U.S. Department of Transportation
Federal Railroad Administration

Report to Congress:

Automatic Track Geometry Measurement System Technology Test Programs

Joint Explanatory Statement, Departments of Transportation and Housing and Urban Development, and Related Agencies Appropriations Act, 2021

Automatic Track Geometry Measurement System Technology Test Programs

Contents

Abbreviations and Phrases in this Report

ATGMS	Autonomous Track Geometry Measurement System
ATIP	Automated Track Inspection Program
BNSF	BNSF Railway Company
CN	Canadian National Railway Company
CP	Canadian Pacific Railway
CSX	CSX Transportation
FRA	Federal Railroad Administration
NS	Norfolk Southern Railway Company
RSAC	Railroad Safety Advisory Committee
UP	Union Pacific Railroad

Track Inspection Test Programs

Legislative Direction

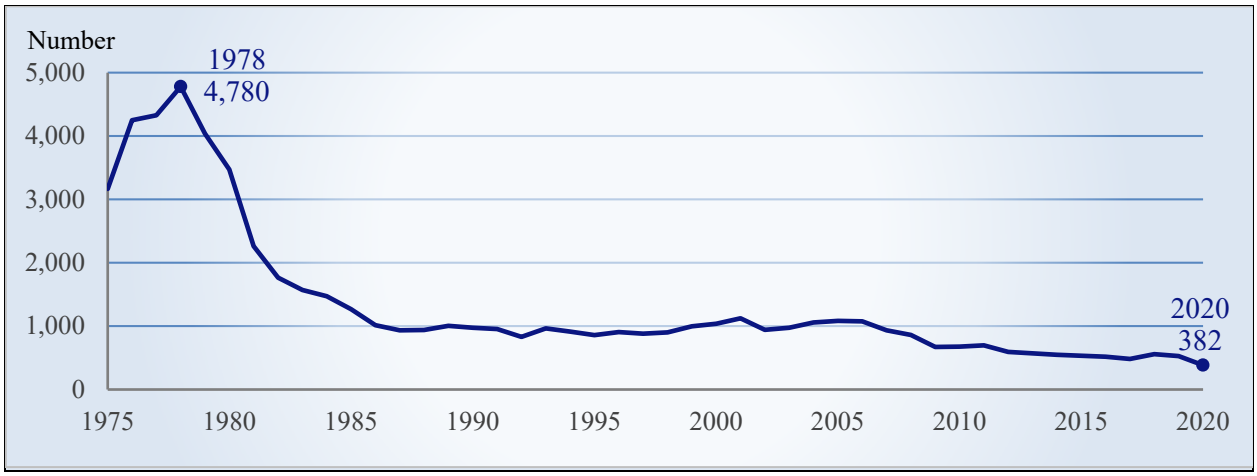
Source: Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2021 (Pub. L. 116-260), 166 Cong. Rec. H8820 (2020).

The agreement directs FRA to provide a report to the House and Senate Committees on Appropriations within 90 days of enactment of this Act, describing all industry-led automatic track geometry measurement system technology test programs and how FRA is evaluating and validating the performance of each technology system. FRA is further directed to report on FRA's process for soliciting, evaluating, and addressing all public comments in response to test program petitions prior to approving each test program.

I. Introduction

Track-related issues caused one-quarter to one-third of all train accidents from 2001 to 2020. Most track-related accidents involve derailments. The number of track-caused derailments in the United States has steadily decreased—from 4,780 reportable derailments in 1978 to 382 in 2020 (Table 1). In recent years, the rate of the decrease has slowed (Table 2).

