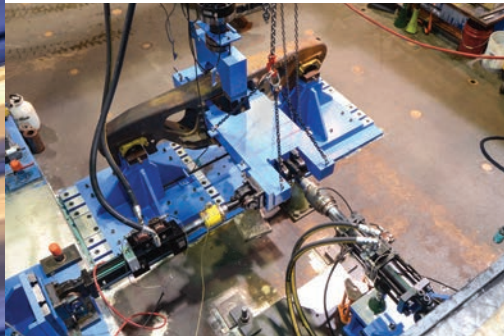


Rail Engineering Services





For more than 50 years, ENSCO's team of engineers has led the rail industry in safety, reliability, and efficiency through our Engineering Services and technologies. ENSCO services and technology help customers improve the quality of their operations while making travel safer.

ENSCO Rail, Inc. is a wholly owned subsidiary of ENSCO, Inc.



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Since 1970, ENSCO engineers have led the rail industry in providing world class Engineering Services. We're proud to offer our customers expert services and technologies to help meet their operation and business objectives.



ENSCO Rail Engineering Services

ENSCO's world-renowned experts provide engineering services to railways around the globe to increase safety, reliability, and efficiency. This effort is augmented to support automation, connectivity, cybersecurity and resilience. ENSCO has the facilities and equipment with engineering, data scientists, and field staff to expand your in-house capabilities which reduces risk, increases network safety, and optimizes maintenance planning. ENSCO's philosophy is to not only solve the problem, but provide training to your in-house staff during the project and grow their abilities in the process.

Customer Needs

- Evaluate Rolling Stock and Components
- Increase Asset Life
- Decrease Maintenance Costs
- Optimize Maintenance Planning
- Decrease Derailment Risks
- Increase Safety
- Increase Asset Availability
- Asset Mapping, Inventory and Management
- Operations Optimization and Evaluation of available Alternatives
- Inspection Technology Staff Supplementation
- Industry Standard Development Support
- Accelerated Component Testing
- Rail Testing Laboratory Development
- HAZMAT & Energetic Material Training and Management Requirement Development
- Technology Transfer and Work-Force Development
- Cybersecurity

ENSCO's Specialties

- World Leading Track Infrastructure & Rolling Stock Condition Data 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
- Asset Register Construction using Inspection Data
- Component Failure Analysis, Laboratory Testing, and Field Testing
- Track Inspection Technology Operations Program and Processes Implementation
- Partnership with Ambipar International leader and HAZMAT and Environmental solutions

Why ENSCO?

Transportation Technology Center (TTC): Beginning in October 2022, ENSCO will be responsible for research, testing and training at the Federal Railroad Administration (FRA) Transportation Technology Center (TTC) located in Pueblo, Colorado, USA. The TTC is the largest railway test center in the world and is the premier site for test track loops, whole vehicle testing, and accelerated track and rolling stock component testing under real-life conditions.

Recognized Industry Leader: With more than 50 years of service, ENSCO is the most established supplier of track research, engineering, and track inspection. ENSCO is the leader in data-driven safety improvement and track infrastructure condition assessment and analysis. This knowledge and experience from establishing research and test programs used throughout the world can be leveraged to help grow your program.

World Renowned Experts: ENSCO's team includes some of the most highly recognized experts in their fields. The supporting staff of engineers and data scientists help our customers and partners find solutions to their needs.

VAMPIRE® Source Code Holders: VAMPIRE is an industry leading vehicle/track interaction modeling software first developed by British Rail Research and now used throughout the world. **ENSCO owns an enhanced user license for access to the VAMPIRE software source code.** This license allows ENSCO to develop new applications of vehicle dynamics modeling and simulation. Among these new applications are automated predictive simulations with track measurement vehicle data.

End-to-End Solution Provider: ENSCO is the only railway industry provider of automated track inspection technology and the in-house subject matter experts to transform the measured data into valuable and practical information for decision-making. ENSCO draws from one of the largest groups of track measurement specialists in the world with a workforce of more than 80 engineers and scientists.

Training Partnership: ENSCO views its role as one that not only solves problems, but also trains railway staff. This transfer of expertise and technical know-how enables you to learn and grow from ENSCO's experts to achieve elevated internal capabilities. All ENSCO's engineering services can include staff training.

Partnerships

ENSCO has selectively partnered with several reputable organizations to support efforts at the TTC, as well as all our client's engineering service needs.



