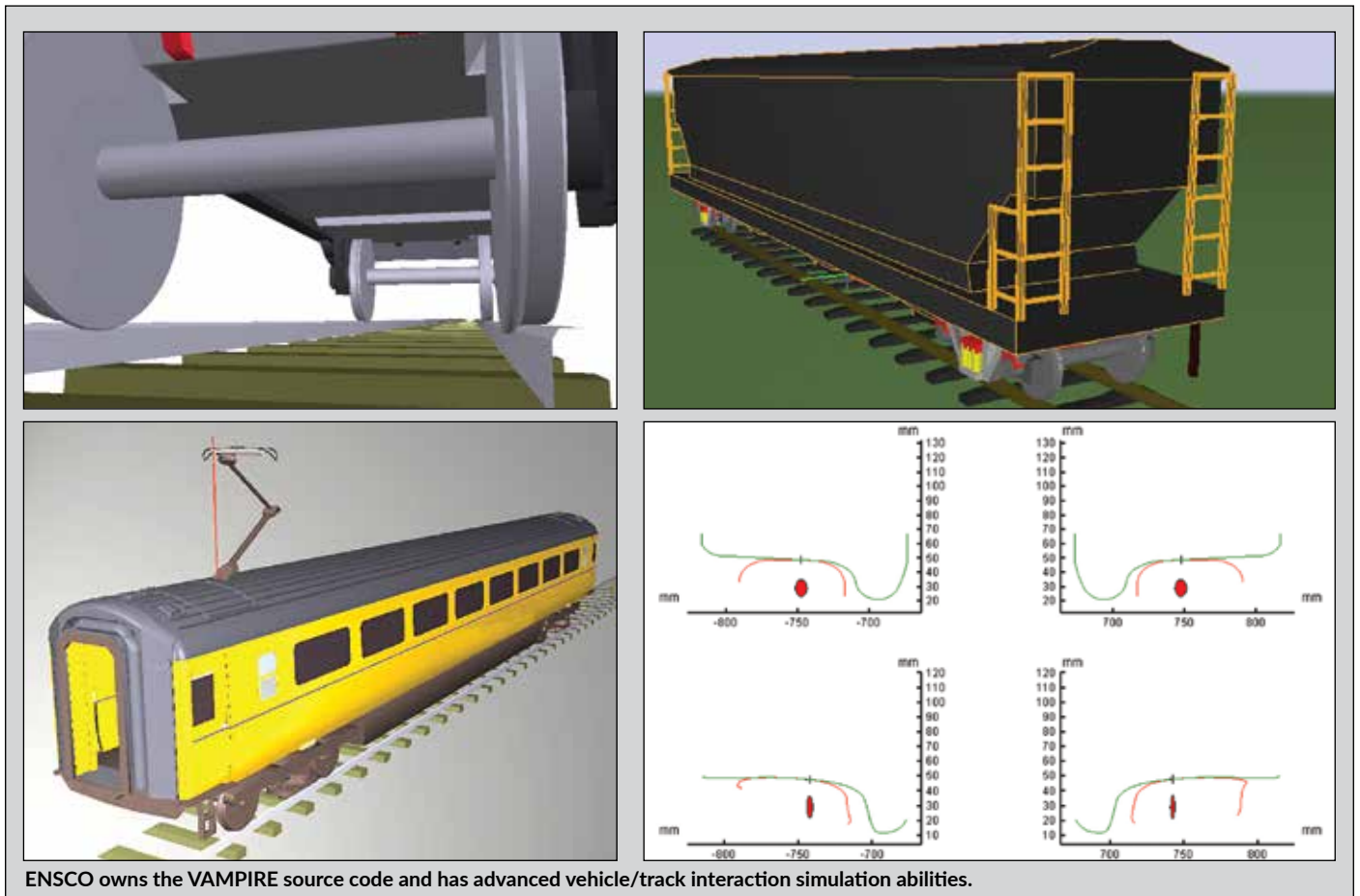
Track/Train Dynamics: Used to simulate an entire train over long stretches of track that includes elevation changes and curves. This type of simulation is often used to assess freight train make-up and train handling. ENSCO uses the software program Train Energy and Dynamics Simulator (TEDS) provided by our partner Sharma and Associates. Results of simulations can be used to assess problems such as:

