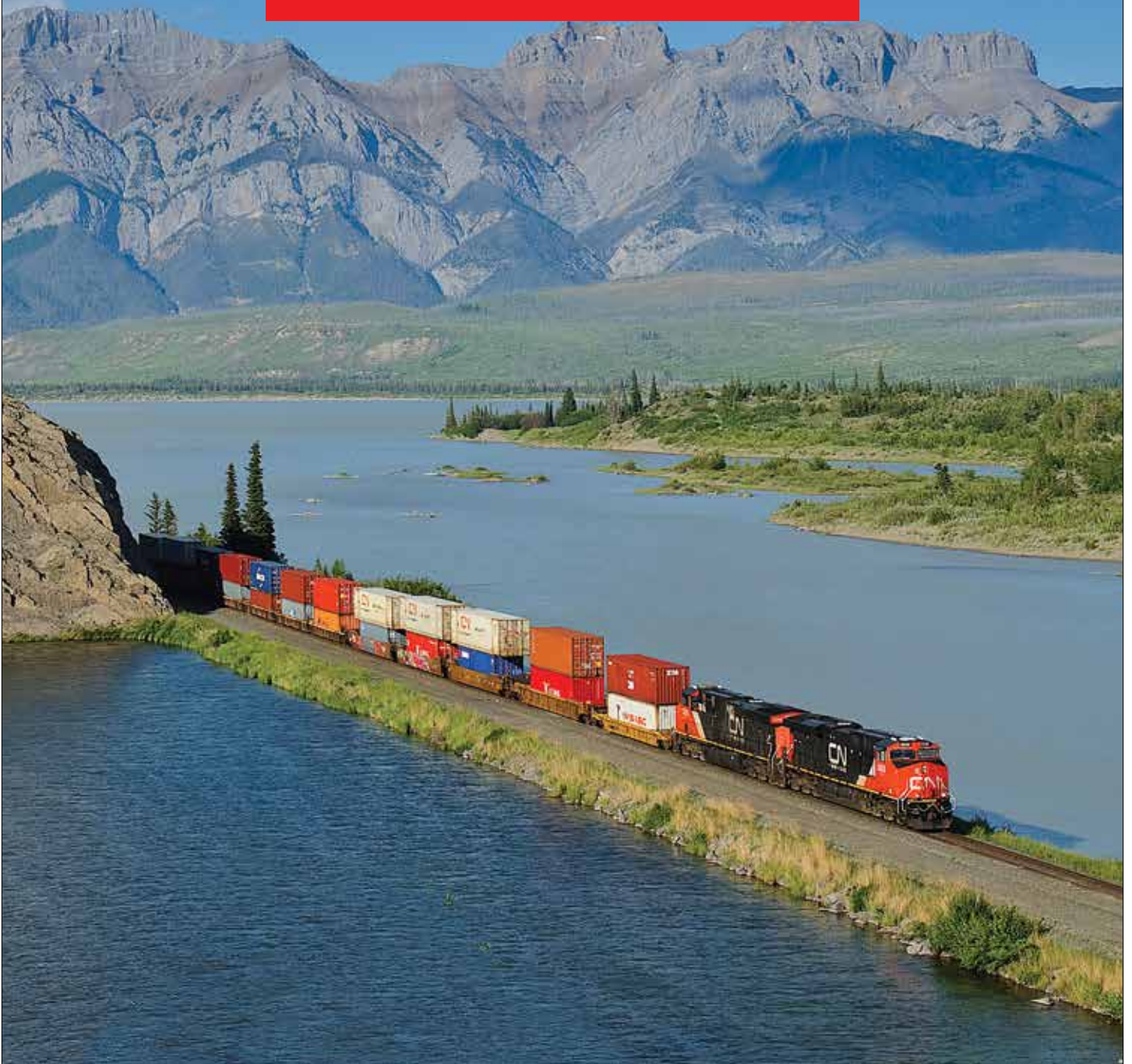




SAFETY IS A CORE VALUE

CN'S SAFETY TECHNOLOGY OVERVIEW



UPDATED: MAY 2018



SAFETY POLICY

Safety is of the utmost importance at CN. The company strives to safeguard our employees and assets, our customers' goods, our neighboring communities, and the environment at all times.

CN is dedicated to providing the leadership, organization, training and resources necessary to help achieve its goal of being the safest Class 1 railroad in North America through a continual focus on:

A Strong Safety Culture

Where every employee is committed to their personal safety, to looking out for each other, and to safely operating through the communities we serve.

A Safe Work Environment

Where safely conducting all operations is the top priority, regardless of the nature, importance or urgency of the job.

Safe Work Practices and Training

That ensure employees have the necessary tools and training to work safely.

CN uses a wide variety of processes and initiatives to maintain a safe workplace. This includes our Safety Management System, a formal framework for integrating safety into day-to-day railway operations, which applies to all company employees and also governs CN's relationship with contractors and other stakeholders while on CN property.

CN cooperates and engages with regulatory agencies. It complies with all applicable regulations to maintain a safe, secure and healthy workplace.

