Issued: February 27, 2024 Railroad Investigation Report: RIR-24-01

Caltrain Passenger Train Collision with Hi-rail Construction Vehicles

San Bruno, California
March 10, 2022

1 Factual Information

1.1 Accident Description

On March 10, 2022, about 10:31 a.m. local time, southbound Caltrain Train 506 struck three hi-rail construction vehicles at milepost (MP) 11.6 on Main Track 2 in San Bruno, California.[1] The train's locomotive derailed, and all three construction vehicles were destroyed. (See figure 1.) Released fuel from the construction vehicles fed a fire that spread to one of the passenger railcars. Eight people were transported to local hospitals. One railroad construction employee sustained serious injuries. One train crewmember was treated and released at a local hospital. Six passengers were treated for minor injuries and subsequently released. Visibility in the area at the time of the collision was clear; the temperature was 60°F with no precipitation. Caltrain estimated that the property damage exceeded $1.4 million.

[1] (a) All times in this report are local times. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB accident investigation (case number RRD22MR007). Use the CAROL Query to search safety recommendations and investigations. (c) *Hi-rail* construction vehicles can operate both on roads and on rails.

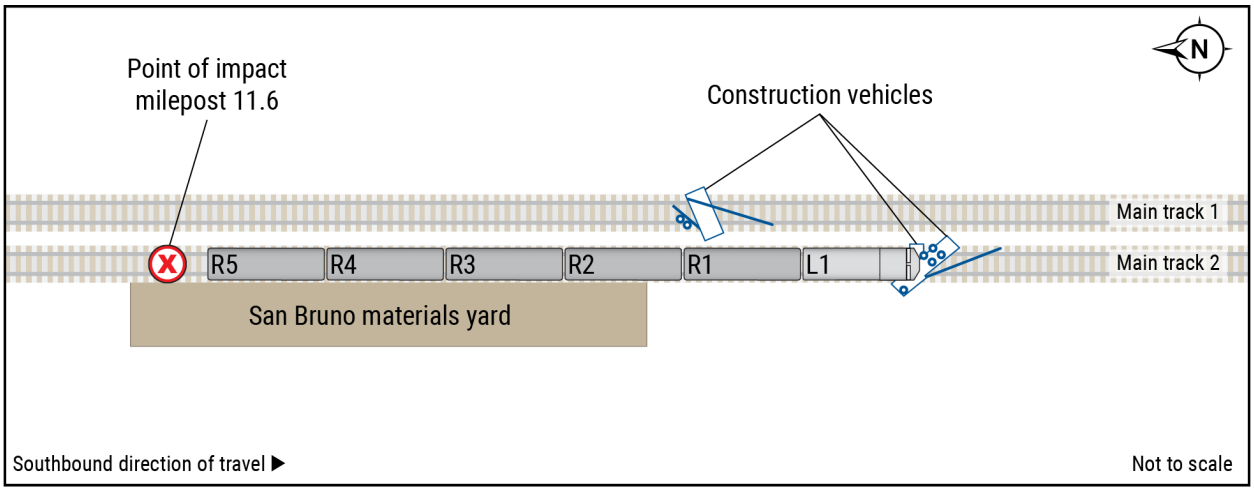

Figure 1. Illustration of the collision.

Train 506 was traveling from San Francisco, California, to San Jose Diridon Station and consisted of one locomotive and five passenger railcars. Event recorder data from the locomotive showed the speed of the train was 64 mph about 1/4 mile from the collision. The construction equipment was positioned on Main Track 2 at MP 11.6 with the pilot vehicle facing north, the crane was in the center position and also facing north, and the boom truck was behind the crane facing south.[2] As the train exited a left-hand curve, the engineer told the National Transportation Safety Board (NTSB) that he could identify construction equipment on a track, but he could not immediately identify which track the equipment was on. Event recorder data show the engineer applied the emergency train brake 13 seconds before colliding with the construction equipment. After applying the emergency brake, he sounded the train's horn to alert the construction work group of the impending danger and braced himself for impact. The train slowed to about 43 mph before it struck the first construction vehicle. The train then continued to strike the other two construction vehicles before stopping.