- Building operational rules for train make-up and train handling
- Evaluating larger freight train sizes for safety
- Assessing proposed designs of new track, industrial leads, and balloon loops for safety and expected use deterioration
- Investigating and predicting derailment risk and identifying mitigating strategies



Vehicle/Track Interaction: ENSCO uses VAMPIRE for vehicle/track interaction simulation for the purpose of predicting vehicle motions and wheel/rail interaction forces when interacting with measured track conditions. Results of simulations can be used for:

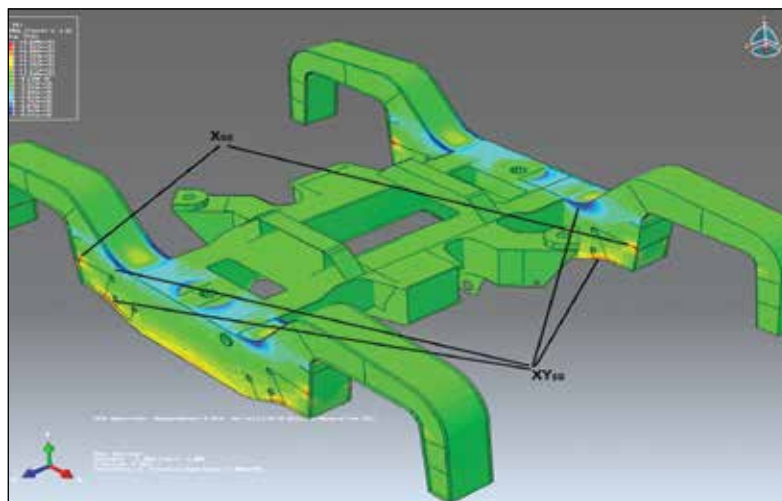
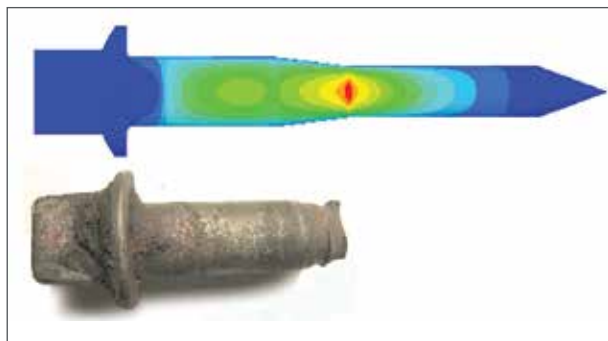
- Understanding premature wheel and rail wear or RCF generation
- Investigating and predicting derailment risk and identifying mitigating strategies
- Identifying root causes of rapid track deterioration conditions
- Evaluating new vehicle or suspension types



ENSCO owns the VAMPIRE source code and has advanced vehicle/track interaction simulation abilities.

Finite Element Analysis (FEA): This modeling technique simulates the stress and deformations that individual components undergo during railway operations. ENSCO uses various FEA simulation packages including Ansys, ABAQUS, and LS-DYNA. Results of simulations can be used for:

- Investigation of rolling stock and track components failing from fatigue
- Evaluation of design changes to components
- Life-extension studies of rolling stock



ENSCO uses Finite Element Analysis (FEA) to aid in investigating premature component failure, such as screw spikes.