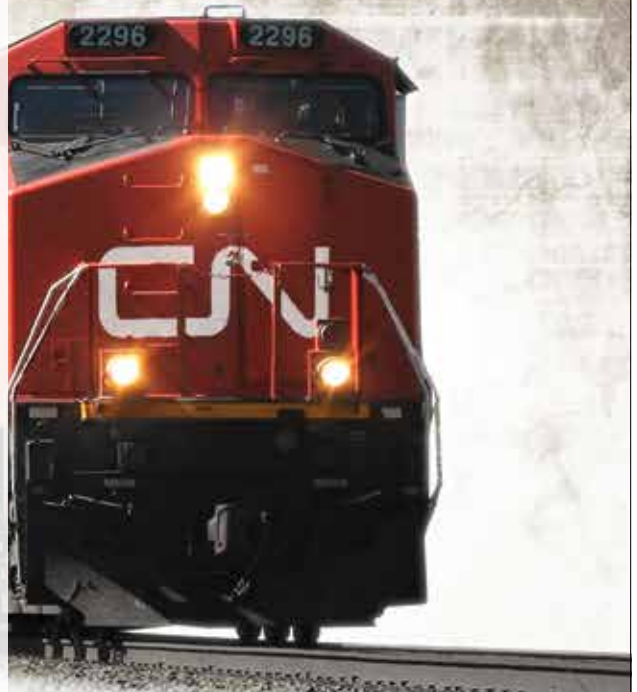
All employees are responsible for complying with all company safety policies, rules and procedures.

JJ Ruest

Interim President and CEO, and
Vice-President and Chief Marketing Officer

Mike Cory

Executive Vice-President and
Chief Operating Officer



CN'S SAFETY TECHNOLOGY OVERVIEW

CN makes significant investments in infrastructure and technology and early detection and predictive detection analytics technologies to run a safe and fluid network.

The following document provides an overview of the key safety technologies and programs CN has in place, that exceed regulatory requirements in many areas.

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Ultrasonic Rail Flaw Detector (RFD)

LOOKING INTO THE RAIL TO INCREASE NETWORK SAFETY AND RELIABILITY OF OPERATIONS



DESCRIPTION

- Rail flaw detection (RFD) systems are mounted on multiple platforms and travel the network providing the railway with a front line preventive process to assess rail integrity by looking for internal defects using ultrasonic technology. These systems find internal rail flaws that have the potential to cause derailments.
- RFD testing allows CN to locate rail defects that would not be detectable visually. Once located, defects are immediately repaired or monitored in accordance with the Track Safety Rules.

REGULATORY

- Railways are required to conduct this type of testing between 1 and 4 times per year depending on class of track and train volumes. CN has chosen to far exceed regulatory requirements as part of its safety program.

CN'S PERFORMANCE

- CN contracts 20 to 40 vehicles for mainline testing depending on the season. CN presently owns RFD portable equipment used for non-mainline testing.
- CN tests subdivisions throughout the network between 1 and 18 times per year, which in most locations is well above regulatory requirements.
- CN tested over 200,000 miles of track in 2017. It expects to test 205,000 miles in 2018. CN implemented a risk-based review for developing testing frequencies, and it considers track usage, volume of dangerous goods being transported on the track, track quality and other relevant factors. This risk-based approach results in more inspections on higher tonnage tracks and fewer inspections on tracks that have lower risk. Testing remains in excess of regulatory requirements throughout the system.

NEW TECHNOLOGY

- RFD testing is an integral part of all CN's network safety action plans. CN and its suppliers continue to look for new and improved methods and processes to advance RFD technology and performance.



Track Evaluation Systems (TEST) Cars

TESTING THE SAFETY OF OUR INFRASTRUCTURE ENABLES RELIABLE TRAIN OPERATIONS



DESCRIPTION

- TEST Cars are specially equipped railcars that electronically measure important aspects of track geometry including gauge, cross level, alignment, curve spirals, and rail profile (i.e. rail wear).
- Once located, defects are immediately addressed in line with the Track Safety Rules.

REGULATORY

- Railways are required to conduct this type of testing 1 to 3 times per year depending on Class of track and train volumes. CN has chosen to exceed requirements as part of its safety program.

CN'S PERFORMANCE

- CN presently owns and operates two TEST Cars and more than 30 Hi-rail mounted electronic geometry systems.
- CN protects its network integrity and operational safety by testing its rail lines from 1 to 7 times per year.
- CN tested over 73,000 miles of track in 2017. The company expects to test 77,000 miles of track in 2018.