SA SHARMA & ASSOCIATES, INC. Railroad research and test capabilities with expertise in bridges, rolling stock design, and train operations.

ATKINS
Member of the SNC-Lavalin Group Train control research with expertise in implementing train control systems and providing safety consulting services complemented by world-recognized experience in transit, highway, environmental, and construction engineering services.

ambipar response Training and simulation with expertise establishing and operating ground transportation and hazardous material emergency response training centers.

ESI Materials and failure analysis experts with fully equipped metallurgy lab and material testing capabilities.

CTLGROUP Rolling stock major component stress and fatigue testing such as bolsters, side frames, and coupling systems.

ENSCO formed the Center for Surface Transportation Testing and Academic Research (CSTTAR), led by the University of South Florida Center for Urban Transportation Research (CUTR), to provide expertise in research focus areas across all modes of surface transportation to support TTC growth initiatives.



Research & Development, Testing, Engineering, and Training at the Transportation Technology Center

Starting in October 2022, ENSCO will manage and operate the Transportation Technology Center (TTC) in Pueblo, Colorado. The TTC is the largest railway test center in the world: 135 square km (52 square miles) of land and approximately 80 km (50 miles) of test track. The TTC serves as a center for rail and ground transportation innovation that combines state-of-the-art test and training facilities and a multi-disciplined team of experts in research and engineering.

TTC at a Glance

On-Track Vehicle Testing

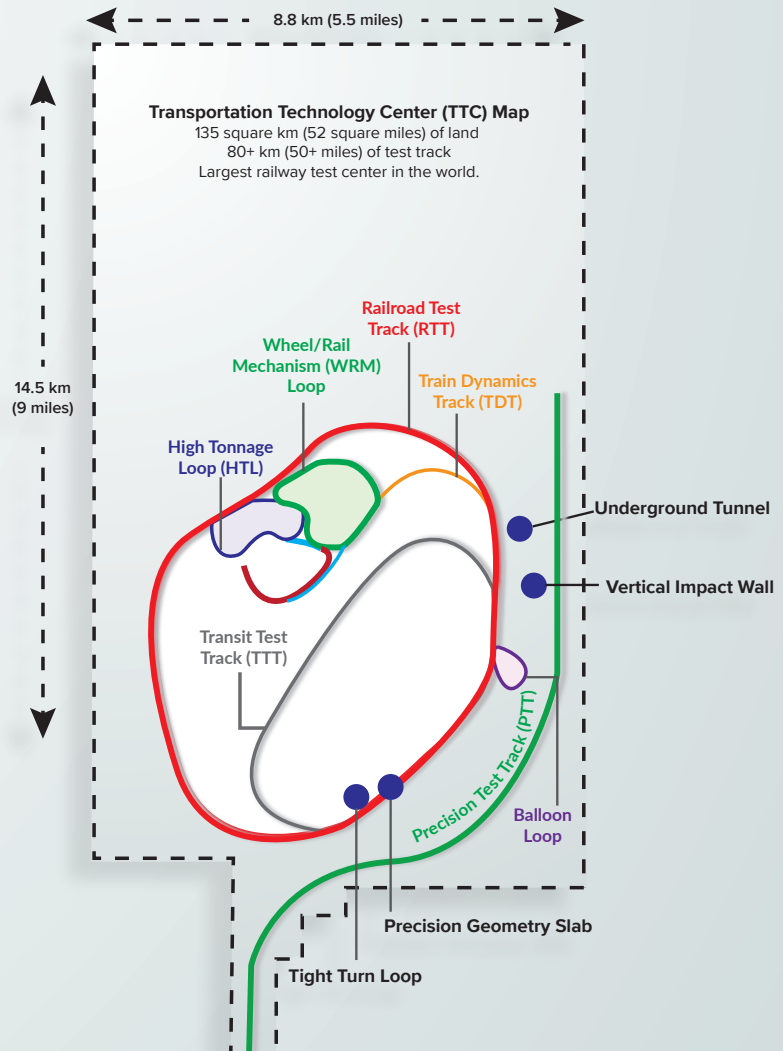
- High Tonnage Loop
- Rail Transit Track Loop
- Transit Test Track
- Wheel Rail Mechanism Loop
- Tight Turn Loop
- Precision Geometry Slab Track
- Vertical Wall for Impact Testing
- Underground Test Tunnel

Support Infrastructure

- Passenger-Rail Services Building
- Transit Maintenance Building
- Urban Rail Building
- Wheel Trueing 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
- Provided 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

High Tonnage Loop Accelerated Testing

The High Tonnage Loop (HTL) is a 4.3 km (2.7 mile) loop used to evaluate vehicle and track components under accelerated use. The HTL is a one-of-a-kind facility to generate high tonnage rapidly and in non-revenue environment, perfect for evaluating rolling stock, track components, and associated systems.