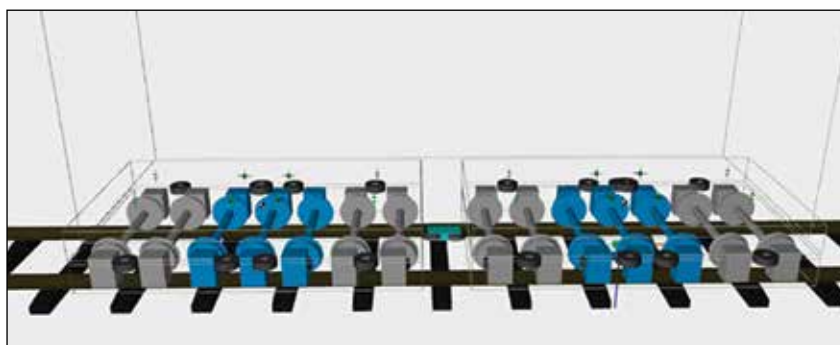
Case Studies: Simulation

Project: Transformer Transport Vehicle

The Challenge: Determine the risk of derailment of a specialized transport vehicle.

The ENSCO Approach: Evaluate derailment risk against speed of operation, to include evaluating track data, clearances, suspension, masses and wheel/rail geometry.

Result: The design and operation were optimized via simulation and successfully implemented.



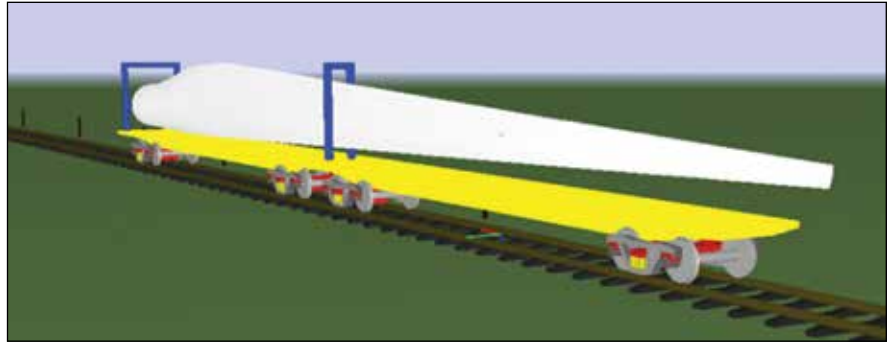
Case Studies: Simulation

Project: Wind Turbine Blade Transport

The Challenge: Determine clearance and derailment risk associated with transporting wind turbine blades by rail.

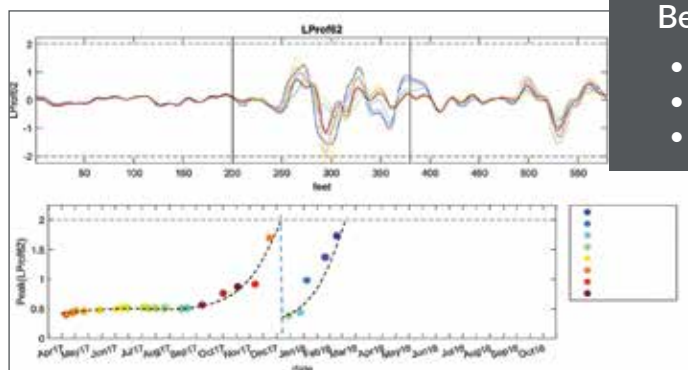
The ENSCO Approach: Evaluate derailment risk based on vehicle dynamics simulation predictions.

Result: Implementation of proposed operations.



Analytics

ENSCO employs subject matter expert-driven data analysis of track measurement train, instrumentation, and simulation data. ENSCO uses small and large data analytics tools and methodologies including statistical, artificial intelligence, and machine learning.



ENSCO applies the latest tools in machine learning/artificial intelligence.

Benefits of ENSCO Data Analytics

- Root Cause Identification
- Prediction
- Optimization

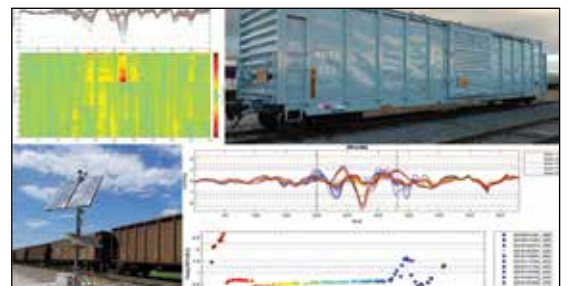
Case Studies: Data Analytics

Project: Ballast Fouling and Trending Study

The Challenge: Determine criteria for class-based approach to fouled ballast safety enforcement.