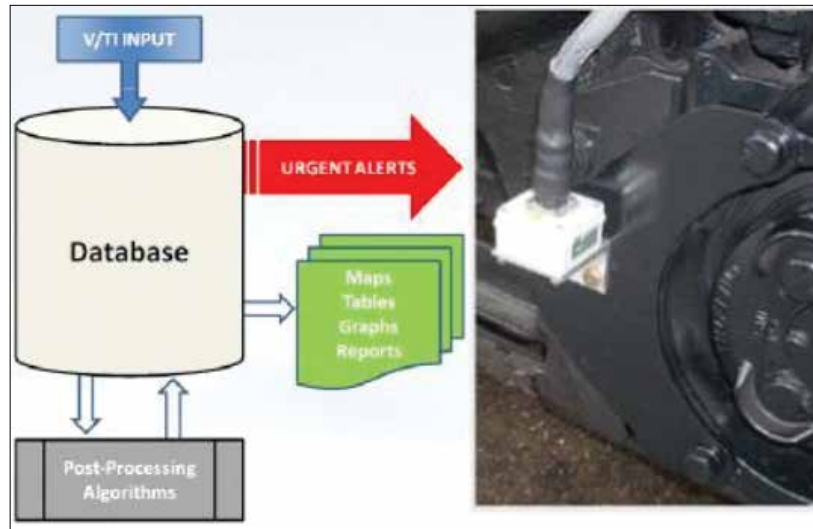
NEW TECHNOLOGY

- CN's TEST cars features an innovative joint bar inspection technology that inspects rail joint bars at track speed and identifies missing bolts and cracked joint bars.
- CN recently purchased three light geometry and joint bar inspection hi-rail vehicles. These vehicles perform electronic geometry inspections and identify joint bars that are missing bolts or have cracked bars. These vehicles have helped reduce the number of joint bar related incidents since implementation in late 2015.
- Ground penetrating Radar (GPR) technology is used to provide detailed assessments of ballast and subgrade conditions. The data collected by these systems can be used to better identify potential problem areas and plan undercutting programs.
- In 2018, CN will continue to collect GPR data at specific locations, and in the future, consider purchasing a system for installation on a TEST car.



Vehicle Track Interaction Units (V/TI)

UTILIZING LOCOMOTIVES TO FURTHER TEST TRACK QUALITY



DESCRIPTION

- V/TI units are accelerometers mounted on locomotives that identify unusual movements or accelerations resulting from track geometry or rail joint issues.
- Potential exceptions are identified by GPS and automatically sent out from a modem on the locomotive.
- The potential exceptions are inspected to assess condition and to determine required action.
- These systems represent an additional line of defense to reduce the risk of main track derailments.

REGULATORY

- There are currently no regulatory requirements for V/TI units.

CN'S PERFORMANCE

- CN has installed V/TI units on 35 locomotives to date.

NEW TECHNOLOGY

- V/TI units represent an additional line of defense to monitor the quality of our track and help prevent main track derailments in an automated fashion.



High Rail Units Track Geometry Testing/ TG and Joint Bar Inspection

INCREASING TRACK GEOMETRY TESTING AND JOINT BAR INSPECTION TO IMPROVE SAFETY



DESCRIPTION

- Hi-rail vehicles equipped with full geometry and optical joint bar measurement systems are utilized in order to increase track and automated joint bar inspections for better overall protection of the plant. The hi-rail vehicles include a series of lasers and camera equipment to measure track geometry and monitor joint bar condition. The data derived from these systems allows CN to pinpoint rail joint bar defects that require immediate attention, and to plan capital and maintenance programs based on the conditions identified. This equipment also adds the ability to perform track geometry inspections on a more regular and pinpointed basis.

REGULATORY

- Railways are required to conduct geometry testing 1 to 3 times per year depending on class of track and train volumes. These are additional vehicles that CN has deployed over the past few years to perform additional inspections as part of our safety program.

CN'S PERFORMANCE

- CN currently has a fleet of 30 light geometry and 3 joint bar inspection hi-rail vehicles.

NEW TECHNOLOGY

- High rail units with joint bar and track geometry testing enable CN to monitor track quality and prevent main track derailments. These units are also valuable in maintenance planning for future capital programs.



New Autonomous Track Geometry Test Box Car

UNMANNED AUTONOMOUS TRACK GEOMETRY CAR TO INCREASE TESTING FREQUENCY



DESCRIPTION

- The Autonomous Track Geometry Measurement System (ATGMS) Box Car is a specially equipped railcar that has the ability to continually measure important aspects of track geometry including gauge, cross level, alignment, curve spirals, and rail profile. This unit is unmanned and can run on any freight train, which allows for added electronic geometry inspection of CN's network.

REGULATORY

- Railways are required to conduct track geometry testing between 1 and 3 times per year depending on Class of track and train volumes. CN tests in excess of regulatory requirements as part of its safety program, and the ATGMS assists to further increase testing capabilities.

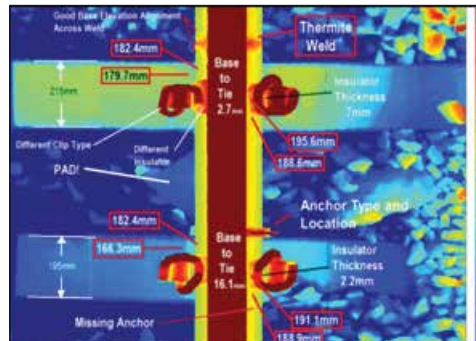
CN'S PERFORMANCE

- CN began commissioning a new autonomous track geometry system (ATGMS) car in late 2015. This system is currently collecting and processing data, and CN expects the ATGMS to complete final commissioning in 2018.



Tie Rating Technology

THE TRT TRACK ASSESSMENT SYSTEM IS OPERATING ON THE CN-1057 TEST CAR



DESCRIPTION

- The Tie Rating Technology (TRT) is operating on CN's 1057 test car. The TRT system is equipped with a 3-D measurement system to more accurately and objectively assess track tie conditions. The enhanced classification algorithms use 3-D surface profiles to measure a number of track components. The system provides a permanent record of track tie inventory and conditions present at the time of the survey.

REGULATORY

- There is currently no regulatory requirement for tie rating, but CN has determined that this system enhances operational safety. This technology assists CN in reducing risk by providing tie assessment ratings for capital planning purposes.