Applications:

- Accelerated track component testing including rail, fasteners, sleepers, ballast, turnouts, and bridges
- Accelerated vehicle component testing including whole wagons, trucks (bogies), and wheel sets.



The High Tonnage Loop (HTL) at the TTC provides accelerated testing of rolling stock and track components.

Impact Testing

ENSCO is capable of full-scale, head-on collision testing at the TTC. Additionally, a specially engineered impact wall is used for a variety of crash tests including side impact tests.



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)

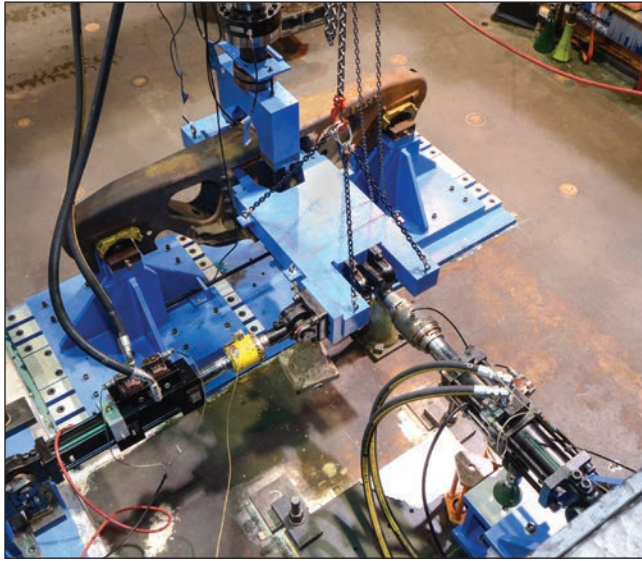
Truck (bogie) suspension vibration testing

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, such as CTLGroup, 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. Testing services include:



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

With partner 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

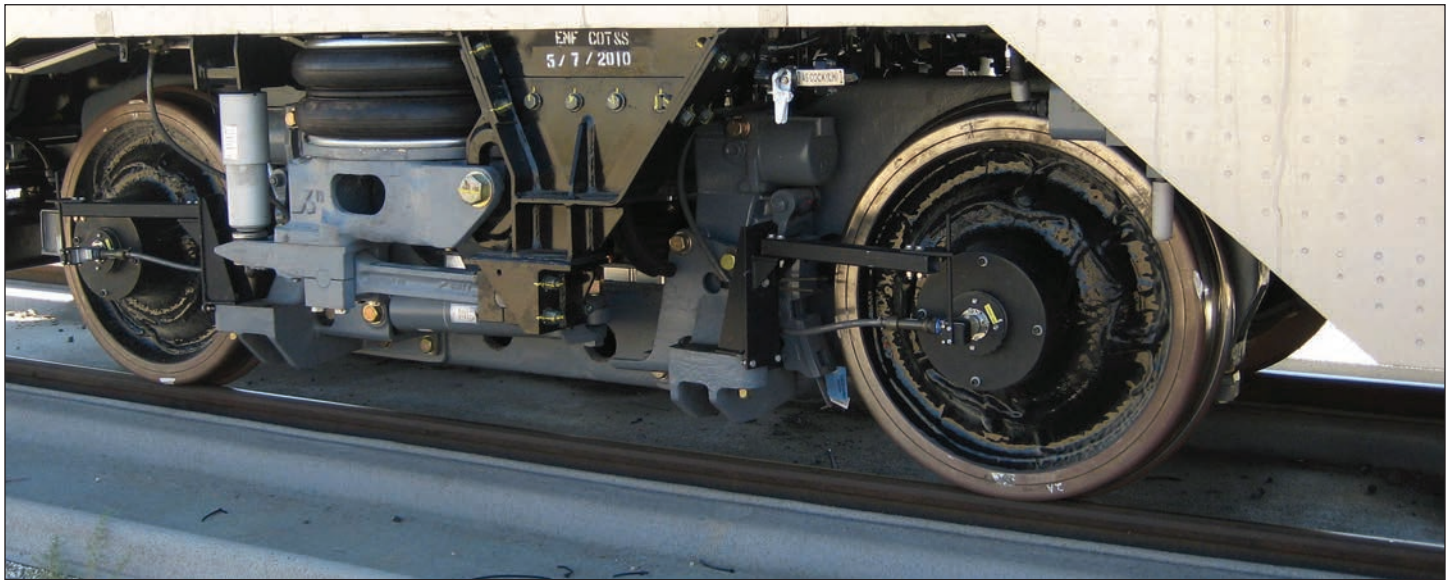
- Component performance deficiency identification
- Railway component failure analysis
- Sleeper laboratory testing
- Industry standard component evaluation
- Chemical composition testing