1.2 Before the Collision

Actions taken before the collision by the construction work group and train crew are described below.

1.2.1 Construction Work Group Activities

The construction work group began the workday about 6:30 a.m. by conducting an inspection of the construction vehicles and participating in a job briefing with all employees at an off-site facility, Visitation Yard. The roadway worker-in-charge (RWIC), an employee of a contracting firm that performs Caltrain's operations and maintenance,

[2] The driver was operating the boom truck in reverse as he was moving to the work site.

who was present at the site conducted the job briefing.[3] Topics discussed in the job briefing included safe work practices, acquiring track and time authority, Form B limits, travel to the highway-railroad grade crossing (grade crossing) to set the construction vehicles on Main Track 2, and that the RWIC was responsible for acquiring and releasing exclusive track occupancy.[4] The track within the working limits was placed under the control of the RWIC by an authority from the train dispatcher (track and time) and through placement of fixed "stop" signals (flags) placed at the entrance to the working limits (Form B).[5]

The RWIC contacted the dispatcher at 9:09 a.m. and discussed where the construction vehicles would be set on the tracks. The dispatcher planned to allow the construction vehicles track access at the Linden Street grade crossing, but that area did not have the space to accommodate the large vehicles. During the 9:09 a.m. call between the RWIC and the dispatcher, a new plan was developed to allow the construction vehicles to access the track at the Center Street grade crossing. After the call, the RWIC traveled to a location near the South San Francisco Station (MP 9.1) where the Form B had been established for catenary pole installation. The three construction vehicles traveled to the Center Street grade crossing and waited for confirmation from the RWIC that the track was protected.

About 9:29 a.m., the RWIC called the dispatcher and informed him the construction crew was ready to work. The RWIC and dispatcher then established two exclusive track occupancy authorities: Track and Time Authority 209 was established on Main Track 2 between Control Point (CP) Sierra and CP Scott until 4:00 p.m., and Track and Time Authority 210 was established on Main Track 2 between CP Scott and

[3] Railroads are required under Title 49 *Code of Federal Regulations* (*CFR)* 214.315 (c) to designate at least one RWIC to be responsible for providing on-track safety for members of a work group.

[4] (a) *Form B limits* (also known as Form B) is a type of exclusive track occupancy which requires the use of red flags at the entrances to the area. A train must not enter the limits unless instructed by the RWIC (*General Code of Operating Rules* [GCOR], effective April 1, 2020, Rule 15.2). (b) *Track and time authority* is a type of exclusive track occupancy where the dispatcher may authorize a train or work group to occupy a track within specified limits for a certain time period (GCOR Rule 10.3).

[5] (a) *Track and time* protection and *Form B* protection are both types of exclusive track occupancy as defined in 49 *CFR* 214.321. The term track and time authority is the administrative control; however, the established work zone is controlled by the positive train control (PTC) system, which is defined in the Rail Safety Improvement Act of 2008 as "a system designed to prevent train to train collisions, over speed derailments, incursions into established work zone limits, and the movement of a train through a switch left in the wrong position." (b) According to 49 *CFR* 214.7, *working limits* means a segment of track with definite boundaries established in accordance with this part upon which trains and engines may move only as authorized by the roadway worker having control over that defined segment of track. Working limits may be established through "exclusive track occupancy," "inaccessible track," "foul time," or "train coordination". (c) A *dispatcher* is the person responsible for train route selection and train movements.