CN'S PERFORMANCE

- The installation of the TRT system was completed in 2015, and it will be used to assess tie condition across the CN system in 2018.

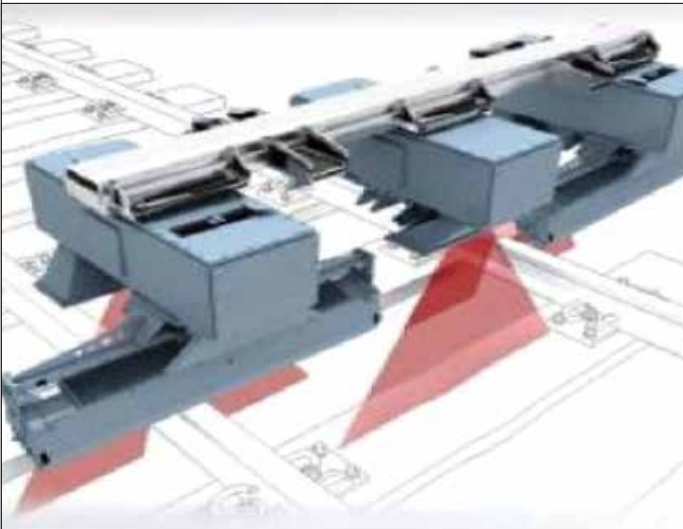
NEW TECHNOLOGY

- The TRT system is a relatively new type of technology for CN. The TRT collects images and data that can be used to pinpoint locations that need monitoring, and for capital tie planning purposes. The software analyzes the surface of the tie, and identifies the size, length, and location of cracks and splits. The system also evaluates the roughness of the surface, measures vertical and differential plate cut along with many other tie and tie fastener parameters.



Optical Track Inspection System

CAPTURES DETAILED IMAGES OF THE TRACK FROM A TEST CAR



DESCRIPTION

- This system uses state-of-the-art technology to capture detailed images of the track from the TEST car. The images and automated algorithms facilitate the review of track components such as tie plates, tie fasteners, joint bars and bolts. It monitors ballast profile to identify locations that may require additional lateral support.

REGULATORY

- There are currently no regulatory requirements for the optical track inspection system, but CN has determined that this system enhances operational safety. The optical track inspection system notifies field forces of locations that have missing fasteners, cracked joint bars and missing joint bolts.

CN'S PERFORMANCE

- CN installed its first Optical Track Inspection System as part of the new CN 1057 geometry car in 2015. The information generated by the optical track inspection system is used for both immediate repairs and for capital planning purposes.

NEW TECHNOLOGY

- The addition of this technology will allow CN to inspect for missing fasteners, cracked joint bars and missing bolts on a more frequent basis.



Rail Grinding

INCREASING SAFETY OF TRAIN OPERATIONS BY GRINDING THE RAIL TO THE PROPER PROFILE



DESCRIPTION

- Rail Grinding helps maintain proper rail profile and assists in controlling rail defects. Over time the profile of the rail changes from its original shape due to variation in wheel shapes and track geometry. As the shape of the rail changes, the wheel/rail interface also varies, causing the lateral and vertical weight of the load to change where it contacts the rail. If the contact area is not kept properly centered on the rail, it will cause the weight to be off-center and impact the L/V ratio between the wheel and the rail. The rail grinder's main objective is to grind the rail, so that it re-shapes the head to meet the preferred rail profile.

- Rail Grinding provides greater reliability for Ultrasonic Rail Flaw Detection (RFD) tests by re-profiling and cleaning the surface of the rail. Rail Grinding also has the ability to remove shells from the gauge face that can otherwise mask defects.
- Rail Grinding is performed by self-propelled vehicles that travel on the tracks throughout CN's network.

REGULATORY

- There are currently no regulatory requirements to grind rail, but CN has determined that the performance of rail grinding enhances operational safety.

CN'S PERFORMANCE

- CN's Rail Grinding Program covered over 18,600 pass miles of rail in 2017 and expects to grind over 19,500 miles in 2018.

NEW TECHNOLOGY

- Grinding contractors are developing more powerful and efficient machines to improve productivity and performance for rail profiling.



Bridge Testing System (BTS)

INCREASED SAFETY FOR TRAIN OPERATIONS
THROUGH BRIDGE EVALUATION AND STRUCTURAL TESTING



DESCRIPTION

- BTS is a mobile laboratory on wheels that uses advanced instrumentation to monitor and analyze various locations on a bridge span in real time under static and dynamic loading.
- The BTS unit is transported to the bridge site on its own wheels where road access is available, or by rail flatcar in remote areas.
- The purpose of the BTS is to perform specialized testing on bridges to monitor bridge capacity and plan for replacement and/or strengthening of components; to review actual loads on bridge members that have been theoretically analyzed in an office environment; and to determine the degree of actual vertical and lateral deflections that will lead to improved serviceability requirements.

- Strengthening or replacement can be safely deferred for bridge spans or bridge components that display reserve capacity based on test results.

REGULATORY

- There are currently no regulatory requirements to test bridge spans, but CN has determined that the performance of bridge testing enhances operational safety.

CN PERFORMANCE

- CN has invested in the safety of its bridge operations through the purchase of one BTS unit, which operates throughout CN's network.
- This unit typically tests 10 to 12 bridges per year

NEW TECHNOLOGY

- The bridge testing technology was upgraded in 2017 to provide more reliability in performing testing operations and less time troubleshooting components. The latest technological advancement also allows for wireless communication of the testing system.



