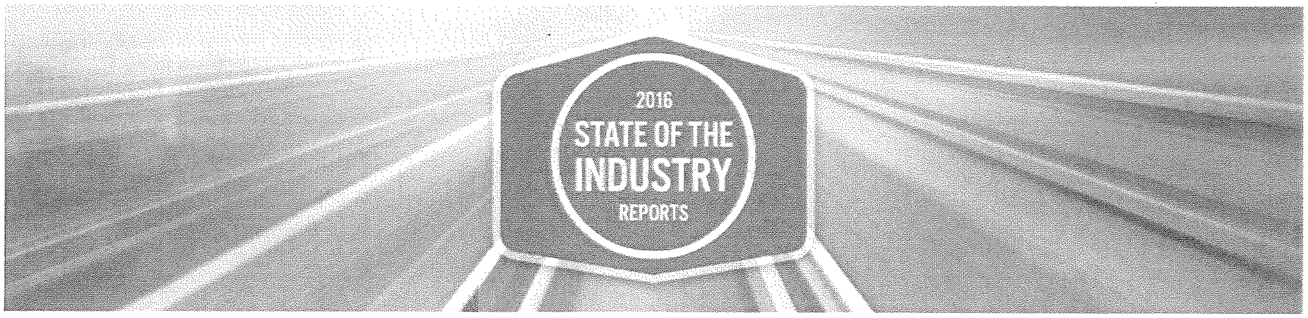


REPORT 1

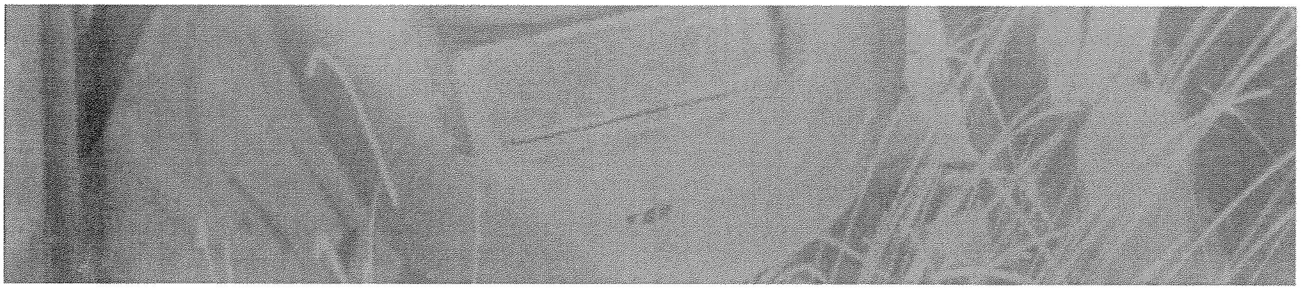
Safety and Innovation

AAR.org/Report

ASSOCIATION OF
AMERICAN RAILROADS

CONTENTS

CHAPTER 1: Investment Paves the Path to Innovation



The train accident rate has fallen by 79 percent since 1980, a stunning figure that has been driven by a powerful force: innovation. Thanks to three decades of balanced regulation, freight railroads have been able to spend $600 billion on the freight rail network — enabling the industry to advance rail safety through new technologies, a commitment to research and testing and employee training programs. In 2016, freight rail will continue to invest in innovative technologies and practices, and in the process, reaffirm the industry's unwavering commitment to safety.

Innovation Investments Underpin Remarkable Story Behind Railroad Safety

By Edward R. Hamberger

"To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science," Albert Einstein said.

Einstein was speaking about innovation as an essential catalyst in the scientific disciplines. But the same holds for freight railroad safety: innovation is the fundamental pillar on which freight railroads have engineered one of the safest industries in America.

The sweeping reduction in freight rail accidents and injuries over the last several decades is the result of a dedicated team of safety experts who conduct rigorous research, examine problems in new ways and apply technological advances and novel changes to processes that ultimately make a safe system of transportation even safer.

The statistics underscore how innovation has transformed freight rail safety. According to government data, the train accident rate has fallen 43 percent since 2000 and 79 percent since 1980, and the rail employee injury rate has fallen 46 percent since 2000 and 83 percent since 1980.

These dramatic advances in safety are rooted in an era of inspired federal leadership, when Congress and the Carter Administration worked together to strip away excessive economic regulations. The balanced regulations that resulted allowed railroads to make huge annual private investments in new rail infrastructure, safety research and innovations that continue to benefit millions of Americans. All told, the industry has spent on average some $25 billion annually over the last five years and a total of $600 billion since 1980.

Indeed, federal data show the direct correlation between the increase in rail network investments and enhanced safety. As investments in new advances in infrastructure have accrued, accidents and injuries have plummeted.

In 2016 the freight rail industry continues its highest-priority commitment to safety. One of the key efforts this year is a focus on improving the performance of the rails themselves. Track and infrastructure failure is a leading cause of train derailments in the United States.

As part of this initiative, the industry is testing a sophisticated system that uses multidimensional ultrasonic technology to locate defects in track before they can cause track failure and a derailment. The industry also is investigating use of unmanned aerial vehicles, or drones, for inspection of track, bridge and other freight rail infrastructure. Industry scientists continually research track composition to assess how metallurgical advances might improve track performance.

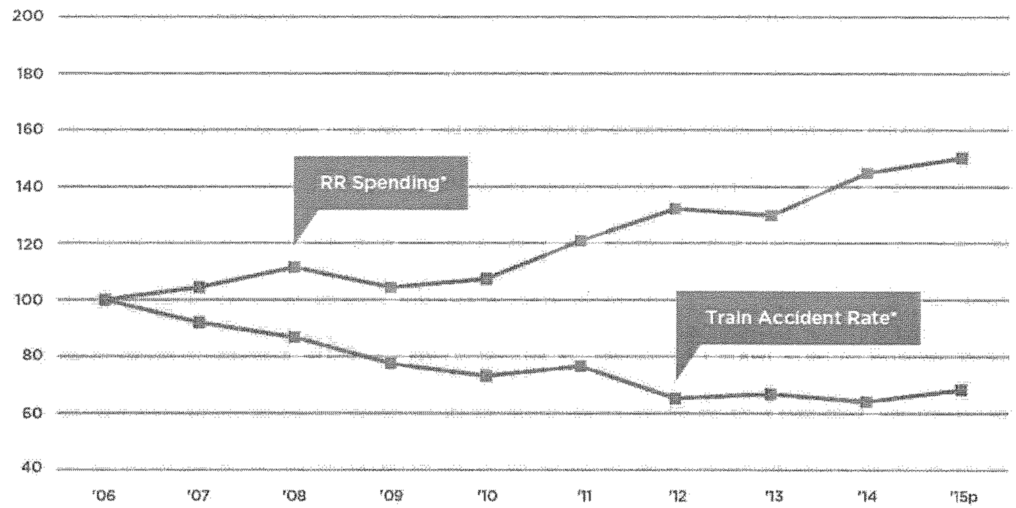
To ensure the safe performance of rail cars that carry the nation's goods and commodities, the industry has deployed a range of detection systems across its 140,000-mile national network. These detection systems examine rail car wheels, brakes, axles and more to proactively identify components for repair before an accident can occur.

In this special report, you will learn about some of these innovations. Outside experts convey the commitment of the industry to safety as its top mission, first responders describe training with railroad emergency personnel, and IT managers discuss how the analysis of Big Data is transforming freight rail operations.

What you will discover is that safety is paramount and that freight rail innovation, like a freight train, is always on the move.