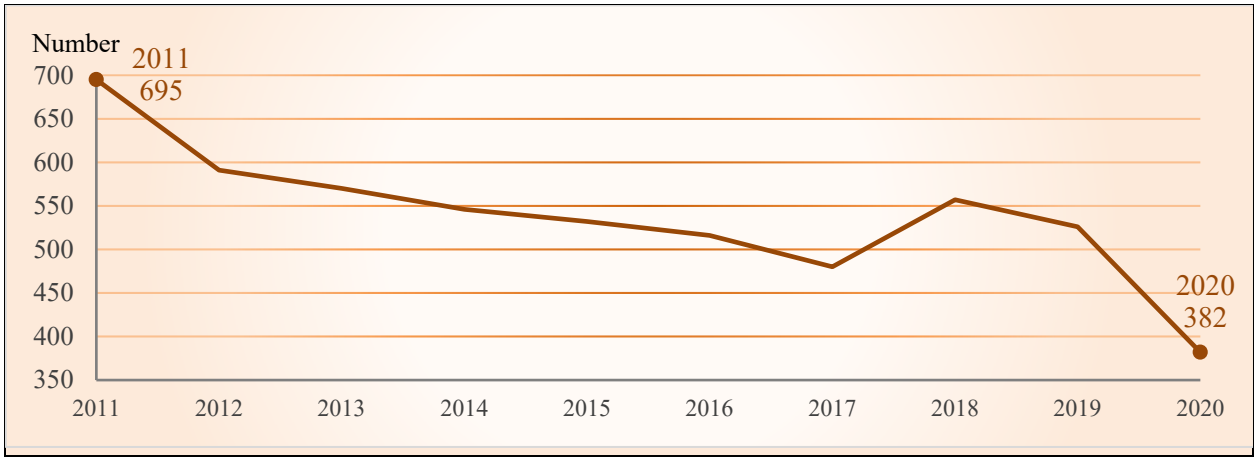
Table 1: Number of Track-Caused Reportable Derailments, Calendar Years 1975 to 2020[1]



Source: FRA safety data.

[1] Track-caused reportable derailments are those in which the primary cause of the derailment was a failure of the railroad's roadbed, track geometry, or track structure where damages exceed the monetary threshold and railroads are required to report certain information to FRA. Railroads do not report to FRA on accidents with damages below the threshold. The calendar year 2021 reporting threshold is $11,200, beginning January 8, 2021. Previously, the threshold was $10,700. https://railroads.dot.gov/forms-guides-publications/guides/monetary-threshold-notice.

Table 2: Number of Track-Caused Reportable Derailments, Calendar Years 2011 to 2020



Source: FRA safety data.

FRA regulations require railroad track inspectors to perform visual inspections to ensure the railroad's roadbed, track geometry, and track structure meet FRA minimum track safety standards. Use of automated track inspection technologies, in addition to visual inspections, has helped drive down the number of track-caused derailments. Today, every Class I railroad uses automated inspection technology for track geometry.

FRA and Class I railroads are conducting test programs as an initial step in gathering data to evaluate whether increasing the use of automated track inspection technology in Federal regulations, specifically technology that measures track geometry, would improve railroad safety. As of September 30, 2021, five railroads have conducted an FRA-approved automated track inspection test program, and one railroad's program is ongoing.[2] Each program was designed to test whether the use of autonomous track geometry measurement systems (ATGMS) to supplement visual inspections could justify decreasing the frequency of those visual inspections. Initially FRA did not seek outside input before approving the test programs, but going forward, FRA will ensure that opportunities exist for stakeholder input, collaboration, and comments about the test programs and automated inspection technologies. No train derailments related to track geometry issues have occurred on any test program territories.

This document responds to Congress's request that FRA report on automatic track geometry measurement system test programs and FRA's process for obtaining and responding to public input. Section II provides a summary of automated testing and describes the test programs. Section III discusses how FRA is evaluating and validating the performance and implementation

[2] *See* Table 4.

of each system. Section IV discusses FRA's process for approving each test program and considering public comments. Section V provides conclusions.