Slide Detection/Roadbed Stability Detection

INCREASING SAFETY AND RELIABILITY FOR TRAIN OPERATIONS BY DETECTING PROBLEMS OVERHEAD



DESCRIPTION

- Monitoring of rock fall, landslide, high water levels and roadbed instability are used to detect potential safety problems and to warn approaching trains to prevent derailments. They provide restrictive signals when approaching areas that have been alarmed in the detection area. Some detectors have talker alarms that provide direct feedback to the train crews.
- Slide detectors, roadbed stability detectors and warning devices are located on the tracks or adjacent to the right of way in areas that have been determined to be exposed and most vulnerable through expert analysis. A small number of detectors are also used in high water and potential flooding areas, and at bridge locations to detect potential scouring or washouts.
- Generally, detectors are comprised of track level electro-sensors, tip over monitoring posts, trip wire fence or water level sensors that trigger an alarm when abnormal conditions such as a broken wire, sinking roadbed, or flooding occur. Such geo-hazard detectors also flash a white signal with the letter "T" on it in the field. The CTC signals

will display a restrictive approach signal when this "T" signal is activated. Additionally, derailment detectors are used to protect key infrastructure points such as bridges by providing a direct alarm to the train crew should a derailment be detected.

REGULATORY

- There is currently no regulatory requirement for slide detectors and roadbed stability detectors, but CN has determined that this type of review and notification reduces risk and enhances operational safety.

CN'S PERFORMANCE

- CN has established 79 slide detection locations across its network, including some sites with multiple detectors. It has also installed 448 derailment detectors.
- For any type of alarm, CN has established written instructions for trains to reduce speed, and be prepared to stop short of an obstruction, until the lead locomotive is clear of the limits, or the track is known to be clear.

NEW TECHNOLOGY

- CN has been improving detectors by including talker-based alarms. These announce an emergency message on the end-to-end radio channel if activated.
- In addition, there are a number of technologies that CN is evaluating and testing for future implementation, including: laser slide detection, acoustic rock fall detectors, guided radar landslide detectors, interferometric LIDAR analysis, and satellite imagery.



Hot Bearing Detector (HBD)

HOT BEARING DETECTION FEELS FOR PROBLEMS BEFORE THEY OCCUR

DESCRIPTION

- HBDs, first introduced to the industry and CN in the 1950's, monitor the temperature of railway car wheel bearings as they travel CN's network. The HBDs are placed on the rail and monitor each wheel set as it passes directly in front of it.
- One of the main items that HBDs identify is overheated bearings ("hot boxes"), which occur when inadequate wheel bearing lubrication or mechanical flaws cause a significant increase in bearing friction, which, in turn, causes the wheel bearing temperature to rise. This can lead to bearing failure and a potential derailment if left untreated.
- Once an overheated bearing is located by a HBD, the information of the specific wheel set that triggered the HBD is communicated directly to the train crew using "talker" technology.

REGULATORY

- In Canada, Transport Canada requires an inspection by HBD or visual every 60 miles, as a result of the railways change to caboose less train operations. In addition, key routes (those handling 10000 cars of DG per year) require a HBD every 40 miles. CN has chosen to far exceed this as part of its safety program.

CN PERFORMANCE

- In 2018, CN's re-spacing program will include four new hot bearing detectors on key routes and key branch lines. CN will also upgrade over 25 existing locations to the latest detector technology.
- CN continued to reduce WIS spacing to the CN standard of 12 to 15 mile intervals on core



routes. In 2017, the company upgraded 24 WIS locations across its network to the latest detector technology. As of December 2017, CN had over 909 WIS detectors on its system.

- CN has integrated these detectors into a central computer system, which allows for proactive monitoring of "warm" bearings and ensures their removal prior to a problem. This proactive use of the technology has allowed CN to significantly reduce HBD alarms and derailments caused by overheated bearings. For instance, derailments due to overheated bearings have dropped by more than 60% since the late 1990's, and average only 1-2 per year.
- Because CN has determined that HBDs are a critical tool in network safety, CN's core network features spacing of 12 to 15 miles, which is the best spacing for core main track in the industry.
- CN scanned almost four billion car and locomotive roller bearings on its WIS network in 2017

NEW TECHNOLOGY

- CN and its suppliers continue to find new and improved methods to advance HBD technology and performance.



Dragging Equipment Detector (DED)