RAIL INVESTMENT LEADS TO FEWER TRAIN ACCIDENTS

Train accidents per million train-miles down 79 percent since 1980 and 43 percent since 2000



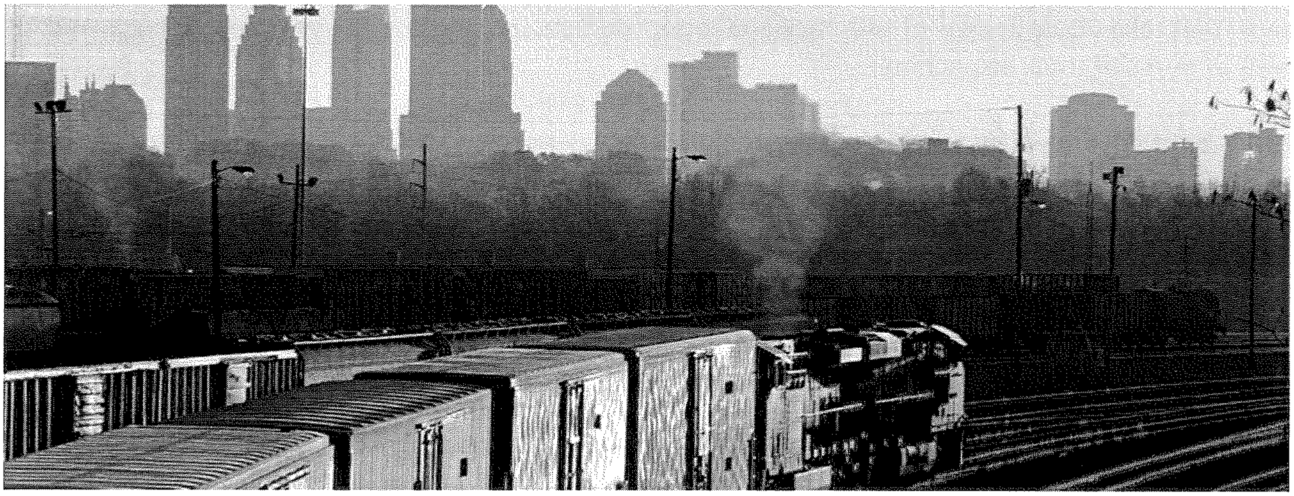
With more than $25 billion spent annually in recent years on upgrades to and maintenance of the privately-owned freight rail network and equipment, the train accident rate on America's freight railroads is at an all-time low. In fact, from 1980 through 2015, railroads have spent approximately $600 billion on infrastructure and equipment while the train accident rate has fallen 79 percent.

Notes: *Class I railroad capital spending and maintenance expenses for infrastructure and equipment
** Total train accidents per million train-miles
2006=100

Source: Association of American Railroads, U.S. Federal Railroad Administration

ASSOCIATION OF AMERICAN RAILROADS

Freight Rail Industry, Government Partner on Boosting Safety



The freight rail industry and the Federal Railroad Administration, or FRA, are partners when it comes to ensuring a safe rail network. The successful partnership is underscored by the industry's safety record. Freight railroads experience half the number of accidents compared with a decade ago, and the train accident rate has plummeted by 79 percent compared to 1980, when the industry was partially deregulated.

John Tunna, director of the FRA's Office of Research & Development, discusses what accounts for the improvements in safety, how the industry and FRA work together on safety, and the additional safety technology on the horizon.

Q: There have been significant railroad safety improvements since the 1970s. What, in your view, has accounted for this change?

A: It is a combination of what's been done at the regulatory level and what's been done by the industry. At the regulatory level, one very important area has been in writing and regulating track safety standards. We now have for the different classes of track very clear standards that represent minimum safety limits that the railroads have to maintain the track to.

That is an example of an activity led by the FRA, but what the industry has been doing in the meantime is investing in rail renewal. The rail that they put in today is much better quality than it was in the '70s, so it is less likely to fail from internal defects.

While we're talking about the track, another thing that was improved in that time frame is track inspection technology. We now have rail cars that will measure track geometry and report sections of track that don't comply with the safety standards and allow the railroads to take some action. We also have new systems for inspecting inside the rail to look for internal defects. Then there are other systems that take visual images of the track and report defects. Technology has come along leaps and bounds in terms of track inspection.

Q: How about advancements made in inspecting freight rail equipment for potential safety problems?

A: On the equipment side, the industry has deployed wayside detectors to look for defects. As the train goes past, detectors look at various performance properties and report where there are problems.

The number and variety of those detectors has increased. Also, the industry is better at analyzing the data that comes from those detectors.

That's what has contributed to, for example, preventing burned-off wheel bearings. There is a network of hot bearing detectors, and data from those is processed to look for trends and bad actors. There is another type of system that listens to the sounds the bearing makes when it goes past, and those two together are largely responsible for dealing with the problem of burned-off bearings.

Together with the industry, we have also made improvements to rolling stock when it's involved in a derailment. For example, over this time period we have done a lot of research and testing of tank cars and used that to determine structural improvements.

Q: The rail industry stresses that its investments are a big contributor to safety.

A: Oh, yes, absolutely. One of the reasons why track-caused derailments are fewer than they were decades ago is because the railroads have been installing new rail.

Q: The FRA's long-range research and development plan talks about requiring research into the most significant remaining safety risks. Can you explain how research is helping to solve these particular issues?

A: The FRA's research and development program is aimed almost entirely at improving safety. We look at the history of accidents to see where the risks are highest and that's where we focus our attention. When we do that today, we find that broken rails are the main cause of track-caused derailments. So we do a lot of research on improving the detection of rail defects before they become breaks and before they cause derailment. Our contractors that do this kind of research work to develop systems that eventually, once prototyped and commercialized, go into service.

Q: One example is the system that uses phased array ultrasonic technology to spot small defects in rail?

A: Yes. That's one of them. [Another] interesting area that we're working with the railroads on is using unmanned aerial vehicles, or drones, for track inspection. That's a new thing, and it is pretty exciting in terms of what could be done, but we have quite a few practical issues that need to be resolved first.

Also regarding track, we are continuing to revise the track safety standards. I mention those as a main contributor to improving safety in the past. We continue to look at those safety standards to see where they can be improved. We just completed an exercise that took about five years to revise them for the highest-speed track classes, and now we're getting started on the low-speed track classes.

Q: What are other examples of FRA and industry collaborating on safety?

A: It's reflected very strongly when it comes to research and development. Of the FRA's annual research budget of typically $39 million, a third of that goes towards research conducted by TTCI [an industry-owned transportation research and testing organization] at the federal Transportation Technology Center. That, more or less, matches the funding that the AAR provides for joint research through its strategic research initiative program. TTCI conducts FRA's research there, it conducts AAR's research there, and quite a number of projects are jointly funded by the both FRA and AAR.

It's a very good example of the public-private partnership. One of the facilities at TTCI is the Positive Train Control test bed. This is a fully functional Positive Train Control system, it has both the freight implementation of PTC and Amtrak's implementation. It has all the wayside units, the onboard units, radios and back office server. It means that people developing the system can come and test their component there and iron out the bugs before going out into railway service. Again, that's a tremendous example of how we are working to help the railroads implement this technology.

Q: What are other areas in which the FRA is helping improve freight rail safety?

A: We often provide railroads the ability to test new technology. A good example of that is we have a regulation right now that says if the railroad detects an internal defect in the rail, they have to stop inspection and get out and verify that the defect is there with a manual process. Then depending on the severity of the defect, they take corrective actions.

We've recently allowed some railroads not to stop immediately, but to continue inspecting and build up a list of defects and then have somebody go back and check. What that means is the systems that do these inspections can be used much more effectively because they are not continuing to stop. Because the track ends up getting inspected more often, we believe that the safety risk is reduced.

FRA also has its own inspection cars. So in addition to the railroads running around checking things, we have our fleet of cars that go around checking things. We share all the data that we record and the railroads add that to the data that they've got to get a more complete picture of the condition of the network.

Another focus for the FRA is safety culture initiatives. A good example of this is the confidential close-call reporting system that we piloted. If anybody in the railroad workforce witnesses a close call or near miss, in a confidential manner they can report it to a neutral third party that gathers all the information. When they see signs of a common cause emerging, then they raise a flag and call together a team to see what could be done about it. That reflects a big shift in approach away from prescriptive regulations towards a more collaborative way of addressing risk.

Q: What are the FRA's research focuses for 2016?

A: Going forward, we continue to spread the available funds as far as we can over the main areas of trespass prevention, grade-crossing safety, derailment prevention and collision mitigation.

If I had to pick out individual projects, it would be broken-rail detection — I think there's a great opportunity for us to collaborate with the industry on that. And I don't just mean the railroads, I also mean the parts of the industry that provide that service to railroads.

Another one to pick out would be track geometry measurements. We're moving in the future to autonomous track geometry measurement systems, away from manned, dedicated test cars that have to be scheduled to operate in revenue service. The new devices are put onto regular rail cars and run around, reporting back track geometry measurements.