II. Automated Track Inspection and FRA-Approved Test Programs

Federal track safety regulations require railroads to conduct various track safety inspections, which include visual inspections at specified minimum intervals.[3] The regulations require qualified inspectors, either on foot or by vehicle, to conduct routine visual track inspections at specified minimum frequencies according to the class and type of track.[4] While FRA regulations don't generally require freight railroads to inspect track geometry using automated track geometry measurement systems, voluntary use of this technology to prevent derailments has been increasing since its inception in the 1970s.[5] Keeping the tracks within the allowable tolerances is critical in reducing the likelihood of track-caused derailments.

Automated track geometry measurement systems[6] provide an objective method to evaluate track conditions (i.e., gage, crosslevel, warp, alignment, and profile) and identify defects—conditions that do not comply with Federal regulations—or conditions that could lead to defects. Traditional automated track geometry measurement inspection systems require dedicated crews to operate the testing equipment. Automated track inspection systems can be autonomous; that is, they are capable of performing inspections without direct human involvement (i.e., uncrewed operations), with equipment mounted to a car or locomotive in the train. These systems are referred as autonomous track geometry measurement systems, or simply ATGMS. Onboard computers process raw data in real time and produce reports, noting the locations and indications of track defects or deficiencies. These reports are transmitted to the railroad's data processing center where the data is verified for accuracy before being transmitted to field personnel for remediation within 24 hours. Attaching autonomous track geometry measurement systems to trains in operation enables geometry measurement inspection of all track the trains cover, compared to the time- and distance-limited traditional track geometry measurement systems.

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[3] Code of Federal Regulations, title 49, sections 213.231 to 213.241 (49 CFR §§ 213.231–213.241).

[4] 49 CFR § 213.233(c) requires, for example, weekly visual inspections of Class 1, 2, and 3 main tracks used once a week or more, and twice weekly visual inspections of Class 4 and 5 tracks.

[5] Track geometry measurement system inspections are required for track classes 6- 9 and under rare circumstances in track classes 1- 5. 49 CFR § 213.333(a).

[6] The Joint Explanatory Statement references automatic systems but this report will use the standard industry term automated.

ATGMS can accurately measure track geometry, detecting deviations as small as four one-hundredths of an inch, as shown in Table 3. In comparison, a human performing a routine hi-rail[7] visual track inspection can detect larger magnitude track geometry deviations easily, but for smaller deviations the inspector would need to take measurements using hand tools to ensure accuracy. When using high quality hand tools during a walking inspection, an inspector might be able to measure these parameters within one-sixteenth of an inch, but more likely within one-eighth of an inch.

Table 3: Examples of ATGMS Track Geometry Parameters and Tolerances

Parameter	Measurement Tolerance
Gage	+/- 0.04”
Crosslevel/Superelevation	+/- 0.06”
Warp/Twist	+/- 0.10”
Longitudinal Profile	31 ft +/- 0.06”
Alignment	31 ft +/- 0.06”
Curvature	+/- 0.15 degrees

When necessary to conduct an FRA-approved test program, FRA’s regulations allow the agency to suspend a substantive safety rule, provided the suspension is limited in scope and application as “necessary to facilitate the conduct of the test program.”[8] Further, FRA must condition any rule suspension on “the observance of standards sufficient to assure safety.”[9]

On September 26, 2018, after more than five months of discussion and deliberation, FRA approved BNSF Railway Company’s (BNSF) program to test automated track inspection methodologies, beyond those then in use, and to determine the most efficient, safe, and effective mix of automated and visual track inspections.[10] FRA found that suspension of certain requirements, with additional conditions to ensure safety, was necessary to conduct the test program. For example, class 4 main line track is required to be visually inspected twice weekly with at least one calendar day interval between inspections.[11] The FRA-approved program allowed BNSF to assess its new, un-crewed track geometry car in different combinations of visual and automated inspections, using a four-phase methodology on specified track in Nebraska, South Dakota, and Wyoming. BNSF’s expectation was that incorporating new automated technologies and reducing the frequency of visual inspections would reduce the safety risks to the track inspector associated with visual inspections, improve quality of defect detection, and help enhance infrastructure integrity and freight capacity. Throughout the

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[7] A *hi-rail vehicle* refers to a roadway maintenance machine manufactured to meet Federal Motor Vehicle Safety Standards that has retractable flanged wheels so the vehicle can travel on a highway or railroad tracks.