CP Center Street until called, meaning the RWIC or the dispatcher would communicate the release.[6]

Phone records indicate that the RWIC placed a call to the subgroup coordinator (SC), who was managing the construction crew, at 9:33 a.m. After a conversation, the RWIC and SC determined that an additional track occupancy authority would be needed on the adjacent track, Main Track 1, to allow the construction vehicles to briefly foul both tracks while they maneuvered into position on Main Track 2. This resulted in a request for another form of on-track protection. At 9:43 a.m. the RWIC told the dispatcher that the work group needed Main Track 1 for 5–7 minutes, the dispatcher said that he would call the RWIC back. At 9:47 a.m., the dispatcher called the RWIC with Track and Time Authority 211, which was for Main Track 1 from CP Scott to CP Center Street until called. The dispatcher informed the RWIC they had about 7 minutes before a train would be ready to pass the area. Figure 2 illustrates the locations of the construction vehicles on the train dispatcher's display.

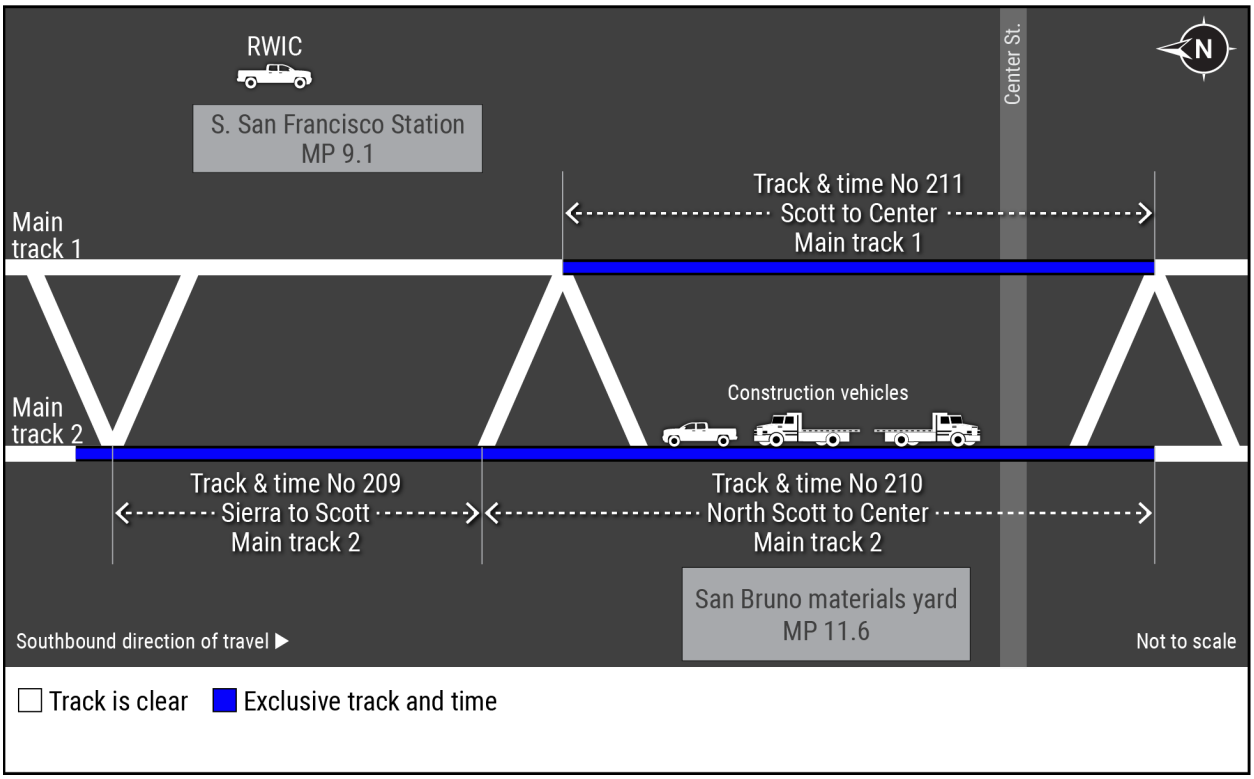

Figure 2. Location of the construction vehicles on the train dispatcher's display.

[6] *Until called* is a method of granting track and time authority until the dispatcher calls the RWIC and requests the time back, or the RWIC calls and releases the track and time authority. In either case, the track and time authority remains in effect until the proper release procedures are followed.