FRA R&D PROGRAM AREAS AND ACCIDENT AND INCIDENT CAUSES

Relation of division and program areas to the most frequent causes of accidents and incidents

R&D Division and Program Area	Accident or Incident Cause: Trespass	Grade Crossing	Derailment	Train Collision	All Other Causes
OFFICE OF R&D					
Railroad Systems Issues					X
HUMAN FACTORS DIVISION					
Human Factors Research	X	X	X	X	X
TRACK DIVISION					
Track and Structures			X		X
Track and Train Interaction			X		
Facilities and Equipment	X	X	X	X	X
ROLLING STOCK DIVISION					
Rolling Stock and Components			X	X	
Hazardous Materials			X		X
Train Occupant Protection		X	X	X	X
TRAIN CONTROL AND COMMUNICATIONS DIVISION					
Train Control and Communications			X	X	X
Grade Crossings and Trespass	X	X			

One of the critical success factors of previous FRA R&D achievements is the organization of the office into four divisions and ten program areas. The table above shows how divisions and program areas of the FRA relate to the most frequent causes of accidents and incidents. Projects will continue to be executed by program managers reporting to Division Chiefs. This structure allows professional development of engineers and scientists in their particular disciplines. The new focus on key safety hazards will encourage staff in different divisions working on common risks to collaborate and adopt systems-based approaches to achieving goals.

Source: U.S. Federal Railroad Administration

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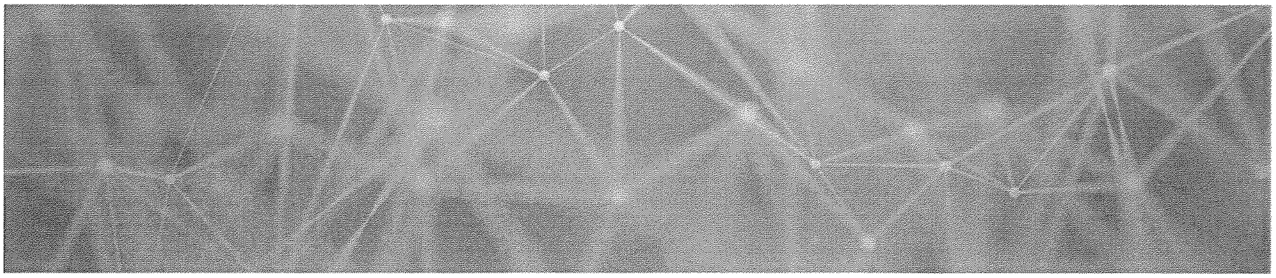
CHAPTER 2: Big Data's Big Imprint on Rail Safety



America's freight railroads collect enormous amounts of data about equipment performance, rail car usage, repairs and fleet health. Together with industry partners, railroads are finding innovative new ways to use that Big Data to ensure safety. Collecting and analyzing data throughout the entirety of the nation's rail network allows railroads to track the health of rail equipment and find patterns that can predict when repairs are needed. By predicting problems before they happen, the industry can better manage its equipment and infrastructure and create new standards meant to make America's safe rail network even safer.

How Railinc and Big Data Ensure Efficiency across the Rail Network

As trains travel the U.S. rail network, they pass intelligent sensors that monitor the movement and health of rail cars. Railinc analyzes this information to provide near real-time results that improve safety, help companies manage inventory and plan production schedules, and assist railroads in planning for maintenance and upgrades.

In the age of Big Data, railroads have harnessed the power of information to build the safest, most efficient and cost-effective rail network in the world.

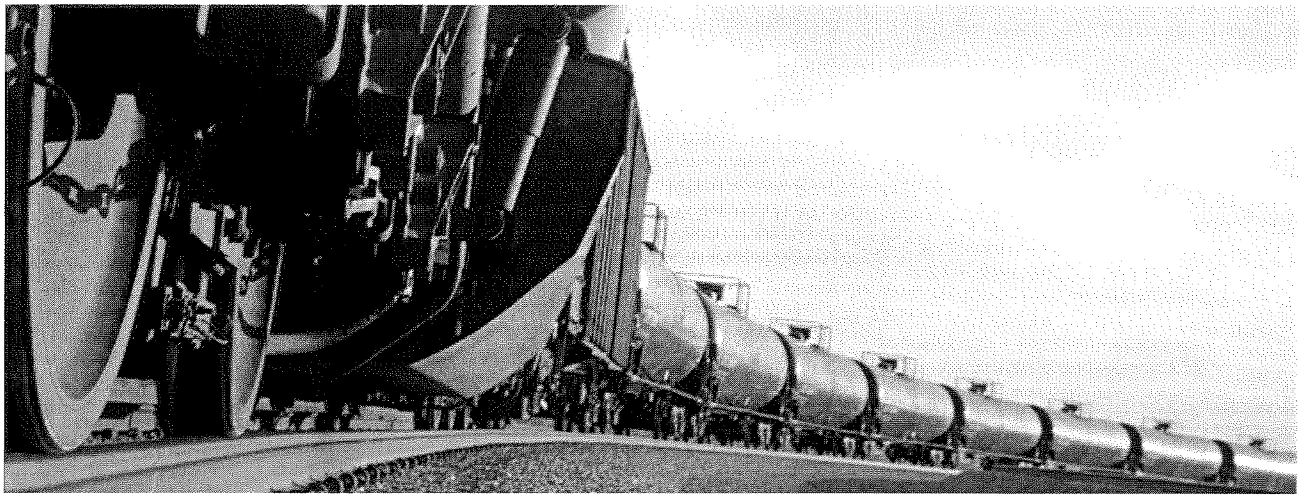
At the center of this information revolution is Railinc, an IT and information services company in Cary, North Carolina. Founded nearly 40 years ago, Railinc has built a groundbreaking computerized inventory system that logs the size, dimensions and carrying capacity of the industry's shared fleet of rail cars. Armed with this information, railroads can decide whether a rail car can be loaded with certain commodities. They can also map out the best routes certain car types should take to safely transport those commodities.

Today, Railinc collects more railroad data than ever before. As trains travel America's 140,000-mile, approximately 570-railroad network, they pass intelligent sensors that track the movement and health of rail cars along the way. Railinc analyzes this information to provide railroads and their customers with essential analysis to improve safety and efficiencies.

Through programs like the rail industry's Asset Health Strategic Initiative and other Railinc data systems, railroads can identify a repair before it is needed, time the delivery of cargo down to the hour, and safely and efficiently coordinate the movement of millions of rail cars.

America's rail network will only become smarter in the years to come as Railinc helps railroads implement advanced technology — such as installing sensors beside track and directly onto locomotives and rail cars — to identify improvements in freight loading. Big Data will continue to help railroads make intelligent decisions about the rail network and maintain a system of cargo delivery second to none.

Intelligent Databases Help Build a Safer Rail Network



Freight railroads are harnessing the power of data — lots of it — to improve the health of the nation's rail network. Working with North Carolina-based Railinc, railroads are collaborating in an unprecedented way to identify equipment-related problems before they occur, improve the efficiency of repairs and enhance safety across the nation's rail network.

A freight train pulls to a stop on a stretch of track in the American Midwest. Just as the sun is setting on another safe day on the rails, a potential problem with the train is detected. The conductor does an inspection to make sure there is no immediate danger. After a short delay to ensure the train's safety, the locomotive and the cargo it is hauling are back in motion. Even though the service interruption was brief, it is logged in a database, because this one small data point has the potential to improve freight rail operations in a big way.

In today's Information Age, ensuring the safe operation of rail equipment is no longer just about, well, equipment. America's high-tech freight rail industry is going one step further by sharing data among railroads to help predict rail equipment issues before they arise.

In recent years, railroads have made huge safety strides, including a significant reduction in train derailments, through investments in high-tech tools and processes. Always looking for ways to improve on safety, the CEOs of the largest Class I freight railroads in 2011 asked Railinc, a subsidiary of the Association of American Railroads that provides information technology services to freight railroads, to help the industry take another step forward.

Less than a year later, in collaboration with industry leaders from the railroads' mechanical and information departments, the freight rail industry launched the Asset Health Strategic Initiative (AHSI).

A multi-year program, AHSI compiles and analyzes massive amounts of data being collected and stored by individual railroads and uses it to address the industry's most critical rail equipment challenges.

AHSI brings together and builds upon previous industry-wide and local railroad initiatives that monitor the health of rail cars, including the Component Tracking and Equipment Health Management System (EHMS) programs. The Component Tracking program allows six types of rail car components to be easily tracked and monitored across the nation's 140,000-mile network. To do this, the manufacturers of the components label them with unique tracking codes. When new rail cars are built, these individual components are assigned to the cars through the program. As these rail cars move across the network, EHMS compiles other information such as service records and data from trackside monitors to provide an "electronic health record" of rail cars. These systems allow a rail car with a faulty component — such as an out of round wheel — to be identified faster than ever before.