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.

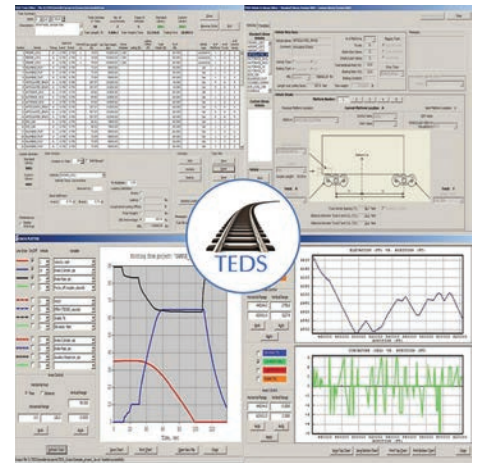


Simulation

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



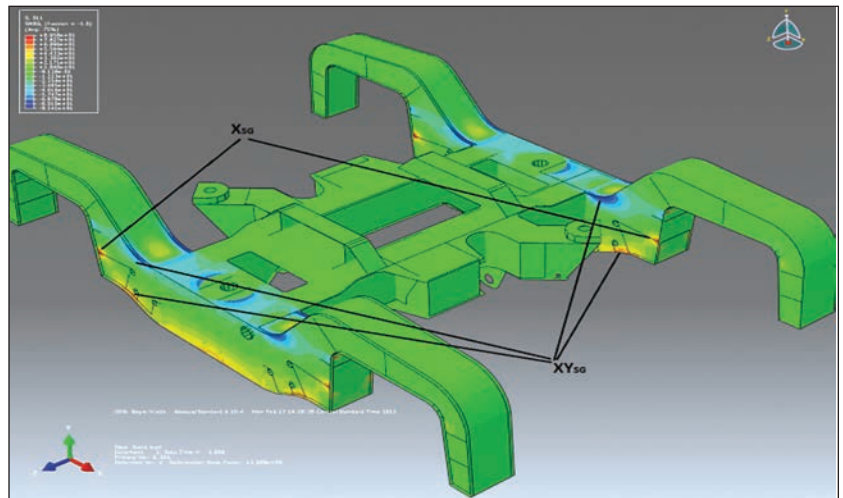
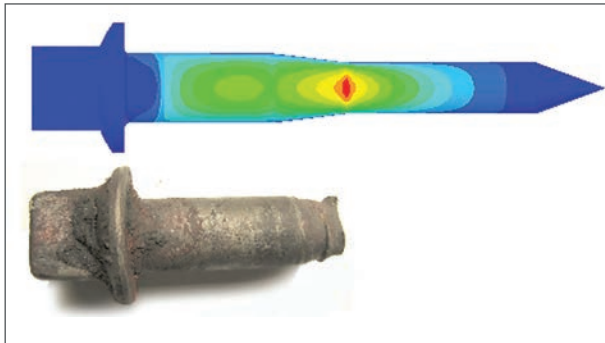
Vehicle/Track Interaction: ENSCO uses VAMPIRE® for vehicle/train interaction simulation for the purpose of predicting vehicle motions and wheel/rail interaction forces when interacting with measured track conditions. Results of simulations can be used for:

- 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.