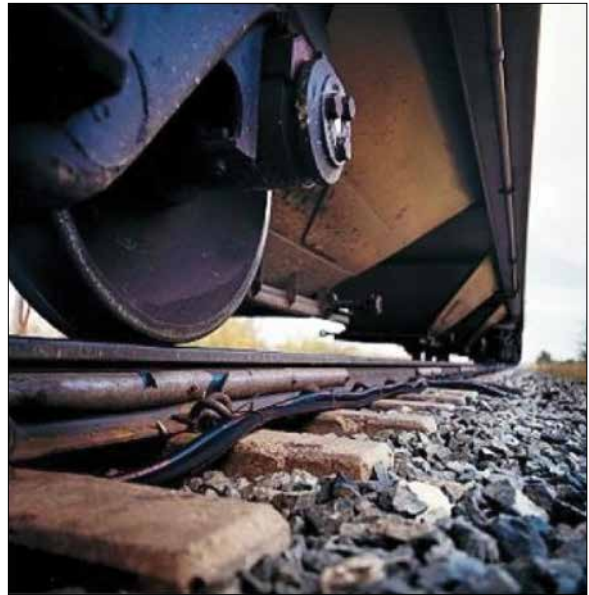
DRAGGING EQUIPMENT DETECTORS ARE KEY TO SAFE AND EFFICIENT PERFORMANCE

DESCRIPTION

- DEDs are installed on railway ties and monitor each wheel set as it passes directly in front of it.
- DEDs detect objects or components hanging under the body of a car or locomotive while they are transiting on CN's network. When detectors are struck, the alarm is relayed to the train crew. Once the alarm is given, the train is stopped and the conductor inspects the train to look for the dragging equipment. Any defective car will then be set off or allowed to continue based on the results of the inspection.

REGULATORY

- In Canada, Transport Canada requires a visual or wayside inspection every 60 miles, as a result of the railways change to caboose-less train operations. CN has chosen to far exceed this as part of its safety program.



CN PERFORMANCE

- In 2017, CN installed 2 new derailment detectors system-wide. In total, CN has about 448 stand alone dragging equipment detectors, which are in addition to those that are already integrated with the more than 909 WIS units.
- DEDs are placed on CN's mainline network at 12 to 15 mile intervals, and also protect key structures and risk locations.
- CN has also used standard DED's to act as low hose detectors. For this purpose, the sensor paddle is raised slightly in order to detect low hanging air hoses. Low air hoses could separate should they hit a crossing and could result in delays and, in some cases, minor derailments. Five such installations are currently in place.



Hot and Cold Wheel Detectors (HWD & CWD)

DETECTING HOT AND COLD WHEELS BEFORE THEY BECOME A HAZARD

DESCRIPTION

- HWDs, first introduced to CN's network in the 1980's, are used to monitor the temperature of the railway car wheels as they operate across the railway. A hot wheel is normally an indicator of a stuck hand or air brake. When a wheel reaches a specific temperature (or beyond), the detector alerts the train crew to stop the train and inspect the "suspect" wheel. A car will then be set off or allowed to continue with special monitoring based on the results of the inspection.
- CN uses HWD's to monitor overheated wheels across its system. The same HWDs can be used to identify "cold" wheels at the bottom of long grades, which indicate a lack or reduction in brake shoe force.
- The main use of HWDs is to allow the identification of defective air brakes, which can lead to unsafe wheel conditions. Industry analysis shows that wheels that have been heated are more prone to breaking.
- Both HWDs and CWDs are located adjacent to the railway's right of way.

REGULATORY

- There is currently no regulatory requirement for HWD & CWD's but CN has determined that this type of testing enhances operational safety.

CN PERFORMANCE

- CN has over 674 Hot Wheel Detectors as well as 6 Cold Wheel detectors; over 100 more than it had just 5 years ago. CN owns and maintains all of the HWD sites on its network.



- In 2017, CN performed over 37,800 single car air brake tests. The tests enable CN to diagnose air brake problems more accurately and to address service interruptions from stuck brakes. The company implemented a new process to identify cars that have multiple occurrences of hot wheels.
- Because CN has determined that HWDs are a critical tool in network safety, CN's core network features spacing of 12 to 15 miles.
- In 2018, CN's re-spacing program will include 13 new hot wheel detectors on key routes and key branch lines. CN will also upgrade over 25 existing locations.
- CN has integrated these detectors into a central computer, which allows for proactive monitoring of "warm" wheels for trend analysis of potential brake problems. Pro-active monitoring of warm wheels before they reach alarm levels has allowed CN to significantly reduce hot wheel alarms by 80% over the last three years.



Wheel Impact Load Detector (WILD)

INCREASING TRACK LIFE AND SAFETY OF TRAIN OPERATIONS THROUGH PRO-ACTIVE WHEEL DETECTION

DESCRIPTION

- WILDs measure the impact transmitted by a specific wheel onto the rail while railcars are in transit. Industry and CN testing of WILDs began in the 1980's and CN started the first network of interconnected WILD sites since 1993.
- This technology allows railways to detect out-of-round wheels, wheels with flat spots or other imperfections that could lead to derailments if left untreated. The principal defects found by WILD are wheel tread "shells" and "spalls". These defects appear as shallow (1/8" to 1/4" deep) pitted areas of the steel tread surface about 1" in diameter or more and are the steel equivalent of highway surface "potholes". They originate from localized metallurgical overstress, overheat and brittle fatigue of the steel.
- CN changes about 80,000 wheelsets (pairs of wheels) per year for all reasons, including sets with shells or spalls found by WILD.

REGULATORY

- There is currently no regulatory requirement for WILD detectors but CN has determined that this type of testing enhances operational safety.

CN'S PERFORMANCE

- CN currently has 41 WILDs across the system. This is the highest density of any railway in North America and represents approximately 1/3 of the total number of WILDs in North America.



- CN's WILD network is connected to a central computer that allows for coordinated monitoring, assessments and actions. Once an impact is registered at a CN established maintenance threshold, CN automatically sends the car to a repair location for wheelset removal.
- CN is also connected with all North American WILD detectors, meaning that it receives alerts which allow for preventive action.
- CN has recently enhanced its WILD detectors by adding capability to monitor overloads and imbalanced loads that can damage the rail cars and track and lead to derailments.