[8] 49 CFR § 211.51.

[9] *Id*.

[10] https://www.regulations.gov/document/FRA-2018-0091-0002.

[11] 49 CFR § 213.233(c).

program, visual track inspections continued at different frequencies in combination with automated inspections.

FRA subsequently approved the test programs of five additional Class I railroads—Norfolk Southern Railway Company (NS), Canadian National Railway Company (CN), CSX Transportation (CSX), Union Pacific Railroad (UP), and Canadian Pacific Railway (CP)—to evaluate the effectiveness of their ATGMS and combinations of visual and automated inspections at different frequencies.[13] FRA found that suspension of certain requirements was necessary for each test program with additional conditions to ensure safety. Therefore, FRA suspended applicability of certain visual inspection requirements,[14] so that each program could gradually decrease visual inspections according to its phased approach. The details vary among test programs, with all using non-contact, optical, and inertial sensors to measure track geometry. The test programs do not change the railroads' responsibility to comply with all other Federal track inspection regulations.

Table 4: Current Test Phase or Latest Phase if Concluded (as of* November, 23, *2021)

Railroad	*Notes*
BNSF	Completed 5 of 5[12]	Completed January 31, 2021
NS	Completed 3 of 3	Completed September 30, 2021
CN	2 of 4	Extended until November 23, 2022
CSX	2 of 3	Extended until November 23, 2022
UP	1 of 2	Extended until November 23, 2022
CP	2 of 3	Extended until November 23, 2022

Each program was modeled after the BNSF program and included a phased methodology and specific safety metrics the railroad must meet before it transitions to its next phase. The phased methodology requires railroads to conduct more track geometry testing with ATGMS, while reducing the frequency of visual inspections. The incremental phases were structured to collect data to help find the combination of visual and automated inspections that produces the greatest level of safety. BNSF and NS have completed their test programs. As of November 23, 2021,

[12] On February 1, 2021, after completing its test program, BNSF transitioned to an FRA approved waiver of compliance on the test program territory and BNSF's Southern Transcon Route from Chicago, IL to Los Angeles, CA based on the successful results of the test program. The waiver is discussed in more detail in Section IV. Consideration of Public Comments. FRA anticipates other railroads will petition for similar waivers based on their specific test program results.

[13] BNSF, https://www.regulations.gov/docket/FRA-2018-0091; NS, https://www.regulations.gov/docket/FRA-2019-0099; CSX, https://www.regulations.gov/docket/FRA-2020-0013; CN, https://www.regulations.gov/docket/FRA-2020-0014; UP, https://www.regulations.gov/docket/FRA-2020-0031; CP, https://www.regulations.gov/docket/FRA-2020-0056.

[14] 49 CFR § 213.233(c).

CN, CP, CSX, and UP's test programs have been extended until November 23, 2022 (Table 4) so the test programs can be completed.

III. Evaluation, Monitoring, and Validation of Technology and Operational Performance

FRA has a three-fold method to evaluate, monitor, and validate the technologies and operational performance of each test program. First, in evaluating each railroad's test program, FRA considered findings from its previous research on ATGMS.[15] This research generally demonstrated that ATGMS technologies effectively measure the physical geometry of railroad track (i.e., gage, crosslevel, warp, alignment, and profile) for compliance with the Federal Track Safety Standards.