The SC applied a supplemental shunting device (SSD/shunt) to Main Track 2 near the Center Street grade crossing to protect the construction vehicles from highway traffic. When a shunt is applied to railroad tracks, the signal system can detect the shunt in the same way it detects the presence of a train. The shunting device also activates the grade crossing warning system to alert highway users by activating the lights, gates, and bells at the Center Street grade crossing.

About 9:49 a.m., the RWIC began a series of communications with other trains.[7] About 9:54 a.m., the RWIC contacted the dispatcher and released Track and Time Authority 211 on Main Track 1. The dispatcher then asked the RWIC to inform him when the work group was clear of the track being protected by Track and Time Authority 210. The RWIC responded that he would release Track and Time Authority 210 soon.

About 9:58 a.m., the RWIC contacted the dispatcher by phone and released Track and Time Authority 210 and Main Track 2 was no longer protected by track and time authority at MP 11.6, where the construction work group was still loading catenary poles. Caltrain procedures required communication between the SC and the RWIC before releasing track and time authority, but there was none.

About 10:00 a.m., 2 minutes after the RWIC released Track and Time Authority 210, the SC contacted the RWIC on the radio and asked for a radio check. The below table outlines the conversation between the RWIC and the SC.

Table. Conversation between RWIC and SC.

Speaker	Statement
RWIC	"MW 200 (RWIC's identifier) to SC, I have you loud and clear. What is your location?"
SC	"Subgroup Coordinator to MW 200, radio check was good, we are at 11.6, the San Bruno yard, they are picking up material."
RWIC	"Ok, 11.6, yeah, ok, great, great, uh, after you do that proceed, ah, north onto Main Track 2 down to South Francisco and you'll pick up your, ah, ah, your other individual."
SC	"Understood, once we are done here, we are going to proceed north and pick up Watchman and proceed to the work spot."
RWIC	"That is correct, thank you, sir. 200's out."

At this time, the construction work group was on Main Track 2 at MP 11.6, as confirmed by the radio communications, but there was no track and time protection for that area. The dispatcher's signal system screen indicated there were no construction vehicles in that area. Although the SC had the SSD he used earlier, he did not apply it to the track while the work group loaded catenary poles.

The SC was positioned between the pilot vehicle and the first crane when a work group employee alerted him to the oncoming train on Main Track 2. Both the SC and

[7] Of note, about 9:56 a.m., the RWIC and dispatcher began communicating with Train 112 that was needing permission to pass through the Form B-designated area on Main Track 1. Train 112 was delayed but received permission to pass through the Form B-designated area on Main Track 1 about 10:09 a.m.

work group employee alerted all employees of the impending collision. A foreman working in the crane control cab of the first crane jumped from the crane and sustained injuries.

1.2.2 Train 506

On March 10, Caltrain mechanical department employees completed inspections and tests of the equipment which would become Train 506 later that morning. The engineer went on duty at 3:45 a.m. and the conductors went on duty at 4:45 a.m.

Train 506 began its trip by departing San Francisco at the 4th and King Street Station about 10:14 a.m. on Main Track 2. The train made its only station stop before the accident at the 22nd Street Station about 10:19 a.m. Then, about 10:24 a.m., the train crossed over to Main Track 1 at CP Sierra and, about 10:30 a.m., it crossed over again to Main Track 2 at CP Scott. About 10:31 a.m., the train passed the San Bruno Station. It was traveling at 64 mph when the engineer first observed the construction equipment while in a left-hand curve on descending grade. After he ascertained the equipment was also on Main Track 2, the engineer placed the train into an emergency brake application and sounded the horn. The train slowed to 43 mph before it struck the pilot vehicle.

1.3 Personnel Information

1.3.1 Construction Work Group

The SC began working in 2015 on Caltrain property for a contractor tasked with installing catenary pole foundations. In 2018, he was hired as a watchman for Caltrain.