NEW TECHNOLOGY

- CN is constantly analyzing and enhancing our detector data. This allows us to leverage multiple information sources to identify specific at risk conditions.



Truck Hunting Detector

PREVENTS EXCESSIVE RAIL WEAR, EXCESSIVE TRUCK WEAR, AND DERAILMENTS.

DESCRIPTION

- These detectors help CN detect railway equipment trucks that oscillate with the potential to derail (ie hunting). This prevents excessive rail wear, excessive truck wear, and derailments.
- Such detectors look for dynamic behaviour of vehicles on the track, to determine if they are hunting or if they exhibit behaviour indicating their propensity to hunt.

REGULATORY

- There is currently no regulatory requirement for Truck Hunting Detectors but CN has determined that this type of testing enhances operational safety.

CN'S PERFORMANCE

- As of the end of 2017, CN has 5 Truck Hunting Detectors located at strategic locations across our network.
- CN is also connected, through AAR, with the alerts from over 80 Truck Hunting Detectors of other Class I railroads.



Wheel Dimension and Profile Detector (WDPD)

MEASURING WHEELS PREVENTS SAFETY HAZARDS

DESCRIPTION

- WDPDs are based on a new technology that uses laser-video and strobe-video to capture wheel profile information as a train passes over the site at speeds of up to 65 mph.
- This technology allows CN to intercept worn wheels that need replacement.

REGULATORY

- There is currently no regulatory requirement to measure wheel profile but CN has determined that wheel profiling enhances operational safety.

CN PERFORMANCE

- CN has established 3 WDPDs using two different technologies that monitor the same defects.
- CN is actively identifying worn wheels for replacement.

NEW TECHNOLOGY

- CN's suppliers continue to find new and improved methods to advance WPD technology and performance.

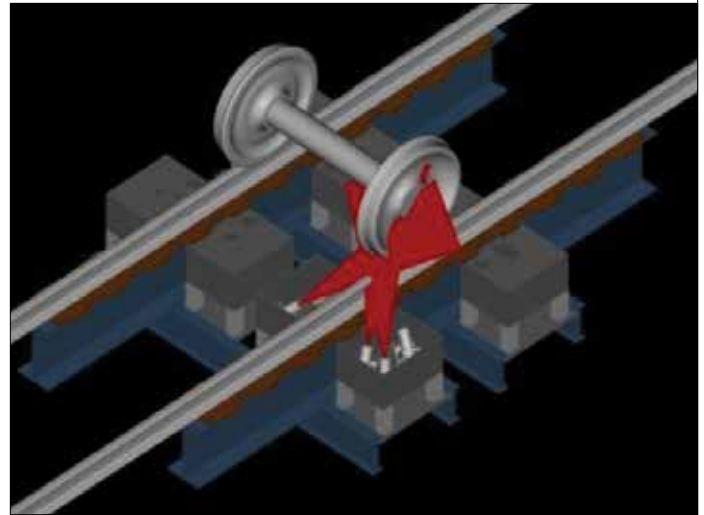


Image Detection System

ASSESSES RAILCAR COMPONENTS AND TRACK SAFETY CONDITIONS.

DESCRIPTION

- CN uses image detection systems specifically designed to provide valuable information in a variety of areas to effectively assess railcar components and identify potential safety defects.
- This system can find a missing bolt, or other missing / damaged components, on a train moving at track speed using automated machine vision algorithms. The system has a different perspective than a traditional visual inspection; with cameras in place between the rails, defects that would be difficult to identify visually, are identified with ease. The system sends images of defects in real time, 24 hrs a day. Currently CN identifies worn trucks as well as critical coupler securements. The use of technology to identify defects in challenging conditions strengthens safety of the network.

REGULATORY

- There is currently no regulatory requirement for such image detection systems, but CN has determined that this system enhances operational safety by monitoring rail car components.



CN'S PERFORMANCE

- CN has two state of the art Image Detection Systems – one on the Edson sub, just west of Edmonton, and the other on the York sub just east of Toronto.

NEW TECHNOLOGY

- CN will continue to add functionalities to its Image Detection System technology.



Locomotive Digital Video Recorders and Telemetry

DESCRIPTION

- Locomotive telemetry equipment allows CN to improve monitoring of train operations, identify train handling coaching opportunities and provide timely response to issues and rapidly analyze causes of critical incidents. The information provided by these systems is being used to support fuel conservation, safety monitoring, locomotive health monitoring and incident investigation.
- Locomotive digital video recorders (LDVR) capture the image in front of a train as it moves across the network. The information is paired with other locomotive data to support incident investigations.
- CN stores most of the information from the Locomotive Telemetry systems in its data warehouse. This data is cross-referenced with data from other Transportation and Mechanical systems, and can be used to identify trends as well as opportunities for improvement.

REGULATORY

- There is currently no regulatory requirement for such systems, but CN has determined that these systems enhance operational safety through monitoring.

CN'S PERFORMANCE

- At the end of 2017, CN had over 1,300 LDVRs installed on locomotives.
- At the end of 2017, CN had approximately 1,650 telemetry units installed on locomotives.

NEW TECHNOLOGY

- CN will continue to improve functionalities to its telemetry systems.



