Modern Freight Railroads Run on Technology

Technology is the digital infrastructure that powers America’s freight rail network, creating a world-class transportation system that moves the economy forward. Freight railroads use technology to keep employees, communities, infrastructure and equipment safe while improving customer service and decreasing the industry’s carbon footprint. Realizing the full benefit of technology requires modernized regulations that recognize the value a technologically advanced rail industry brings to the nation.

**Automated Track Inspection (ATI) Technologies:** ATI enables railroads to measure how the track structure performs under the load of a train. ATI systems use lasers and cameras mounted onto locomotives or rail cars and inspect track as the train travels across the network. The system tests each foot of track under the same force as exerted by a loaded train. The data from the inspection devices transmits to a centralized location where employees verify and schedule maintenance as necessary. Along with improving safety, ATI minimizes supply chain impacts exacerbated by closed tracks, slow orders and the rare occurrence of derailments, and the subsequent time-consuming and resource-intensive accident clean-up and repair efforts that flow from such.

**Track Inspection Vehicles:** Track inspection vehicles (also known as track geometry cars) use lasers and ultrasound as they travel along the tracks to measure every inch for track alignment, elevation in curves, gauge (how thin or thick the track is) and many other measurements. Using these vehicles, rail inspectors can see inside a stretch of rail and examine it for microscopic internal defects that could lead to accidents. These tools enable rail employees to analyze the track alignment of 1,500 curves in just a few hours. It would take a team of four people ten months to manually complete the same task. Advanced algorithms provide rail maintenance planners with the data they need to schedule maintenance proactively.

**Wayside Detectors:** Preventing train wheels and bearings (the component that keeps wheels turning smoothly) from overheating as they travel across the nation’s vast network helps prevent train derailments. Smart sensors alongside the tracks use various technologies — such as infrared and lasers — to assess the strength and health of wheels and bearings as they travel by at speed. “Hotbox” detectors monitor the temperature of the wheel and bearing while acoustic bearing detectors evaluate the sound bearings make. By combining the acoustic data with the data from hotbox detectors, railroads use machine learning and artificial intelligence (AI) to sift through massive amounts of data, find patterns, and predict three months in advance when a bearing may overheat.

**Machine Visioning:** With hundreds of thousands of rail cars operating nationwide each day, railroads closely monitor and plan for equipment maintenance. New machine visioning technology uses specialized cameras that collect 40,000 images per second to inspect trains as they pass by at up to 60 MPH, reducing inspection times to mere seconds. A series of algorithms then analyze the images to identify any anomalies, allowing railroads to resolve issues faster than they could with manual inspections alone. The technology helps railroads look at many elements all at once, providing a comprehensive view of locomotives, trains and their components.

**Machine Learning & AI to Improve Predictive Maintenance:** Machine learning and AI help railroads predict and prevent several maintenance issues — such as track wear and tear — based on patterns and trends found by analyzing huge amounts of data collected from various sensors across the network. These predictions provide a five-year look-ahead window allowing railroads to plan repairs and maintenance proactively.
More than 630 freight railroads daily provide safe and sustainable transportation for thousands of customers across North America’s rail network. Advanced software, mobile apps and other programs improve rail operations and customer communication, improving rail’s ability to move vast amounts of freight efficiently and cost-effectively.

**Dispatching Software**: Like air traffic control systems, dispatch-planning software helps optimize train movement across the network. The software analyzes system-wide train schedules, speed restrictions and crew schedules to help train dispatchers determine the best operating plan for their portion of the rail system. Today, this advanced software can reassess a train management plan every two minutes, allowing dispatchers to respond in near-real-time to changing conditions, such as train delays, weather events and unplanned maintenance work.

**Customer Application Program Interfaces (APIs)**: Railroads provide their customers with granularized data to support shipment tracking. This information helps rail customers better manage their operations and inventory. Many railroads have developed specialized tools — from API integrated directly into customer platforms to shipment tracking tools — that provide greater transparency for everything from the location of their products on the rail network to rail car availability and ordering.