The RWIC was hired by the contracting firm that performs Caltrain's operations and maintenance in 2000 and has been a RWIC for about 17 years. The NTSB reviewed the RWIC's work history and records show he worked 7 days without a day off leading up to the accident. In the 5 days before the accident, each work shift was between 11 and 14 hours long. In an interview with the NTSB, the RWIC stated that although his official

40-hour schedule did not include weekends, a typical work week included 75 hours of work at a minimum, often including working on the weekends.[8]

1.3.2 Train Crew

The engineer was hired as an engineer in 2021 and was certified that same year. He had worked on the Caltrain system for about 7 months and operated along the Caltrain corridor as his regular assignment.

The conductor was hired as an assistant conductor on the Caltrain system in 1993 when it was operated by Amtrak (National Railroad Passenger Corporation). He was promoted to conductor in 1994. Serving as a conductor on the Caltrain system was his regular work assignment.

The assistant conductor was hired into that position in December 2021, and was certified in February 2022. He completed his new-hire training and rules examinations in December 2021. This was the assistant conductor's regular work assignment.

1.4 Postcollision Toxicology Testing

Postaccident toxicology testing was performed on the engineer, the conductor, the assistant conductor, the RWIC, the SC, and the dispatcher for alcohol and other drugs in compliance with Title 49 *Code of Federal Regulations* (*CFR*) 219.201. Results were negative for all tested-for substances.

[8] The Federal Railroad Administration examined biomathematical model findings for the RWIC's fatigue assessment. The Fatigue Audit InterDyne model uses an estimate for the average person whose sleep requirement is about 8 hours per night, but cannot account for individual differences in sleep needs. Because the Fatigue Audit InterDyne model calculations do not account for individual differences in sleep requirements (8 hours versus 6 hours), the NTSB relied on the factual and situation-specific workload factors in determining the human performance contributions to this accident. The FAID model uses data from populations of workers to make predictions about the likelihood that fatigue may result from different work schedules. It is a useful tool to identify work schedules that are more or less likely to lead to worker fatigue. InterDynamics, the company that makes the FAID tool, cautions against its use for making predictions about individual workers. In their paper titled, *Practical and Contextual Use of Biomathematical Models* they note, "the results of analysis using general biomathematical models in terms of estimated fatigue levels should never be interpreted as applying to any one individual." The NTSB has also described the strengths and weaknesses of biomathematical models. For example, in a 2012 recommendation letter to the Federal Railroad Administration, the NTSB said, "in general, biomathematical models have been calibrated to represent a population average rather than real-time fatigue levels of a specific individual."

1.5 RWIC Hours of Service

Investigators reviewed the RWIC's work schedule for the 16 days before the incident. These records show that the RWIC worked 15 of those days, with his last day away from work occurring 7 days before the accident. The RWIC also filled out a time record for the off day, in which he indicated he spent the day at physical therapy and various doctors' visits. In the 5 days before the accident, each work shift was between 11 and 14 hours long. In an interview with the NTSB, the RWIC stated that he had worked the previous two weekends, outside of his assigned schedule, and those shifts were nearly 15 hours each. Although his regular 40-hour schedule did not include weekends, he stated that a typical work week included 75 hours of work at a minimum, often including working on the weekends.

1.6 Policies and Procedures

Caltrain employees are required to follow three primary policies and procedures to plan construction activities and protect workers on main tracks: a "Snapshot" document, Form B, and track and time authority.

1.6.1 Snapshot Document

Caltrain uses a planning document called a Snapshot to inform operations and construction workers of the locations where single-tracking requests will be in effect each day. The Snapshot document for March 10, 2022, indicated that "Pole Install" (catenary poles) would begin at 9:30 a.m. using track and time protection on Main Tracks 1 and 2 until 4:20 p.m. The document indicated that a Form B request was submitted, and that travel and loading would occur on Main Track 2 between CP Scott and CP Center Street.