"Component tracking allows us to know who manufactured a wheel and when," says Steve Josey, Railinc director of new products and services. "As a result, industry experts can determine if other wheels manufactured at the same time are also problematic. If so, these wheels can be located more quickly and removed from service."

Prior to EHMS and AHSI, railroads relied largely on data gathered from wayside detectors — trackside technology that monitors the rail cars of passing trains to identify when select components on those cars are beginning to show signs of wear and tear — located only in their service territory. Unfortunately, while rail cars (which are owned by various entities) regularly traveled across multiple railroads, their performance data did not. A railroad only knew how a rail car performed on its own tracks — a partial picture that slowed down diagnoses of potential systemic industry problems and necessary repairs.

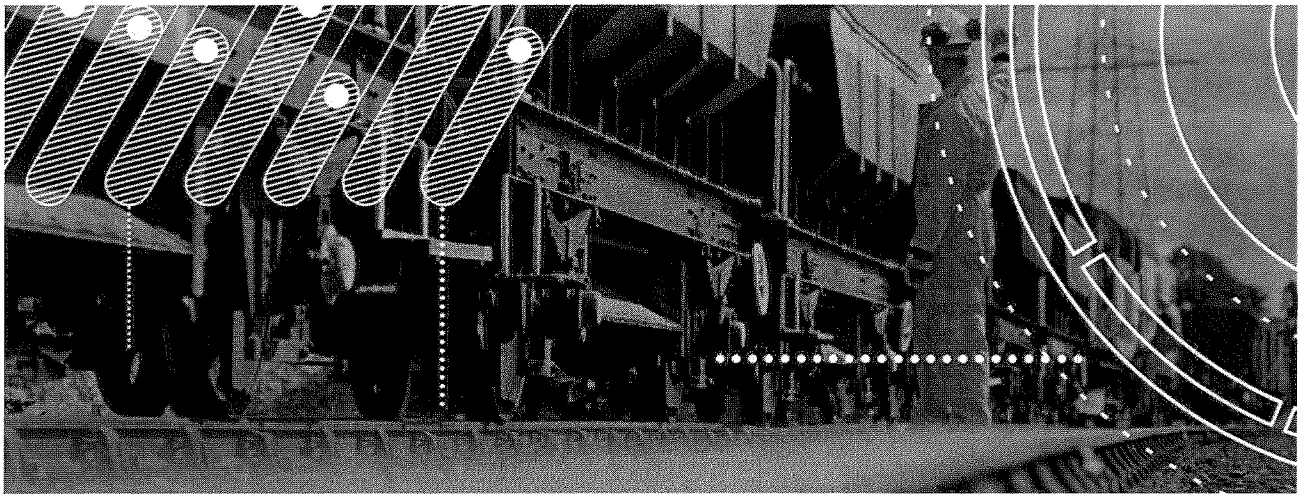
Today, AHSI is aggregating these disparate railroad databases in a way that allows railroads and rail car owners across the country to share information and make better decisions about the maintenance, care and operation of their rail cars and improve railroad safety.

While AHSI is still in its early stages, efforts to identify poorly performing rail cars using this data are estimated to have prevented more than 1,000 service interruptions in 2015. Given the great potential of AHSI, the rail industry is gearing up to expand the program to monitor additional rail car components as well as components on locomotives. Railroads recently incorporated data into AHSI from line-of-road failures — emergency braking of a train due to an unknown factor — and wheel temperature detectors.

Eventually, AHSI will be able to identify problems before they occur. By analyzing new datasets and identifying patterns among rail car usage, equipment problems and repairs, railroads and car owners might be able to predict situations that will lead to excessive wear and tear, and recommend specific repairs or steps to prevent damage.

"This initiative will only continue to grow," Josey says. "As we gather more and more data, we enable the industry to solve problems in ways that were not possible before."

Sounding the Alarm: Big Data Finds Problems Before They Happen



Helping predict equipment failure is one way that Big Data creates innovations that improve safety. Scientists at the Transportation Technology Center, Inc., an industry research and testing facility, are analyzing volumes of data to support new safety rules.

To improve freight rail safety, Tony Sultana, principal investigator at the Transportation Technology Center, Inc., or TTCI, in Pueblo, Colorado, analyzes massive amounts of freight rail data to help prevent an accident before it can occur.

"There are approximately 12 million railroad wheels in motion around North America in any given day," he says. "About 400 of them break each year, and sometimes they can cause a problem. We want to find them before that happens. The question is, 'How?' "

Finding that 0.0033 percent, he says, takes Big Data and what are known as "composite rules."

A "composite rule" is the rail term for safety protocols that are developed by identifying a combination of factors that can determine if a piece of equipment is near risk of failure. One composite rule might address worn-out wheels, while another might govern faulty brakes, bearings or trucks, or even the safety of an entire fleet.

Composite rules are possible because today's rail data warehouses store hundreds of trillions of bytes of information about rail equipment – the equivalent of more than a hundred million digital photos. The rules are important because to make freight rail safer, railroads must predict the rare conditions under which equipment or track is most likely to fail. Big Data enables railroads to identify combinations of factors that lead to problems.

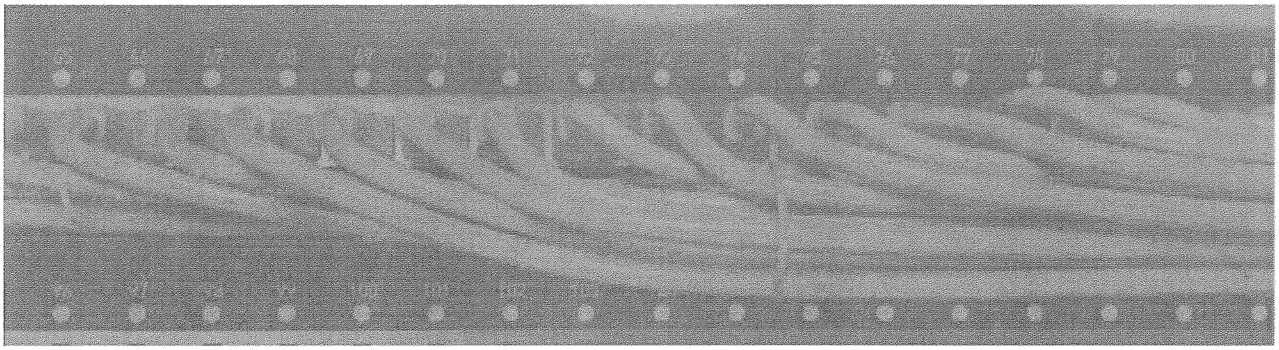
Individual factors by themselves might not be predictors of defects, but in combination they could be, Sultana explains. The industry's use of wayside detectors to analyze rolling stock has created the opportunity to collect and analyze data to find critical combinations of factors.

Individual railroads and the Association of American Railroads, or AAR, started targeting what are known as combination defects. These are the factors that may ultimately make up a composite rule. For example, the wheels of a train can break. Some minor wear and tear is allowable, but the trick is preventing a small problem from turning into a bigger one. That is where Big Data analysis comes into play. By looking for combination defects, inspection engineers are able to pinpoint the factors causing wear and tear problems.

After extensive study, AAR recently issued a composite rule that sets the industry-wide standards for when wheels must be removed before they break.