**Mobile Apps in the Yard**: Railroads have deployed mobile apps to expedite truckers’ entire intermodal experience, minimizing the time spent in rail **yards**. Many yards also have biometric scanners that recognize truck drivers’ thumbprints, video portals that automatically read truck ID numbers and apps that provide receipts and digital paperwork as part of an Automated Gate Systems. These advancements help speed up a truck entry from two minutes to about 30 seconds, reducing idling and emissions while getting goods to customers faster.

As freight demand is expected to rise 30% by 2040, the nation’s railroads want to be and must be a part of the solution to **climate change**. Thanks to targeted investments, technology and evolving operations, railroads are the most fuel-efficient way to move freight over land, with one train three to four times more fuel-efficient than trucks, on average. Railroads are taking steps in every aspect of their operations to reduce emissions further, increase fuel efficiency and preserve the natural environment.

**Modern Tier 4 Locomotives & Fuel Management Systems**: Today’s locomotives have hundreds of sensors that generate thousands of performance readings per minute to maximize efficiency. Advanced **fuel management systems** assess track grade, train weight, wind speed and more, giving the locomotive engineer real-time power and speed recommendations that improve fuel efficiency up to 14%. Technologies like these help railroads move one ton of freight almost 500 miles on a single gallon of fuel.

**Lower & Zero Emission Locomotives**: Railroads are exploring up to 100% **renewable diesel and biodiesel** in existing locomotives, which could quickly and dramatically reduce carbon emissions by 20-25%. Future lower and zero-emission technologies include (1) Battery-electric Locomotives: Railroads and suppliers are testing and demonstrating battery-powered line-haul and switching locomotives to meet intensive rail operation demands. (2) Hydrogen Fuel Cell Locomotives: Railroads, suppliers, and academic institutions are researching zero-emission hydrogen fuel cell line-haul and switching locomotives, which could potentially replace diesel locomotives. (3) Hybrid Consist: Railroads are testing battery locomotive prototypes for main-line train consists, which recharge each time a train brakes and could reduce emissions by nearly 30%.

**Anti-idling Technologies & Zero-emission Cranes**: Anti-idling technologies like stop-start systems that shut down a locomotive when it is not in use and restart it when needed can reduce unnecessary idle time by 50%. **Zero-emission cranes**, which recharge their batteries each time they lower a load, transfer goods between ships, trucks and trains in busy intermodal ports and rail facilities and reduce ambient noise and pollution.
The rail industry is one of America’s safest workplaces, with lower employee injury rates than most other industries. Advanced training centers with simulators and virtual reality enable employees to practice real-life skills in a safe, rigorous and controlled environment, while innovations like remote control locomotives and high-definition cameras allow employees to perform their jobs effectively from a distance where possible, keeping them out of harm’s way.

**Positive Train Control (PTC):** Life-saving technology called Positive Train Control is fully deployed on lines that carry passengers and high volumes of hazardous materials. PTC monitors train location, speed, track signals and many other inputs to prevent certain train-to-train collisions and derailments caused by human error. Beyond safety, PTC systems and their foundational components have the potential to drive further efficiencies and innovation across the nation’s rail network. With detailed geo-mapping, advanced communications systems and upgraded locomotive hardware, railroads have new tools in their ongoing efforts to increase capacity, optimize customer service and reduce fuel use and emissions.

**Training Simulators:** Many railroads use a combination of field training, on-the-job training and distance learning to create their professional workforce, with some railroads owning dedicated technical training centers. Simulators range from locomotive and power-operated switches to grade crossing simulators. For example, engineers can virtually learn train handling procedures on different track parts. They can also experience how the PTC system initiates by constantly assessing many variables to guarantee the train has the necessary time and space to come to a stop safely where necessary to do so along the route.

**Remote Control Locomotives (RCL):** RCL allows employees in rail yards to control and operate locomotives with hand-held transmitters, which helps reduce incidents where an engineer operating a locomotive could inadvertently injure another worker in the yard due to miscommunication. Federal Railroad Administration (FRA) data shows that employee injury rates are approximately 20% lower for RCL operations than for conventional switching operations.