The ENSCO Approach: Collect and analyze pertinent information via track inspection vehicles, long-term wayside instrumentation and ground-penetrating radar.

Result: Objective criteria for more consistent enforcement of fouled ballast safety.



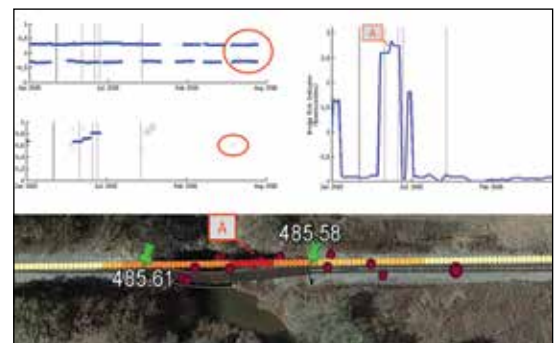
Case Studies: Data Analytics

Project: Track Feature Risk Assessment Using V/TI Data

The Challenge: Assess track feature health/risk using Vehicle/Track Interaction monitors and determine if the approach can scale to fleet size and offers greater coverage than traditional systems.

The ENSCO Approach: Use analytical models that can be trained and applied to a variety of track features to develop a risk assessment index algorithm to rank features and conditions, and identify/prioritize high-risk sites.

Result: Track feature-specific Bridge Risk Index that provided health and derailment risk assessments for bridges to prioritize maintenance.



HAZMAT and Energetic Material Management

In collaboration with Ambipar Response/Ambipar USA, ENSCO delivers comprehensive Training and Energetic management support to the USDOT at the TTC. Ambipar Response stands as the world's largest commercial response organization,



boasting over 70 years of expertise in managing environmental incidents and responding to major hazard events globally, including oil spills and chemical incidents.

Additionally, our partnership encompasses training modules tailored to simulated emergency response scenarios, such as train derailments and highway accidents. Participants undergo rigorous training in live fire conditions under the guidance of qualified instructors and safety personnel. The program also includes simulated HAZMAT response and handling exercises, along with specialized training in emergency response for hydrogen and battery-powered vehicles.



ENSCO's partner Ambipar providing HAZMAT training at the TTC in Pueblo, Colorado.



<https://ambipar.com/artc/>



Knowledge Transfer and Work Force Development

ENSCO goes beyond merely offering solutions; we strive to enhance customer comprehension. Through knowledge transfer and workforce development initiatives, ENSCO equips its clients with expertise in all areas of railway technical workforce development, derailment investigation, track and rolling stock data analysis, and vehicle/track interaction dynamics.

ENSCO and its partners offer unique and tailored hands-on training that can be hosted at the TTC. Additionally training can be provided at our customers' locations or online. Contact us today to see how we can meet your workforce development needs



ENSCO experts take the opportunity to provide training and knowledge sharing with our customers.



Center for Critical Infrastructure Protection (CCIP)

ENSCO is proud to host the Center for Critical Infrastructure Protection (CCIP), located at the TTC in Pueblo, Colorado. CCIP's mission is to aid critical infrastructure government and industry organizations in meeting their Cyber and Physical Security protection requirements.

Mission and Focus Areas

CCIP focuses on four key areas to support Critical Infrastructure organizations:

- **Training:** Cyber and physical security training courses for all skill sets, including executives.
- **Assessment:** Cyber Vulnerability Assessments, Compliance Assessments, Threat and Vulnerability Assessments (TVAs), Systems Security Plan (SSP).
- **Testing & Modeling:** Penetration Testing, Large-Scale Incident Testing & Modeling.
- **Protection:** Cyber and physical security consulting,

Cyber Lab

CCIP features a Cyber Lab at the TTC to test Operational Technology (OT), enhancing our capability to address the evolving cyber and physical security landscape.