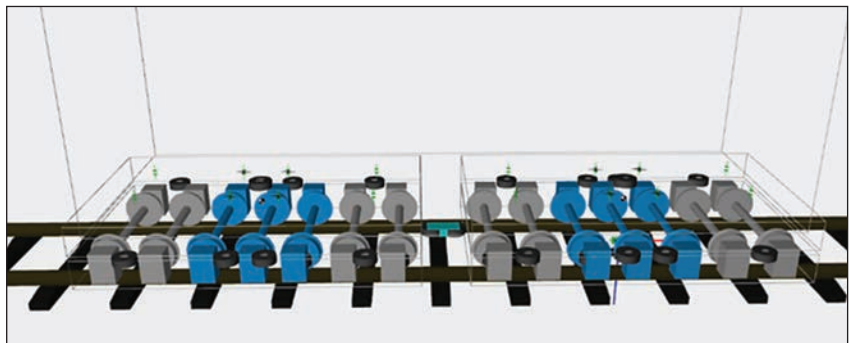
Case Studies: Simulation

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.



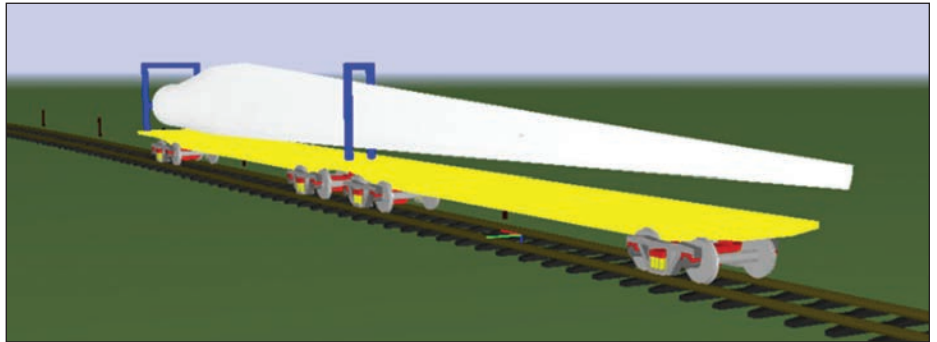
Case Studies: Simulation

Project: Wind Turbine Blade Transport

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

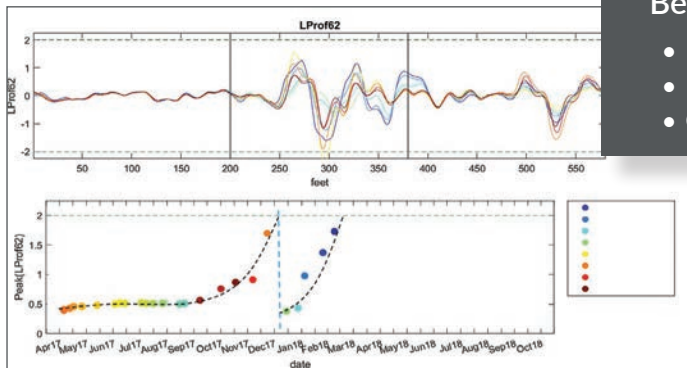
The ENSCO Approach: Evaluate derailment risk based on vehicle dynamics simulation predictions.

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.



Benefits of ENSCO Data Analytics

- Root Cause Identification
- Prediction
- Optimization

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

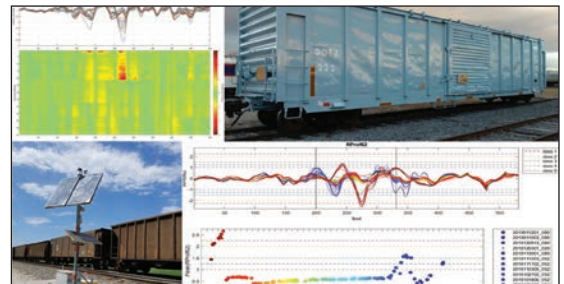
Case Studies: Data Analytics

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.

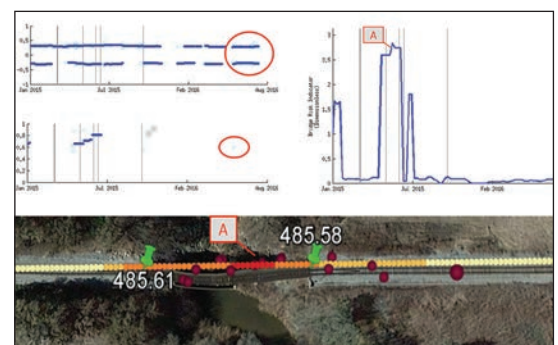


Project: Track Feature Risk Assessment Using V/TI Data

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.