1.6.2 Form B

Caltrain uses the *General Code of Operating Rules* (GCOR), effective April 1, 2020, as the railroad's operating rules. Rule 15.2 – *Protection by Track Bulletin Form B* requires that a train must not enter the limits of a track protected by Form B unless instructed by the RWIC and that a train crew contact the RWIC at least 2 miles before reaching the Form B limits to avoid train delays. Train speed through a Form B is limited to the maximum authorized speed, or a limit set by the RWIC, whichever is lower.

Form B 7493 was granted on Main Tracks 1 and 2 between MP 8.3 and MP 9.8 from 9:00 a.m. and 4:30 p.m.

1.6.3 Track and Time Authority

Caltrain also uses track and time authority which means a segment of centralized traffic control track may be occupied by a train, work equipment, and employees under

GCOR Rule 10.3 – *Track and Time*. Caltrain enforces its track and time authority through its positive train control (PTC) system. In this process, a dispatcher can authorize a train or a work group to occupy a track within specified MP limits for a certain time period. The authorization must include the track designation, track limits, and either a time limit or the words "until called," which means it is in effect until the dispatcher calls and asks for it to be removed or the RWIC calls the dispatcher and says that it is removed. Rule 10.3 further states that the track must be released before the time expires; however, if contact is not made between the RWIC and the dispatcher, the authority is extended until the dispatcher can be contacted. When a track and time authority is released between two specific points, it means the train can be operated between those points.

Before granting track and time authority, the dispatcher must apply a "block" through the dispatching system to prevent train movement into the limits.[9] A dispatcher can only grant track and time authority if the limits are free of traffic, and the block must not be removed unless the limits have been released back to the dispatcher from the employee who received the track and time authority.

1.7 Postcollision Actions

After the collision, Caltrain communicated a safety stand down message to all employees working on the Caltrain system describing the collision and raising awareness of the risks associated with railroad construction and maintenance. Caltrain also took several additional actions as discussed below.

1.7.1 Supplemental Shunting Devices

Before the collision, Caltrain did not require an SSD to be placed on the track when equipment was stopped on the track for construction activities. Following the collision, Caltrain examined the use of SSDs and conducted field testing. Caltrain learned that SSDs were the preferred method of protection for employees working in the field. SSDs have the advantage of being applied by the worker being protected and can be visually observed to be in place. Caltrain also learned that in some locations, an SSD is not the ideal form of redundant protection due to interference with grade crossing warning devices. In these locations, Caltrain created a complementary procedure known as signal system interruption (SSI). Unlike SSD, SSI does not require an employee to physically access the track to place a device between the rails. Instead, an employee notifies a signal maintainer who enters the wayside signal bungalow and disconnects a specific wire designed to create a track occupancy indication on the dispatcher's

[9] A *block* is a track section of defined limits. In signaled territory, a block is the track section between two consecutive block signals governing movements in the same direction. It is also the track section from a block signal to the end of signaled territory.

screen.[10] The wire is then locked and tagged to prevent an unintended release of the track protection. To the dispatcher and the dispatching system, there is no difference between an SSD or an SSI track indication, the track circuit or section of track will indicate occupied. The use of SSDs and SSIs is now required by Caltrain when equipment is stopped on the track for construction activities.

A new procedure was written and implemented, and employees were trained on when, where, and how to use SSDs and SSIs for redundant signal protection. In both cases, the new procedure requires that the RWIC request track protection from the dispatcher. The RWIC then places the shunt, or the signal maintainer places the SSI, and then the RWIC calls the dispatcher to verify that the track shows as occupied in the dispatching system. Before releasing the track protection, the RWIC and a second employee verify workers and equipment are not on the track.[11] Then, the SSD or SSI is removed. These actions are verified with the dispatcher and workers in the field before the track protection is finally removed from the dispatching system.