Second, FRA established procedures to help ensure that each railroad maintained safety throughout its test program. FRA track inspectors conducted baseline visual inspections during the initial phase of each test program. As FRA required in the program approvals, railroads report monthly to FRA on track inspections performed, defects identified, field verification measurements, and remedial actions taken. FRA compares the railroads' inspections findings to data from the baseline inspections and from FRA's Automated Track Inspection Program (ATIP) vehicles.[16] FRA inspectors conduct field verifications of reported defect locations to ensure that the railroads' geometry measurements are consistent and accurate, and that the railroads take proper remedial action to repair defects. Railroads also must report to FRA any derailments on the test program territories, regardless of the amount of damage. For regular operations, railroads report only those accidents that exceed the monetary damage threshold, which is currently $11,200.

Third, FRA's procedures for monitoring and auditing technical aspects of each test program include thorough review of each petition and supporting information, inclusion of specific safety metrics, and continuous monitoring and auditing during the program. Each railroad included in its test program petition equipment specifications as well as procedures for system calibration,

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[15] Examples include FRA, *Autonomous Track Geometry Measurement Technology Design, Development, and Testing* (2018); Soheil Saadat et al., FRA, *FRA Autonomous Track Geometry Measurement System Technology Development – Past, Present, and Future* (2014); Soheil Saadat et al., FRA, *Development and Use of FRA Autonomous Track Geometry Measurement System Technology* (2014); Cameron Stuart et al., *Development of Autonomous Track Geometry Measurement Systems for Overall Track Assessment* (2011); Gary A. Carret al., *Autonomous Track Inspection Systems – Today and Tomorrow* (2009).

[16] FRA uses ATIP cars to conduct automated surveys of the U.S. rail network. FRA uses ATIP data to assess railroads' track inspection and maintenance processes, analyze track condition trends, and help railroads identify maintenance needs. ATIP also supports FRA's Office of Research, Development, and Technology develop and demonstrate new track inspection technologies. https://railroads.dot.gov/track/automated-track-inspection-program-atip/atip-overview.

data validation, data handling, defect filtering, and validation. The test program calibration procedures are the same as those FRA uses on its ATIP vehicles. Moreover, test program ATGMS equipment fully complies with the minimum Federal standards for high-speed rail (track classes 6 to 9), which specify the minimum frequency for testing, equipment design standards, measurement parameters, data processing, and qualifying remedial actions.[17]

IV. Consideration of Public Comments

FRA's process for analyzing the test program results includes multiple opportunities for input from stakeholders and the public before any proposed changes are finalized in FRA regulations. These test programs are first steps to gather data to enable all stakeholders to evaluate the feasibility of improving railroad safety by increasing the use of automated track inspection technology in Federal regulation. Consistent with FRA's regulations,[18] FRA published notices for each test program approval in the *Federal Register,*[19] and posted each test program and approval decision to a public docket.[20] FRA did not seek public comment on the test programs described in this report prior to approving those programs. However, going forward, FRA will seek public comments on all automated track inspection test programs.

FRA's waiver petition review process is subject to public notice and comment procedures, if a railroad requests a safety regulation waiver based on an FRA-approved test program's results. For example, BNSF petitioned FRA to waive certain visual track inspection requirements and apply its test program inspection strategies to its entire rail network. FRA issued two notices for public comment on this request and posted the test program data and analysis in a public docket.[21] FRA reviewed and responded to the two comments it received[22], analyzed the test program data, and granted a limited approval for a structured expansion of the inspection methodologies to new sections of BNSF's network, with continuing FRA oversight for compliance with specified safety metrics.[23] As a condition of BNSF's waiver, FRA included two additional metrics to further improve safety performance (one measuring the severity of the

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[17] 49 CFR § 213.333.

[18] 49 CFR Part 211. 49 CFR § 211.51(b) requires FRA to ask for public comment before implementation of an FRA-approved test program when required by statute.

[19] BNSF: 83 Fed. Reg. 55,449 (Nov. 5, 2018); NS: 85 Fed. Reg. 5536 (Jan. 30, 2020); CSX: 85 Fed. Reg. 13,230 (Mar. 6, 2020); CN: 85 Fed. Reg. 20,017 (Apr. 9, 2020); UP: 85 Fed. Reg. 25,506 (May 1, 2020), CP: 85 Fed. Reg. 45,295 (Jul. 27, 2020).