**Drones & Sonar:** Railroad inspectors and maintenance employees regularly use drones to inspect bridges and monitor infrastructure, especially during severe weather events, ensuring they are kept out of harm’s way. Railroads use sonar to assess bridges when significant water flow occurs following big storms or flooding. This is especially useful when the water is extremely murky, making it difficult for a human diver to evaluate — or even see — the piers. Sonar sends sound waves that bounce off the bridge piers and the ground surface below the water. Then, based on the nature of the echo, railroads determine whether there are any concerns with the stability of the bridge piers.

The freight rail industry extends its commitment to safety beyond its yards and tracks and into the communities through which railroads operate. Railways use technology in multiple ways to keep community members safe, from driver and pedestrian safety initiatives to first responder preparedness.

**The AskRail App:** Technology has made sharing information and resources with community leaders in a rare rail incident easier. The AskRail mobile app — a collaborative effort among the emergency response community and America’s freight railroads — provides tens of thousands of the nation’s first responders with immediate access to accurate, timely data about what type of hazardous materials a rail car is carrying so they can make an informed decision about how to respond in the event of a rail emergency.

**Online First Responder Training:** For decades, railroads have worked closely with the nation’s first responder community to educate and train it on rail accident response. When business travel was put on hold due to the COVID-19 pandemic, the Security and Emergency Response Training Center (SERTC) — operated by MxV Rail (formerly TTCI) — launched an online training program to ensure the nation’s first responders have uninterrupted access to critical hazmat response training.
Grade Crossing Apps & Smart Crossings: To help keep the public safe near tracks, railroads have worked with federal regulators and private technology companies to develop technological solutions to improve safety around railroad tracks and rights of way. For example, railroads have partnered with Waze to develop a safety feature that alerts app users to upcoming grade crossings and developed smart crossings that know how fast a train is approaching.

Virtual Reality for Pedestrians & Drivers: Railroads and their safety partners are becoming increasingly creative in ensuring their safety messages are seen and heard. Operation Lifesaver, Inc. (OLI) in Canada — a non-profit organization and internationally recognized leader in rail safety education — provides free virtual reality training to first responders. OLI also developed an immersive “Look. Listen. Live” campaign, which viscerally shows the dangers of unsafe rail behavior. Thanks to efforts like these, collisions and incidents involving pedestrians, vehicles and trains have declined in recent years.

Intelligence & Security Information Sharing: Railroads disseminate, receive and analyze intelligence daily with public and internal law enforcement, Transportation Security Administration, Department of Homeland Security, Federal Bureau of Investigation, and Transport Canada to inform effective security practices, measures and procedures. Railroads also learn from non-rail incidents worldwide to better understand how illicit activities are planned and executed to adjust plans and measures. A dedicated industry alert network circulates timely security information to the nation’s freight and passenger railroads almost daily.

Preparedness & Training: Railroad employees receive security training augmented by shared intelligence and related security information. Freight railroads and their security partners participate in an annual industry-wide exercise that simulates physical and cyber threats to evaluate preparedness and enhance procedures. Railroads have participated in hundreds of security preparedness exercises with local police, emergency responders, and U.S. and Canadian government departments and agencies. Individual railroads also maintain security training programs and initiatives.

Railinc is the leading provider of information technology, related network operations and financial services, and near real-time network data to North America’s railroads. Beginning as an information technology department within the AAR, Railinc has evolved to meet the dynamic information needs of the railroad industry. Today, Railinc’s product lines help railroads, rail equipment owners, third party logistic providers and others increase productivity, achieve operational efficiencies and keep their assets moving safely. A highlight of Railinc is the Asset Health Strategic Initiative (AHSI). Launched by the Class Is and rail-car owners, the AHSI is a multi-year, multi-phase effort that the AAR Safety and Operations Management Committee oversees. The goal is to provide a view of the health of rolling stock available to all stakeholders, particularly the railroads on which the cars and locomotives operate.

MxV Rail — formerly Transportation Technology Center, Inc. — is the railroad industry’s world-class rail research and testing facility that works to improve the safety and efficiency of freight railroads throughout North America and the world. MxV Rail’s team of researchers, engineers and other experts develop and test the emerging technologies that keep railroads on the cutting edge. MxV Rail’s Strategic Research Initiative (SRI) maintains a comprehensive portfolio of 24 initiatives within infrastructure, mechanical, and operations systems.