Expert Staff to Plan and Operate Inspection Technology

ENSCO has operated and maintained track inspection vehicles for more than 50 years. Our staff has direct experience supporting railroads in establishing the operational procedures for successful track geometry test programs, ultrasonic rail test programs, track mapping programs, and many others. This experience and know-how includes all aspects of the test regime including safety procedures, operational procedures, data distribution, establishment of thresholds, and establishment of test frequencies.

Additionally, ENSCO can support the operation and maintenance of all test and measurement equipment on a turnkey basis or a knowledge transfer partnership to effectively train railroad staff.

Track Inspection Technology Operations Program and Processes Implementation

ENSCO is a world leader fully developing track inspection programs—from maximizing track inspection technology to building internal processes and developing documentation.

ENSCO's expertise in this area can be applied to:

- Building internal staffing requirements and training plans to facilitate the establishment of quality in-house staff for the life of the asset and in a manner consistent with railway's practices.
- Building operation plans on how to integrate track inspection vehicles into railway operations including track control interaction, surveying, and storage
- Building maintenance plans incorporating railway's maintenance resources.
- Building or update internal track inspection standards to incorporate the track inspection technology. This can include recommended exception thresholds and maintenance responses to exceptions.
- Providing financial analysis and budget planning.



ENSCO staff can operate and maintain your track inspection technology on your behalf.



ENSCO can provide expertise in building your internal track inspection program.

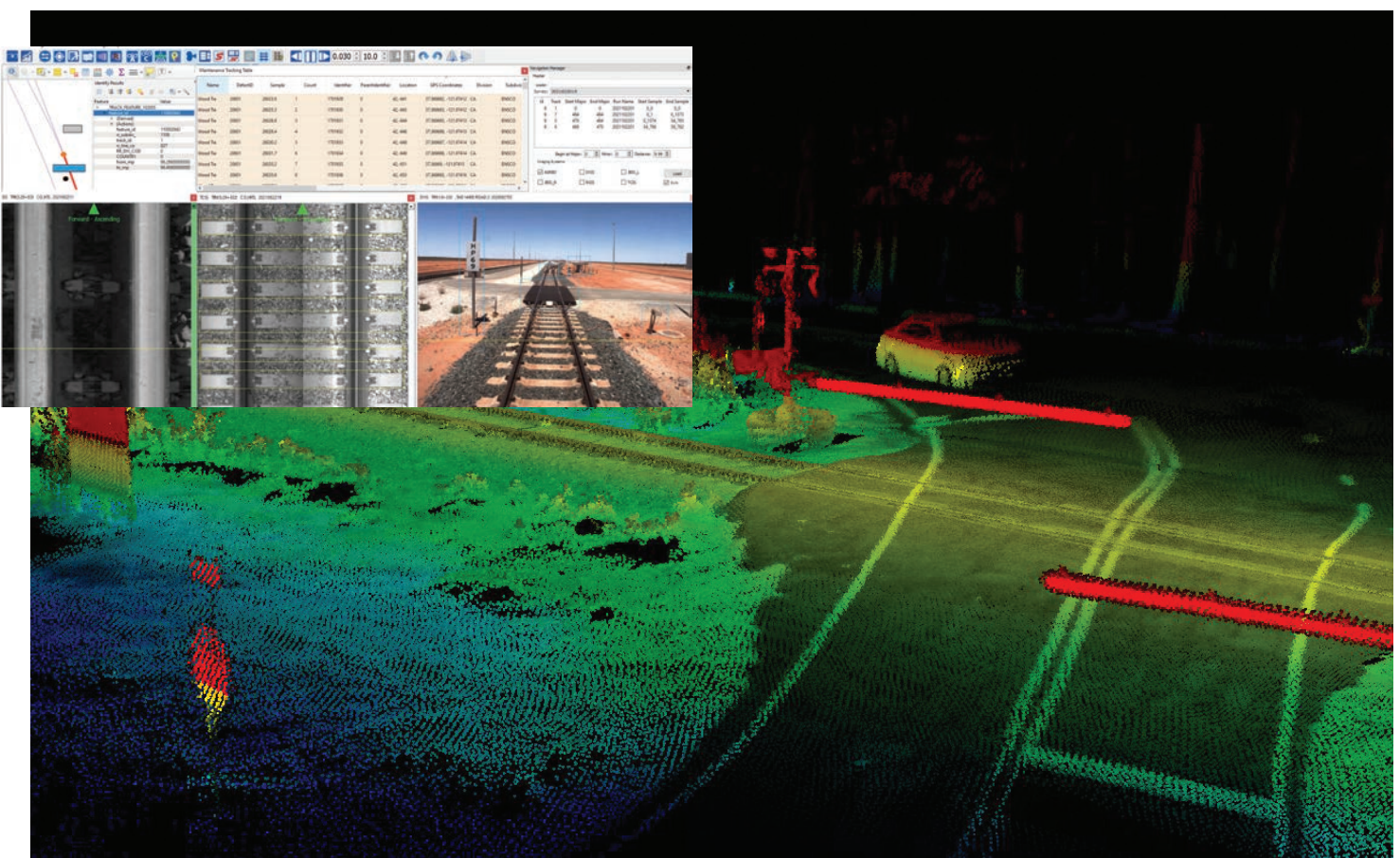
Asset Mapping and Register Construction Using Inspection Data