[20] BNSF, https://www.regulations.gov/docket/FRA-2018-0091; NS, https://www.regulations.gov/docket/FRA-2019-0099; CSX, https://www.regulations.gov/docket/FRA-2020-0013; CN, https://www.regulations.gov/docket/FRA-2020-0014; UP, https://www.regulations.gov/docket/FRA-2020-0031; CP, https://www.regulations.gov/docket/FRA-2020-0056.

[21] https://www.regulations.gov/docket/FRA-2020-0064.

[22] https://www.regulations.gov/document/FRA-2020-0064-0006 ; https://www.regulations.gov/document/FRA-2020-0064-0008

[23] https://www.regulations.gov/document/FRA-2020-0064-0011.

geometry defects identified by automated inspections and a second measuring the number of defects identified by visual inspections).

Going forward, FRA will require test program data to be shared with its Railroad Safety Advisory Committee (RSAC), which includes representatives of railroads, labor unions, and other stakeholders. In 2019, RSAC accepted a task to consider specific improvements to the Federal Track Safety Standards to enhance rail safety by improving track inspection methods, frequency, and documentation.[24] As part of this task, RSAC's track standards working group is examining "the feasibility to fulfill certain inspection requirements using automated track inspection technologies in lieu of some visual inspections." The data the test programs and any subsequent waivers yield will be critical to RSAC's evaluation of the issue. This RSAC task provides a platform for industry representatives, labor organizations, and other stakeholders to collaborate and provide input on the feasibility of improving railroad safety by further enabling the use of automated track inspection technologies to meet Federal track inspection requirements. This RSAC task will only move forward once all test program data has been reviewed by the task members and a consensus determination is reached.

Gathering initial data through the test programs; subjecting the data, processes, and procedures to notice and comment through the waiver application process; and submitting the data to stakeholders for analysis and collaboration through RSAC also ensure FRA will be able to base any future regulatory revisions on the best data and science available.

V. Conclusions

This report provides information on automated track geometry measurement inspection methods, FRA's process for approving track geometry measurement system technology test programs, and current test program status. This report also describes FRA monitoring of the operational and technical aspects of test programs to ensure safety. This report notes that while FRA did not initially seek public comments before approving the test programs, FRA will seek public comments going forward. Finally, this report explains FRA's multi-step plan for using track geometry measurement system technology test programs, waivers, and RSAC to ensure public comments, feedback, and stakeholder involvement to inform future track inspection regulations.

Technological advancement has become an essential element of railroads' track asset management and safety assurance programs. FRA encourages railroads to continue to develop and test new track geometry measurement inspection technologies, but not to use those technologies as a complete substitute for visual track inspections. These test programs are first steps to gather data on the feasibility of improving railroad safety by further enabling the use of automated track

[24] RSAC Task Number 2019-05, https://rsac.fra.dot.gov/tasks.

geometry measurement inspection technologies to meet Federal track inspection requirements as a supplement to visual track inspections.

Ideally, autonomous track inspection technologies—specifically ATGMS— along with visual track inspections will foster earlier detection of track defects, facilitate a shift from reactive maintenance to preventative practices, and ultimately reduce the number of track-caused derailments. FRA's decision letter granting BNSF's waiver cited improvements under the BNSF track geometry measurement test program based on the established defect metric, FRA monitoring procedures, and consistency of number of defects located by visual track inspection.[25]

Visual track inspection continues to be a vital part of any track inspection system because structural elements must be inspected visually. Continued evaluation of additional track inspection methodologies, such as ATGMS, will provide the data needed to craft a comprehensive regulatory structure for how automated inspections can supplement visual track inspections to improve the safety and efficiency of the rail network.

[25] https://www.regulations.gov/document/FRA-2020-0064-0011