Certified Workforce

CCIP's highly skilled personnel deliver innovative, value-driven solutions to complex cyber and physical requirements. Specializing in Information Technology (IT) and OT environments, the CCIP team holds over 20 certifications and has extensive experience with the Department of Defense (DoD), federal organizations, and the commercial sector.

Academic Partnerships

CCIP collaborates with respected academic partners, including The Center for Urban Transportation Research (CUTR) at the University of South Florida and the Mineta Transportation Institute at San Jose State University, providing proven physical security training.

Sector-Specific Services

The center offers tailored services to address the unique security challenges faced by various industries:

- **Transportation Systems Sector:** Mass Transit and Passenger Rail, Freight Rail, Pipeline, Highway and Motor Carrier, Aviation, Maritime
- **Critical Manufacturing Sector:** Locomotive Suppliers, Railroad and Transit Car Suppliers, Rail Track Equipment Suppliers, Nuclear Sector Critical Suppliers, Energy Sector Critical Suppliers, Water and Wastewater Critical Suppliers
- **Nuclear Reactors, Materials, and Waste Sector:** Nuclear Reactors, Storage, Medical Use Facilities, Transportation
- **Energy Sector:** Electrical Power Plants, Oil and Gas Facilities, Solar and Wind Energy Facilities, Hydrogen Production and Storage Facilities
- **Water and Wastewater Systems Sector:** Public Drinking Water, Treatment Facilities



Visit ccip-ensco.com
to learn more

TTC Conference & Tour



The Annual TTC Conference and Tour is a premier annual event that bridges government, industry, and academia, providing a unique platform to discuss and showcase the latest advancements in rail transportation. Held over two days in Pueblo, Colorado, the conference offers a comprehensive program designed to foster collaboration, innovation, and networking all set against the backdrop of the world's largest rail testing and training facility.

Conference Overview

- **Day One:**
 - **Location:** Pueblo Convention Center
 - **Activities:** A rich lineup of technical presentations, exclusive networking opportunities, and the chance to connect with government and industry leaders. Attendees can expect diverse sessions covering the most pressing issues and trends in the rail industry.
 - **Networking:** Extended networking sessions ensure meaningful connections and engagement, especially for our sponsors who have the opportunity to showcase their products and services.
- **Day Two:**
 - **Location:** TTC
 - **Activities:** An immersive experience featuring on-track equipment displays, extended tours of the world's largest rail testing facility, and enhanced networking opportunities. Attendees will benefit from live demonstrations, exclusive access, and the chance to see cutting-edge rail research and technology in action.

Key Features

- **Exclusive Tours:** Attendees have the rare opportunity to explore the TTC, witnessing firsthand the innovative testing and training facilities.
- **Live Demonstrations:** On-track equipment displays provide a unique experience not available at most industry conferences.
- **Networking Opportunities:** The event fosters connections among attendees from government, industry, and academia, creating a collaborative environment to discuss and address the most prevalent issues in the rail sector.
- **Sponsorship Opportunities:** The conference offers various sponsorship levels, providing exposure and engagement opportunities for businesses looking to connect with industry leaders and stakeholders..



For more information and to learn more, please visit ttc-conference.com.

ENSCO Inc. holds the distinguished role of operating the Transportation Technology Center (TTC) located in Pueblo, Colorado on behalf of the U.S. Department of Transportation (DOT) Federal Railroad Administration. Spanning a vast 52 square-miles, the TTC is more than just a facility: it's the accelerator of innovation in surface transportation. This pivotal center is dedicated to the relentless pursuit of advancements in research, development, testing, and training, all converging to fortify the pillars of safety, security, and sustainability in transportation. With ENSCO's expert stewardship, the TTC stands as an inclusive institution, catering to every mode of surface transportation, empowering them to realize their objectives. Further elevating its stature, the TTC is also home to the Center for Critical Infrastructure Protection (CCIP). The CCIP's mission is singular: to fortify critical infrastructure entities against cyber and physical threats through comprehensive training, rigorous assessments, meticulous testing, and robust protection measures.



Visit Our Website



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