ENSCO track infrastructure asset management and planning services use track inspection technology to capture and assess fixed infrastructure-related assets to determine and record asset inventory and geographical location of assets.

ENSCO delivers a comprehensive asset register that forms the foundation of your asset management program and the source to link condition data, exceptions, defects, and inspections. As your infrastructure expands or changes, ENSCO creates a digital “track chart” and Geographic Information System (GIS) for record keeping, safety analysis, and maintenance data analysis. It allows senior managers to visually keep tabs on the effectiveness of inspection and maintenance activities. ENSCO can immediately customize existing asset hierarchy/componentization templates specific to rail infrastructure assets to your needs.

Asset Mapping and Register Construction Services

- Operational planning and confirming the total length of track to be surveyed matches predefined sections
- Assets and location identification
- Asset classification
- Quality assurance of all data before importing into your asset register system
- Importing assets into your asset register system (SAP, Maxmo, other enterprise asset management systems), Automated Maintenance Advisor software is available as a condition-based asset register system



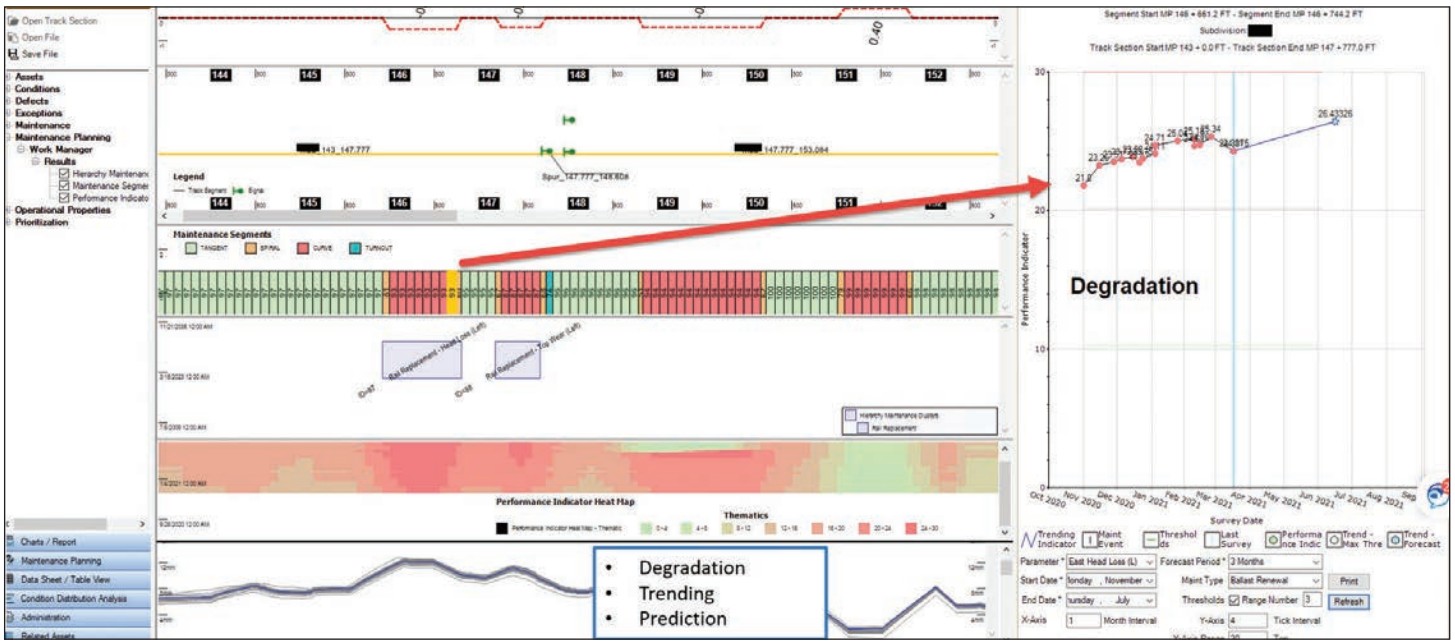
ENSCO is able to use LiDAR, machine vision, and GNSS to build your asset register.