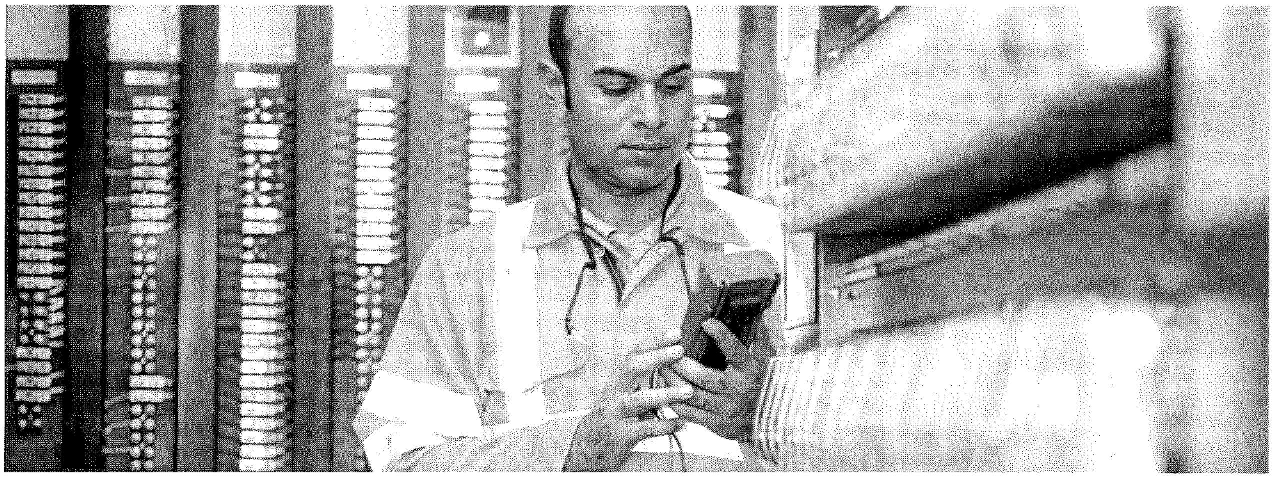
As railroads gather more data, the ability to proactively ensure safety by developing composite rules will only increase. Scientists will be able to identify other causal relationships to support the creation of new composite rules, which reduce equipment failure. This allows a very safe industry to operate even more safely and maximize efficiency by spotting and addressing issues before they become problems.

CHAPTER 3: PTC is Moving Forward Smartly and Responsibly



The freight rail industry is working diligently and methodically to move the incredibly complex Positive Train Control (PTC) safety system from concept to reality. This revolutionary technology analyzes a host of real-time conditions, including train speed and train composition, and automatically stops a train before certain types of accidents occur. In 2016, teams of railroad employees, manufacturers, software designers and safety experts will make significant progress to meet PTC development, installation and testing goals.

Ongoing Commitment for PTC Continues in 2016



The freight rail industry will take major steps in 2016 toward fully implementing Positive Train Control safety technology.

America's freight railroads are moving swiftly to put Positive Train Control, or PTC, in place across the country's vast rail network. This revolutionary safety technology overrides human error and automatically stops a train before certain types of accidents occur.

Last year, Congress took a sensible and much-needed step in the ongoing quest to make the world's safest rail network even safer by passing the Surface Transportation Extension Act of 2015.

Under the new law, Congress extended the deadline for the installation of PTC by three years to 2018, and allowed up to two additional years to finalize full implementation and testing of the new technology provided railroads meet specific benchmarks. Railroads are required to report regularly on their progress to the U.S. Department of Transportation.

When completed, PTC will operate across roughly 60,000 route-miles and be installed on 25,000 passenger and freight locomotives throughout the U.S., which is 90% of all U.S. locomotives. To achieve this mandate, teams of railroad employees, manufacturers, software designers and safety experts are devoted full time to PTC development, installation, testing and validation.

When fully up and running, PTC will complement existing safety technologies in important ways. It will help prevent train collisions, derailments caused by high speeds, unauthorized incursions by trains onto sections of track where maintenance is taking place and movement of a train through a track switch left in the wrong position.

These improvements are made possible by the freight railroads' enormous private investments in this new technology. Railroads already have spent more than $6 billion developing PTC. By the time the technology is fully implemented, railroads will have spent up to $10 billion on this unprecedented safety undertaking.

As of June 2015, the following is scheduled to happen by the end of 2016:

- 38% of 60,153 route miles will have PTC.
- 63% of 22,066 locomotives will be equipped with PTC.
- 51% of the 114,515 employees requiring training will be PTC-qualified.
- 87% of the more than 32,654 trackside signal systems will be PTC-ready.
- 77% of the 3,968 base station radios will be installed.

The additional time afforded by Congress is critical, because when it is up and running, PTC must operate flawlessly. If it does not, it has the potential to bring freight rail operations to a halt. At present, there is much work to do to iron out the kinks. Some railroads are experiencing failure rates of up to 40 percent as they install and test PTC equipment in labs and pilot territories. In 2016, the rail industry will be stepping up critical field-testing in an effort to ensure PTC works properly. In short, the importance of testing PTC, and the breadth of complicated components that comprise it, cannot be emphasized enough.

Each of these steps will move the railroad industry closer to implementing a technology that everyone wants to get right.

The Complexities and Challenges of Positive Train Control

Positive Train Control expert Jeff Young talks about the unprecedented size and scope of implementing PTC across the nation's rail network and why careful testing is essential for identifying flaws in this new technology and ensuring it is safely implemented.

Jeff Young is a railroad industry veteran and a leading expert on Positive Train Control, or PTC, technology. Young worked for Union Pacific Railroad for almost four decades and now serves as a consultant for the Association of American Railroads. Young spoke recently about the biggest challenges the freight rail industry has faced in implementing PTC and some of the lessons learned from the testing process.

Q: What is the biggest overall challenge for railroads in implementing PTC?

A: The main challenge has been creating a system that is completely interoperable. This means PTC must work for any train on any track even though different railroads may have different PTC systems. That has required making substantial upgrades to the four main segments of freight rail operations: the back office server, locomotives, wayside signals and communications components. The complexity and scope of this has revealed numerous issues in each of the areas that need to be identified and corrected through extensive testing.

Essentially, we're developing a new safety system from scratch that needs to seamlessly serve a massive transportation system. It's like creating an entirely new air traffic control system, and it needs to be meticulously choreographed to ensure that it's going to work safely. It's not going to work perfectly right out of the box, so careful testing of the entire system is essential for making it safe.

Q: What are some examples of issues in those four segments that have been discovered and corrected as railroads work through testing PTC?

A: Maybe the most significant problem that's been discovered from a safety perspective is what's called a "false clear," which relates to the locomotive segment of the network. A false clear is when a software defect permits an unsafe operation by allowing a locomotive to pass a stop signal. Basically, the wayside signal is telling the train to stop, but the train's onboard system is saying things are clear.

Field testing has also found instances in which trains have been forced to stop because the wayside signal equipment failed due to improper configuration or software defects. At the end of the day, these types of issues are why railroads need to spend so much time thoroughly testing PTC. There are more than 400,000 components in the entire PTC system, and missing a problem with just one of them can create an unsafe situation in the real world.

Q: What have been some of the most time-consuming elements of implementing PTC?

A: Ensuring all 400,000-plus PTC components are interoperable across various railroads has been a huge task, and it's where the "back office" comes into play.

Interoperability sits upon the foundation of a huge, shared database with information the different railroads need to update and access regularly. This includes information like the precise locations of thousands of railroad switches and wayside signals. This has been an enormous challenge, because rail operators need to keep this information updated even as switch and signal location changes are constantly changing. For example, one railroad could have as many as 60 location changes every week, which must be visually checked by engineers each time there is a change before they can be entered into the database. That takes a lot of time, and it's why railroads have over 2,400 engineers working on these signals.

Just to give you some context for how big of a task this is, a typical 100-mile district could have more than 2,000 track features. If you expand that out across the country, we're talking about collecting millions of pieces of data. The database basically replicates all of these data points, which is the equivalent of mapping all of the interstates and state highways across the country and validating the data in the field for every speed sign, milepost sign, traffic signal, exit ramp and other roadway features.

Q: Ultimately, the goal of PTC is to bring a train to a stop when the system identifies an unsafe situation. What goes into bringing trains to a safe stop like that?

A: This has been almost like developing a self-driving car, and it's been one of the more time-consuming elements of fine-tuning the system. Railroads have had to develop highly complex braking algorithms for both freight and passenger trains that account for numerous factors, and not just the obvious ones like velocity, track gradient or weight. We need to account for outside elements like weather, the brake systems installed on different rail cars and the fact that railroads rely on customers for cargo weight data. This algorithm is constantly being tweaked and adjusted to ensure it will safely stop trains when necessary.

Q: It seems that with so many different rail companies operating on a single, nationwide PTC system, there is the potential for communications to falter.

A: For PTC to work, railroads are creating their own, entirely new wireless communications network across the country to ensure PTC signals can be accessed regardless of the location of a locomotive.

To do this, railroads need to place PTC communication towers in the correct places to allow for optimal communication with moving locomotives. The process used to determine where to locate these towers is not always perfect, and railroads sometimes find "dark spots" in the system. In that case, new equipment must be installed. Again, this demonstrates the importance of thorough testing in creating the safest network possible.