On November 2, 2022, NTSB observed field operations at Caltrain and the use of the new SSD and SSI procedures. The SSDs were labeled with identification numbers and signed out to specific employees. The new procedures are intended to prevent a future accident by causing a red-signal (stop) indication at the control points to trains trying to enter the area, providing a positive stop redundancy in the PTC system.[12]

1.7.2 Caltrain Fatigue Risk Management Plan

After this accident, Caltrain created its Fatigue Risk Management Plan to include fatigue risk associated with long consecutive work schedules imposed on all employees, including RWICs.[13] Caltrain also worked with labor organizations and contractors to limit work hours and work shifts. Specifically, all employees are now limited to 60-hour work weeks, or less.

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[10] A *wayside signal bungalow* is a small secure shed on the side of the track that houses the signal system components.

[11] Although Caltrain rules allows any roadway worker or contractor in the work group to provide the second sign off, generally the foreman of the work group or the lead contractor signs off on releasing the track protection.

[12] *Positive stop redundancy* occurs when a positive train control or PTC system automatically applies the brakes on a train before a red signal, supplementing the actions of the engineer.

[13] As of February 8, 2024, the Fatigue Risk Management Plan is with the Federal Railroad Administration for final approval.

1.7.3 Redundant Safety Protections

Caltrain instituted a redundant safety process for dispatchers requiring them to click a checkbox verifying the release of track and time authority before its release. They also acquired software that will only allow the dispatcher to release track and time authority after both the RWIC and one other authorized person in the work group has entered a special pin code into the system.

Caltrain now requires that a RWIC be physically within the limits of track and time authority when requesting and releasing authority. They also modified On Track Safety Rule 6.3.1 to require the track and time authority form to be initialed by at least one other roadway worker/contractor in the work group confirming that they are clear of the track.

2 Analysis

2.1 Introduction

On March 10, 2022, about 10:31 a.m. local time, southbound Caltrain Train 506 struck three hi-rail construction vehicles at MP 11.6 on Main Track 2 in San Bruno, California. The locomotive derailed and all three construction vehicles were destroyed. Fuel from the construction vehicles released and inflamed a fire that spread to one of the passenger railcars. Eight people were transported to local hospitals. One railroad construction employee sustained serious injuries. One train crewmember was treated and released at a local hospital. Six passengers were treated for minor injuries and subsequently released.

2.2 RWIC Workload and Fatigue

The RWIC is responsible for managing exclusive track occupancy while also continuously monitoring the production and safety of the construction work group.

The RWIC in charge of the construction work group involved in the collision was performing many tasks simultaneously. During the 15 minutes before his conversation with the dispatcher to release Track and Time Authority 210 on Main Track 2, the RWIC had alternating conversations with the SC, train dispatcher, and train crews with little to no time between calls. During the same time period, operations in the work area were changing. Inexplicably, and inconsistent with his normal practice, he had not called the SC to get an update on the construction work group's status immediately before releasing Track and Time Authority 210.

About 2 minutes after the RWIC released Track and Time Authority 210, the SC asked for a radio check. During this radio check the SC stated they were at MP 11.6 in the San Bruno yard picking up material. This conversation was an opportunity for the RWIC to recognize that the work group was located on an unprotected segment of track that had been released and that the work group was not planning to move until the

materials were loaded. That conversation, however, did not alarm the RWIC, suggesting that he was not aware that he had just released track and time authority on Main Track 2 and that the workers in that area were no longer protected. This incident suggests that the RWIC's high workload caused a decrement in his performance that resulted in his loss of awareness of where he was in the process of providing protection for the work crew.

Research on the effect of multitasking on human performance indicates that adding additional tasking to the current activities increases overall cognitive load and impairs performance for both the primary and secondary tasks (Strayer and others 2015) (Owens and others 2018). Specifically, excess workload can result in human performance errors such as slips (a failure of execution or control, for example, substituting one action for another one in a procedure) and lapses (a failure of memory, including where you are in a procedure).[14] In this collision, the detrimental effects of high workload in the days before the collision and the minutes immediately before the collision likely affected the RWIC's ability to perform all tasks effectively.[15] His duties required him to quickly integrate information from multiple sources and make subsequent decisions managing railroad operations. When train and equipment movement were fluctuating and at their busiest, the RWIC lost track of where he was in the process of managing multiple operations and released Track and Time Authority 210 where workers and equipment were positioned on the main track.