Track Maintenance Planning

Combining track maintenance planning experts and cutting-edge software, ENSCO provides both services and software products for science-driven track maintenance plans and capital improvement plans.

ENSCO track maintenance planning tools aggregate data from multiple inspection tests to establish degradation rates and trends and to identify troublesome spots. These tools seamlessly generate maintenance orders and establish optimal maintenance routines.

Proposed maintenance tasks are data driven to identify the specific locations and timeframes that maintenance needs to occur to achieve maximum optimization at the lowest cost.



ENSCO Track Maintenance Planning experts are equipped with software tools and data scientists to achieve data-driven results.

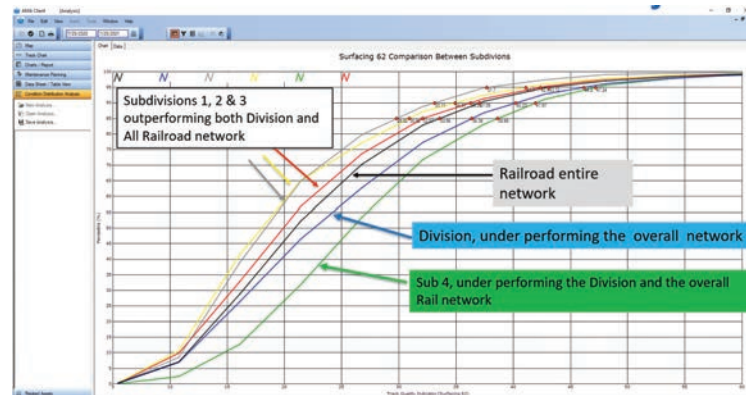
Case Study: Track Maintenance Planning

Project: Condition-Based Maintenance Planning and Advising

The Challenge: Optimize maintenance needs over large, extensive networks.

The ENSCO Approach: Use autonomous and manned track inspection systems to repeatedly collect various measures including track geometry. Process the data using ENSCO's AMA software to identify performance by Entire Network, Division, and Subdivision to identify subdivisions of for further focus.

Result: More objective, data-driven maintenance decisions.



Track Maintenance Planning Capabilities

- Designing track quality indices and health scores
- Using asset condition data and trending to identify needed track maintenance
- Proposing track maintenance such as tamping, ballast renewal, rail grinding, rail replacement, etc.

HAZMAT and Energetic Material Management

Through a partnership with Ambipar Response/Ambipar USA, ENSCO provides Training and Energetic management support to the Department of Transportation at the TTC.

Ambipar Response is the world's largest commercial response organization, with more than 70 years of experience managing environmental incidents and responding to major hazard events such as oil spills and chemical incidents worldwide.



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

Knowledge Transfer and Work Force Development

ENSCO does more than just give answers, we enhance customer understanding. ENSCO provides its customers with knowledge transfer and work force development in derailment investigation, understanding track geometry, and vehicle/track interaction.

Additionally, ENSCO has formed a consortium of eight U.S. universities that are leaders in all modes of surface transportation. The Center for Surface Transportation Testing and Academic Research (C-STARR) offers leading expertise in rail, busses, automobiles, trucks, automation, connectivity and cybersecurity. The consortium develops engineers and technicians to support industry needs in safety, reliability, efficiency, urban planning, resiliency, and security.



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

About ENSCO Rail

ENSCO Rail is recognized globally as a leading provider of railway infrastructure inspection technology. Our products and services are provided to governments and railways in more than 12 countries on five continents. The work ENSCO does helps to prevent train derailments which can have serious impacts on human life, the environment and the economy. ENSCO Rail is part of the greater Surface Transportation Group (STG) within ENSCO, Inc.



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