Trip Optimizer (TO)

IMPROVING FUEL EFFICIENCY AND OPTIMIZING TRAIN HANDLING FOR A SMOOTHER RIDE

DESCRIPTION

- Trip Optimizer (TO) technology is a 'state-of-the-art' onboard locomotive control system developed by GE that essentially functions as an auto-pilot system.
- After initializing TO with train consist details and routing information, the TO system will compute an optimal train handling plan for the given train and route. The locomotive operator still has primary responsibility for providing vigilance, safety, and compliance with all operating rules and procedures.
- When activated by the locomotive operator, TO will then precisely control train speed 'trajectory' and minimize fuel consumption by automatically controlling locomotive throttle or dynamic brake.
- To ensure optimal train performance, TO processes real-time information on train position, train length and weight, track speed limits, locomotive performance, etc.
- In addition to being an onboard locomotive energy management system providing environmental benefits through reduced fuel consumption and green house gases, TO can help to reduce in-train forces, minimizing the potential for train separations and/or damage to customers' goods.

REGULATORY

- There is no regulatory requirement for railways to operate using TO. CN has proactively introduced Trip Optimizer technology to improve train handling, fuel efficiency, greenhouse gasses, and safety.

CN'S PERFORMANCE

- CN uses TO technology across much of its Canadian network. At the end of 2017, Trip Optimizer was operational on just over 500 GE Evolution-series locomotives.



- In June 2018, CN expects to receive delivery of 60 new GE locomotives equipped with Trip Optimizer technology, the first deliveries from a three-year order of 200 new units.

NEW TECHNOLOGY

- CN is working with the TO developers in a continuous effort to make improvements to this technology. Key enhancements introduced between 2009 – 2016 included throttle / DB notch rate limits, sag / crest topography logic, auto-DB control, DB avoidance, and DP auto-independent control based on a physics based 'rope' model.
- The next frontier and major focus for TO enhancement will be improved management of train slack control, particularly important when operating mixed freight trains on more challenging CN territories. Enhancements currently being progressed include the introduction of a real-time 'Fast Sim' model, a new coupler model for end-of-car cushioning (EOCC) devices, and advanced EOCC train handling to minimize in-train forces due to travelling slack waves, etc.



Distributed Power (DP)

DISTRIBUTED POWER ALLOWS LARGER TRAINS TO BE SAFELY OPERATED



DESCRIPTION

- Distributed Power (DP) is a term used to describe a train that is configured with powered locomotives at the head-end and either the mid-train and/or tail-end of the train.
- Locomotives equipped with LOCOTROL, an add-on locomotive onboard control system, allows for 'DP remote' locomotives to be controlled by the locomotive operator positioned in the 'DP lead' locomotive. The DP system provides control of the remote locomotive(s) by using train handling command signals transmitted over a dedicated radio link. The DP system also uses the train's brake pipe as a back-up means of communication to allow the locomotive operator to 'idle down' DP remote locomotive(s) if required at any time should an interruption in DP radio communication occur.
- DP allows longer and heavier trains to be moved and helps to reduce in-train forces by optimizing the distribution of locomotive pulling (tractive effort) and braking (dynamic brake) forces, while also coordinating train air brake control at the DP Remote locomotive(s).
- Prior to DP, moving heavy tonnage trains up steep ascending grades required the equivalent of five or more locomotives. This was problematic because the high head-end pulling forces exceeded the tensile strength rating of the car coupling systems. With DP, instead of concentrating the pulling or dynamic braking forces entirely at the head-end, the forces are brought to lower levels by virtue of relocating some of the locomotives to a mid-train and/or tail-end position. This significantly reduces the potential for train separation, derailment, and the force exerted on track and bridge structures.
- A DP Remote locomotive also provides an additional point of train air brake control and a supplemental source of pressurized air, which significantly improves overall train air brake system performance. This allows longer train lengths to be safely operated during the winter operating season when colder temperatures pose challenges to conventional train air brake operation.
- The DP system allows remotely positioned locomotives to be controlled 'synchronously' or 'independently' (asynchronously) by the locomotive operator. When controlled



Distributed Power (DP)

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synchronously, DP remote locomotives will replicate DP lead train handling control actions. When controlled independently, the locomotive operator can elect to have the DP remote locomotive(s) operate in a different throttle or dynamic brake setting, thus allowing more effective management of train slack.

- In 2017, CN started using DP technology in a new and novel way system-wide to significantly enhance equipment securement. This new process allows an air brake application to be applied on unattended equipment left coupled to a DP remote locomotive while the head-end portion is detached and is performing routine switching operations. During this time, the set out portion is strongly protected due to the combined application of air brakes and hand brakes that, together, yield a more robust and resilient safeguard against unintended movement. In addition to enhancing safety, efficiency was improved due to reduced air brake recharge times.

REGULATORY

- There is no regulatory requirement for railways to operate trains using a DP. CN has proactively implemented DP technology to improve efficiency, train handling, and safety.

CN'S PERFORMANCE

- At the end of 2017, CN's DP fleet comprised approximately 782 DP locomotives with an additional 37 new AC locomotives on long-term lease. In June 2018, CN expects to receive delivery of 60 new GE locomotives equipped with LOCOTROL DP, the first deliveries from a three-year order of 200 new units. CN also has 40 Distributed Braking Cars / Containers (DBC) to assist in maintaining safe train air brake operation and performance during winter operating conditions.



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