Q: How are railroads keeping all of these communications secure?

A: Cyber security is an important factor in implementing any complex technology requiring potentially sensitive information, and it's something that every railroad is taking seriously. To make sure the system is secure, railroads are working on sophisticated encryption keys that will ensure that the communications between railroads, as well as sensitive data, are secure.

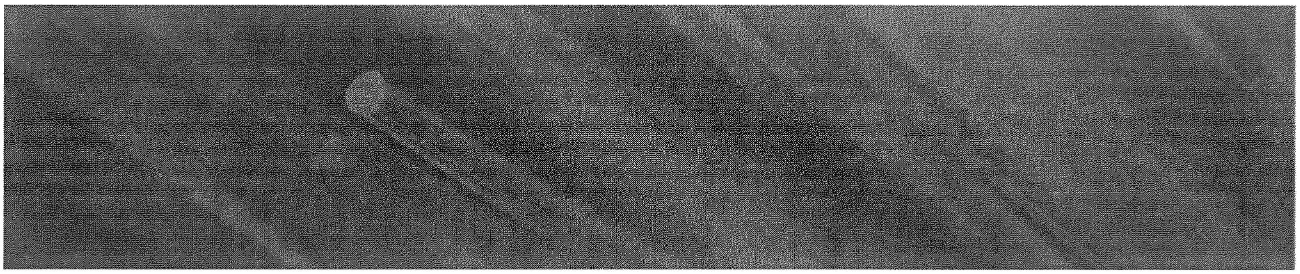
This is quite a meticulous process, because these encryption keys must be updated from time to time, and a situation may arise where they need to be updated at a moment's notice. That would require changing the keys on all locomotives, towers and wayside devices.

Q: What about from a software perspective? What are the main challenges there?

A: Because the PTC system is still in its infant stage, the software is updated every couple of months to address software defects. However, when these updates occur, railroads must then conduct "regression testing," which means they need to make sure the new software will not have any adverse affects on existing pieces of software or equipment. That takes about two weeks in the lab before it can go out for field testing.

Once the lab testing of the new software is finished, it's pushed out for field testing to the locomotives in the field testing areas. Once that process is complete, the software is then pushed to the remaining PTC-equipped locomotives. Needless to say, this takes a lot of time.

CHAPTER 4: Today's Technology is Shaping Tomorrow's Railroads



Just as it has for almost two centuries, technological innovation continues to define America's freight railroads. Today, the industry is pioneering exciting breakthroughs and applying new technologies to make the rail network even safer. Engineers at the Transportation Technology Center Inc. are developing the next generation of ultrasonic inspection technology so they can get a better look inside steel rails, spot invisible imperfections and proactively schedule maintenance before the imperfections pose any problems. Through a partnership with the Federal Aviation Administration, railroads are also assessing the use of drones to help monitor the condition of their network. Finally, advances in technologies such as robotics hold the promise of a new era of bridge safety. By continuing to innovate today, freight railroads are ensuring a safer tomorrow.

Aerial Drones Provide Rail Safety from the Sky

America's freight railroads are exploring the use of unmanned aerial vehicles for a variety of duties in an effort to further enhance safety on the ground.

When record flooding hit Texas and Oklahoma in 2015, the waters washed away homes, businesses and infrastructure – including freight railroad tracks. During this time, BNSF Railway looked to the skies to assist their teams on the ground.

The railroad flew unmanned aerial vehicles, or drones, mounted with high-definition video cameras over areas of the flood zone to inspect parts of the rail network that were difficult to access from the ground.

On the video feeds, the railroad's safety inspectors could see precisely where rail tracks had been washed out. They were also able to examine the condition of rail bridges, some of whose foundations had been slammed with debris. By pinpointing the location of the damage, BNSF was able to safely deploy employees as soon as the floodwaters receded and quickly return the rail line to safe operation.

For the last two years, BNSF has been exploring the use of drone technology, in close collaboration with the Federal Aviation Administration (FAA) with BNSF flying its first long-range drone flight last October.

Today, it is one of three major companies, alongside CNN and PrecisionHawk, participating in an innovative public-private partnership with the FAA designed to research the safe use of drones by various industries and in different geographic settings. BNSF's role in the initiative, called the "Pathfinder Program," involves researching the use of long-range drones, which have the ability to fly hundreds of miles from their operators.

For Gary Grissum, BNSF assistant vice president of telecommunications, the partnership is a natural fit. "The FAA has proven to be an exceptional partner," he says. "They appreciate the benefit of this technology and do want to advance the safe use of drones in the national airspace. And since the number one mission of railroads is safety, they see us as a good partner to help them do just that."

These drones will be able do their detective work despite dangerous conditions, keeping rail employees safe while improving railroads' ability to gather the information necessary to help detect problems, plan and prioritize corrective action, Grissum adds.

Drones could also help tremendously in remote environments like some of the freight rail lines in the north, Grissum says, where temperatures can drop well below zero during the dead of winter.

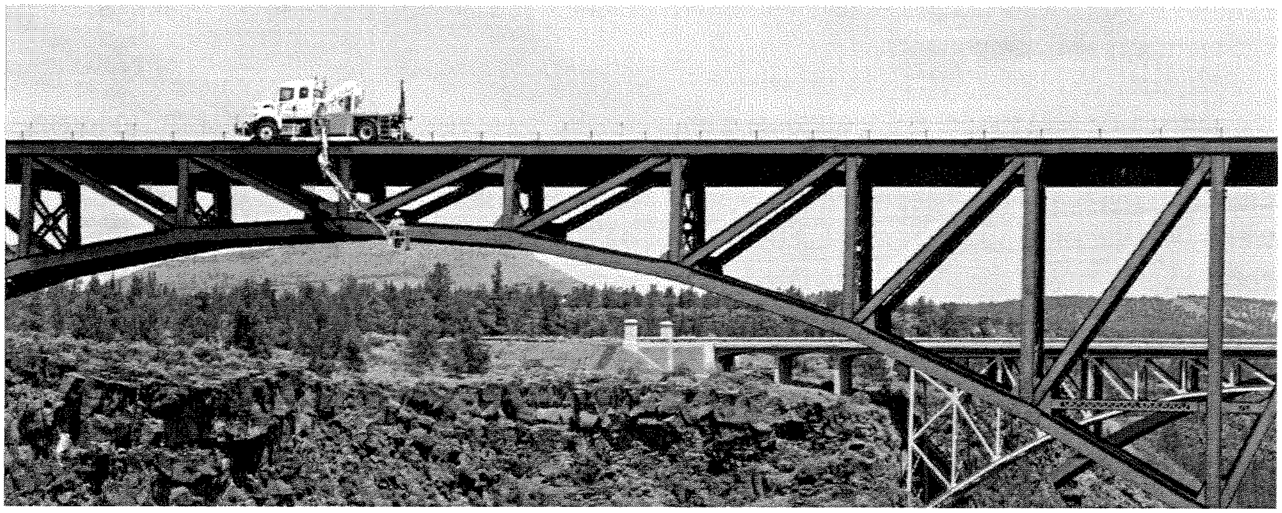
Steel rails contract when temperatures drop, so if a rail is going to crack due to temperature, it will probably occur when conditions are coldest which can often be in the middle of a winter night, in snowy and difficult conditions. Sending a team of inspectors out in these conditions can be difficult and can introduce an element of risk associated with the extreme weather conditions.

As drone and associated on-board detector technologies advance, an inspector could use data gathered by the drone to identify defects rather than needing to physically access the track. To add value to railway safety programs using drones, Grissum says, "We must be able to gather meaningful track and structure information, anytime day or night, and in poor weather conditions." Soon, a drone flying at 500 feet may be able to spot a quarter-inch separation in a rail line even at night and in poor weather conditions.

Several other Class 1 freight railroads are gearing up to incorporate drones, including Union Pacific, which last year secured FAA approval to use drones for aerial data collection. This year, UP anticipates using drones for capturing images and air quality testing. The company also is assessing drones for hard-to-do inspections – such as on telecommunications antennae several hundred feet tall and elevated bridges.

As regulatory and operational hurdles to flying drones are overcome, railroads across the United States are making plans to enhance safety programs with these modern eyes in the sky.

Way Ahead of the Curve on Bridge Safety



Since the earliest days of American railroads, the health of bridges has been connected to the health of the freight rail industry. This symbiotic relationship continues to strengthen bridges, the railroads and the economy.

"Don't judge a book by its cover."

This little piece of everyday wisdom guides the work of railroad bridge engineers at the Transportation Technology Center, Inc., or TTCI, the freight railroad industry's research and test center in Pueblo, Colorado.

"Right now we have three steel [bridge] spans at our test facility that are over 100 years old," says Dr. Duane Otter, principal engineer at TTCI. "They may be old but we're finding that many old bridges like these are safe and strong — well beyond the lifespan that was envisioned when they were first built."

Dr. Otter credits railroad bridge health and longevity to generations of railroad bridge engineers who took a conservative design approach to build bridges that could carry the immense weight of steam-powered locomotives. Some of these original iron horses placed tremendous stress on rail bridges in the early 20th century. Today's environmentally friendly modern locomotives place less stress on railroad bridges.

In the years since the early 1900's, the railroads have closely monitored locomotive and car weights. The industry's conservative approach to bridge construction — and maintenance and inspection — has been instrumental in allowing those bridges to remain in continued safe service.

Railroads have been leaders in bridge safety practices for decades. In fact, long before the federal government began its highway bridge inspection program, the railroads inspected railroad bridges routinely. These inspections require detailed annual checks of each bridge. Safety inspectors sometimes need to scale bridges — often hundreds of feet in the air — to examine the health of bridge members and components.

As the years have progressed, the traditional manual inspection process has improved with "snooper trucks" — specialty trucks fitted with a retractable arm and bucket for inspectors. The introduction of this method, still the primary approach today, sped up the process and improved inspection safety. However, it requires temporarily pausing train traffic on a portion of track in order to inspect the bridge.

Today, railroads are working to further improve the safety and efficiency of bridge inspection, aided by unmanned aerial vehicles, or drones, and other remotely controlled robotic devices. These technologies, currently being developed for freight railroad use, will allow railroads to conduct routine bridge inspections without suspending train traffic and slowing down the network. A bridge can be subject to more detailed inspection if determined necessary by the railroad bridge engineer.

Time-saving innovations like this improve the flow of rail traffic because many freight rail bridges are inspected more frequently than the Federal Railroad Administration's annual requirement.

"Railroads have well-tested guidelines for determining the frequency of inspections based on the weight of trains, volume of train traffic, the types of traffic going over bridges — such as passengers or hazardous materials," says Dr. Otter. "Railroads will often increase the frequency of inspections if a bridge shows initial signs of wear or tear that are significant from a safety standpoint."

Although some bridges may look outdated to the general public, appearances are deceptive. The simple design of most railroad bridges makes them simple and efficient to repair, and that contributes to a safe, extended life.

"Just because a bridge has rust does not mean that it's dangerous," says Dr. Stephen Dick, principal investigator at TTCI. "On the other hand, additional aesthetic design elements, such as decorative beams or arches, can inhibit access for inspection of a bridge. For the railroads, form follows function."

"Without bridges, our industry can't function and commerce would move a lot slower," Dr. Otter says. "The work that we're doing at TTCI has improved bridge safety standards across the industry. We take pride in ensuring that every link in our network remains safe and strong — now and for years to come."

When the Body is 140,000 Miles of Steel Rail

Using the latest customized ultrasound technology, railroads are detecting microscopic flaws in steel rail track before they cause accidents. Railroads are focusing intently on track safety because faulty track is a leading cause of accidents.

Through ultrasound technology, doctors use high-pitched audio waves to look beneath the skin and determine the health of a human body. Freight railroads are exploring a similar technology that sees through steel and determines the health of railroad tracks.

Railroads have been using ultrasound inspection tools for years, but "phased array" ultrasound technology is the newest iteration of this ever-changing technology. Though earlier versions could find 90 percent of largely invisible defects, such as microscopic cracks, railroads knew they could do even better. After years of investment, research and development, they soon will. When phased array is deployed in the next several years, it will help railroads locate almost all of the remaining 10 percent of imperfections.

For more than a decade, experts in the field of non-destructive testing have been developing phased array technology for commercial use. In 2012, America's freight railroads realized that phased array could help the industry overcome the challenges faced with conventional ultrasound inspection, such as inconclusive results from worn rails.

Working with EWI (formerly Edison Welding Institute), Dr. Matthew Witte led his project team of engineers at the Transportation Technology Center, Inc., in Pueblo, Colorado, to conduct exhaustive research and customize the phased array technology to meet the unique needs of railroads. Witte's team also developed a computer system and accompanying software to interpret the results. Within a matter of just a few years, railroads will be able to use the technology across North America's freight rail network.

Once phased array is operational, inspectors will be able to use it to examine a rail from multiple angles simultaneously. Like traditional ultrasound inspection techniques, phased array units will be installed on the underbelly of inspection vehicles and driven down rail tracks. As the phased array unit pulses electronic signals towards the rail, safety experts inside the inspection vehicle will monitor real-time feedback on computer screens. These inspection vehicles will travel the network, regularly monitoring the health of the system's 140,000 miles of steel rail.

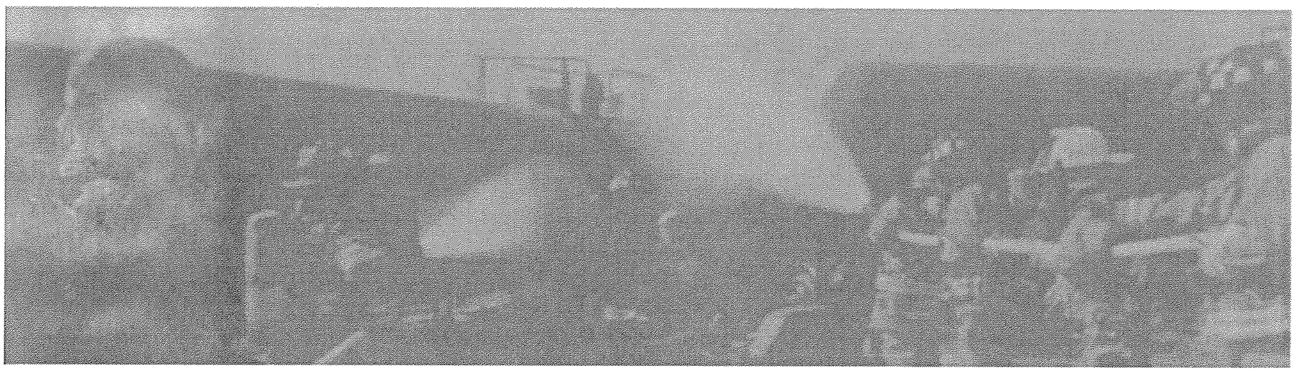
Should it uncover an issue with any rail, phased array technology will allow inspectors to switch into "high definition" mode. With the inspection vehicle stopped over the problem area, inspectors can conduct a more thorough examination of the track from hundreds of angles in a matter of minutes and achieve a level of detailed inspection that was never before possible. Railroads can pinpoint flaws much earlier and resolve them quicker than ever. Such detailed analysis will not only reduce the number of inconclusive results, but it will also provide more certainty when a problem is detected or a rail is declared healthy.

Ultimately, a definitive diagnosis and a recommended repair mean that rail lines safely stay in service.

How Phased Array Works

- A series of crystals are arranged in patterns within a phased array inspection unit.
- The crystals transmit electric pulses through a lubricant (typically water) at pre-determined intervals (or phases).
- The electrical signals strike a rail and rebound toward the crystals.
- The electrical signals return to the phased array unit and are analyzed. If the signals return as anticipated, a healthy picture of a rail emerges.
- However, a worn or otherwise defective rail will warp the trajectory of the signal. By studying the signal's altered course, rail inspectors will be able to identify a problem within the rail or conduct a follow-up inspection to learn more about the anomaly.

CHAPTER 5: World-Class Training, Expansive Community Outreach



Freight railroads wind through thousands of cities and towns across the United States every day. That's why railroads are dedicated to providing first responders from these communities with the training and resources they need to safely respond in the rare event of a train accident. In just two years, more than 3,300 emergency responders have received training in crude-oil-by-rail response techniques at the industry's Security and Emergency Response Training Center in Pueblo, Colorado. Hundreds more have participated in the industry's free online crude-by-rail safety course, which provides a primer for those who cannot travel to Colorado. Meanwhile, out in the field, freight rail's AskRail app is making a difference. First responders like Lt. Jason Hensler of the Clyman, Wisconsin, fire department can use the app — as he recently did — to respond to a train incident. In 2016, the freight rail industry's efforts will continue to grow and prepare fire and rescue personnel to safely handle to any rail emergency.

How Railroads Provide First Responders World-Class Training

Although rail incidents involving crude oil are extremely rare, America's freight railroads annually train thousands of first responders across the United States to ensure they are prepared to keep communities and the rail network safe.

There is suddenly a loud boom. Smoke exhales out of an overturned tank car. Flames reach up toward the morning sky as first responders rush to the scene.

It's just another day at the world-class Security and Emergency Response Training Center, known as SERTC. Located at the Transportation Technology Center, Inc., or TTCI, in Pueblo, Colorado, SERTC is where the freight rail industry's safety experts train emergency responders in how to safely respond to a rail incident. Today at the facility, a 19-car train with tank cars designed to carry flammable liquid is set up as a mock derailment — complete with actual fire. First responders attending the center's crude-oil-by-rail, or CBR, safety training program are learning how to respond to a CBR event.

Although a CBR event is extremely rare (statistically, there is a 0.01 percent likelihood of a rail incident involving crude oil), railroads make every effort to educate and train emergency responders so they are prepared. As the volume of crude oil shipments has increased over the past few years, railroads have worked with the Federal Railroad Administration, U.S. Department of Transportation's Pipeline and Hazardous Safety Materials Administration (PHMSA) and SERTC to develop customized training.

"Crude-by-rail training was developed to assist our member railroads in training emergency responders from their service territories," says Mike Cook, TTCI's executive director of hazardous materials compliance and training. "Training and safety is a top priority and that's why individual railroads stepped up to pay both for the training setting as well as the emergency responders' tuitions."

Like railroads, SERTC is committed to supporting first responders. The center has over 30 years of experience providing training that covers everything from hazardous materials to CBR to toxic inhalation hazards. Since the CBR program launched in 2014, SERTC's training team has mentored more than 3,300 first responders from across the country, both in the classroom and in the field. In 2015 alone, 1,795 first responders took the three-day class at Pueblo and experienced derailed cars first hand. More than 800 students registered for the free online training course in 2015, which provides CBR basics for those who can't travel to SERTC.

"Many firefighters are new to the rigors of CBR safety when they arrive at SERTC," says Glen Rudner, a seasoned safety expert and general manager at the center. "Learning these basics is still a necessary competence."

Over the course of three days, each emergency responder receives personalized instruction to meet their specific needs. Attendees learn about railroad tank cars, the different types of crude oil and how to safely respond to a CBR emergency based on the capabilities of their community.

"I think this is an absolute must for all fire personnel," says John Sigler, fire chief of Boone, Colorado, and a program graduate. "I am absolutely more prepared to cope with a potential crude oil situation in my community."

In recognition of the quality of its training programs, TTCI recently received additional funding for hazardous materials emergency response training from the U.S. Department of Homeland Security's National Domestic Preparedness Consortium, or NDPC.

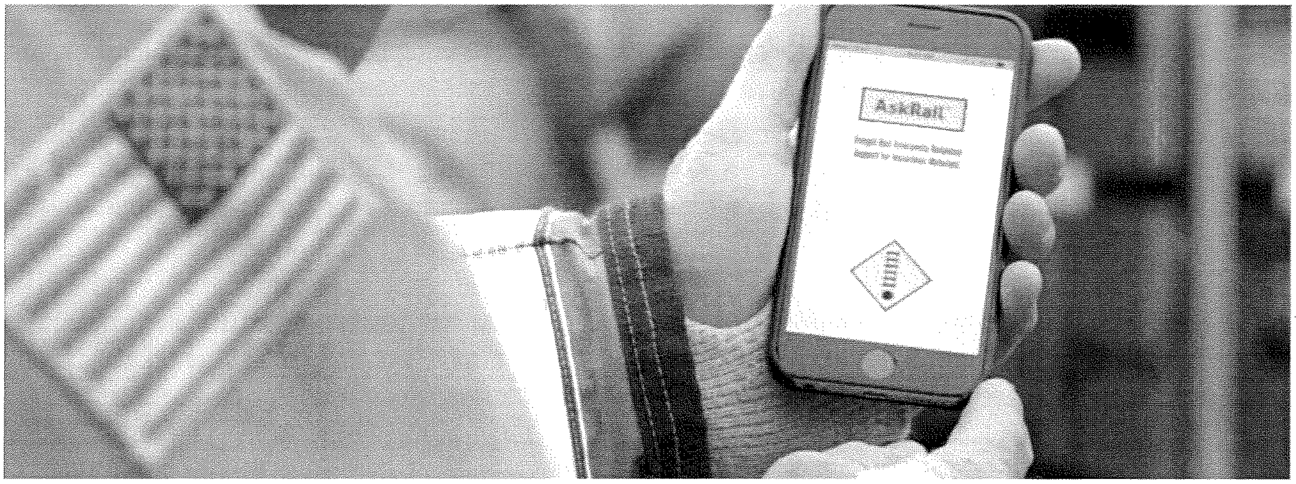
Through the new grant – which includes travel costs for students — TTCI officials estimate they can train a total of 1,556 first responders in various courses, including 540 students for CBR response techniques over the next two years.

Thanks to an additional $2.4 million award from PHMSA, the Center for Rural Development has partnered with TTCI's rail safety experts and will travel the country to instruct rural volunteer emergency responders about flammable liquids emergency response. Because firefighters have limited time for training, SERTC experts created a specific eight-hour classroom and hands-on training course. A portion of the grant funding will go toward creating a new Web-based training module about flammable liquids moved by rail. The module will launch in early 2016.

The Class I railroads have reserved close to 700 seats for first responder training in 2016, and with the new NDPC-funded training, SERTC looks to train at least 2,700 students in CBR this year in Pueblo.

After completing SERTC training, responder-students bring what they learned back home to mentor their colleagues. "Our goal is to give the students greater knowledge of crude transportation," says Cook. "And in that rare event they need to respond to a crude incident, they will have the tools needed to make a decision and take action."

How I Used Freight Rail's Mobile App to Mitigate an Emergency



As Lt. Jason Hensler arrived at the scene of a derailed train, he pulled out his mobile phone and gathered critical information from the rail industry's AskRail™ mobile app. The information helped him craft a plan of attack to protect a community and his engine crew.

Watertown is one of the handful of towns that interrupt the farms and fields of Dodge County, Wisconsin. Multiple Class I railroads crisscross the county, carrying freight — including crude oil — between Minneapolis and Milwaukee, and on to points beyond.

On Nov. 8, 2015, a train carrying crude oil derailed nearby. Jason Hensler, an engine crew member in the Clyman, Wisconsin, fire department and a member of the Dodge County Hazardous Materials (HAZMAT) Response Team, was one of the first emergency responders on the scene.

Lt. Hensler recently described how he used the freight rail industry's AskRail™ app to determine the contents of the derailed tank cars and execute an emergency safety action plan. Thanks to the efforts of Lt. Hensler and other first responders, no fires or injuries were reported. Here, he describes the experience in his own words:

"Driving to the incident, I was concerned because I know the community pretty well, and know that there are a large number of homes and a park relatively close to the derailed train. My first thought right out of the gate was the safety of the people in the community and the safety of our first responders.

"We had to walk about a quarter of a mile from our vehicles to get to where the 13 train cars had derailed. As we were walking, I opened the AskRail™ app to be 100 percent certain of the contents in each tanker car and confirm how many cars were on the train.

"The app gave me good detail about what was inside each tank car — specifically, how many gallons of oil were in each. If we had just relied upon the four-digit UN classification number stamped on the outside of the tank cars, it would give us a sense if hazardous materials were inside, but not exact details. And even though we were working with railroad representatives who were on the scene, the AskRail™ app was able to give us a unique level of detail with the push of a button. That information helped me and my team craft an action plan and mitigate the situation as quickly as possible.

"HAZMAT response is difficult — the scenes can go from very straightforward to very extreme in a matter of seconds. As a HAZMAT technician you need as much information as you can get, as quickly as possible.

"I would recommend the AskRail™ app to other first responders because the information you need in an emergency is right at your fingertips. You don't need to get information from third parties or rely upon UN classification numbers. AskRail™ tells you if the rail cars are full, if they're empty and what's inside — vital pieces of information that really helped us resolve the Watertown incident safely."