In the days leading up to the collision, the RWIC worked 7 consecutive days without a rest day, with some days reaching as many as 14 hours per day. However, this was not the only factor the NTSB took into consideration when evaluating whether he was fatigued.

Several factors that could result in fatigue were eliminated in this investigation. Specifically, over the last several weeks before the collision, the RWIC's schedule did not rotate between day and night shifts. He regularly worked during the day and his on-duty start time never varied by more than an hour. He maintained a set sleep schedule at night and consistently achieved his required amount of sleep to feel rested. He had no medical condition nor was he taking any medications that affected his alertness level. In an interview with the NTSB, the RWIC said that he felt alert on the morning of the accident. He had been on duty for only 4 hours when he mistakenly released the track. The time of that error (about 10:00 a.m.) coincides with a period of peak alertness for daytime workers. After considering all of these factors, the NTSB determined that there

[14] *Slips* and *lapses* are errors which result from some failure in the execution and/or storage stage of an action sequence. These types of errors are more likely to occur when steps in a procedure do not follow naturally or when there are distractions and interruptions in the task.

[15] As workload increases beyond an optimal level, stress also increases, which is associated with an overall loss or decrement in ability to perform complex operational tasks.

was no compelling evidence that the RWIC himself was fatigued at the time of the collision.

However, the NTSB also found that the RWIC's work schedule was conducive to fatigue, meaning that discounting individual differences, such a schedule would likely lead to fatigue in workers in general. The issue of fatigue was discussed in the NTSB's December 27, 2023, response to the Federal Transit Administration's advanced notice of proposed rulemaking titled *Transit Worker Hours of Service and Fatigue Risk Management* (NTSB 2023). In this response, the NTSB cited research from the Transit Rail Advisory Committee for Safety (TRACS) that found that working at least 12 hours a day was associated with a 37 percent increased hazard rate. Data in the TRACS report also suggests that 15-hour duty days, particularly over multiple days, are likely to result in fatigue-related errors and injuries and that an 8-hour off-duty period is not sufficient to allow for adequate sleep (TRACS 2014). In our response, the NTSB highlighted several investigations from the past 20 years in which fatigue was determined to be a factor (NTSB 2006, 2012, 2015, 2020).

Since the accident, Caltrain created a draft Fatigue Risk Management Plan to address fatigue risk associated with long consecutive work schedules imposed on all employees, including RWICs.[16] Caltrain employees are now limited to 60-hour work weeks, or less. After this collision, Caltrain also added levels of safety redundancy to include a dual sign off for the release of track and time authority and acquired software that requires the RWIC and one other authorized person to enter a special pin code into the system before the dispatcher can release track and time authority.

2.3 Roadway Worker Protection

The San Bruno collision is an example of train movement into an area where workers were present and not protected on the track, unbeknownst to the workers, the train crew, dispatcher, and signal system. To the dispatcher and the signal system, the route appeared clear and available for train routing. Had an engineering control, such as a shunt, signal system interruption, or other technology been used as a redundant protection, the signal system and PTC overlay could have prevented the train from entering the track section occupied by workers and equipment, and the collision likely would not have occurred.[17] After the accident, Caltrain required the use of SSDs and SSIs as redundant signal protection, implemented a corresponding procedure, and trained

[16] As of February 8, 2024, the Fatigue Risk Management Plan is with the Federal Railroad Administration for final approval.

[17] *Engineering controls* eliminate or reduce exposure to a physical hazard through the use or substitution of engineered safety features such as equipment.

employees on when, where, and how to use SSDs and SSIs. These engineering controls will ensure that a similar collision will not result from a single employee error.

3 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident is the roadway worker-in-charge releasing exclusive track occupancy protection leaving workers and construction equipment unprotected on the main track due to his degraded performance from excessive workload.

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The NTSB is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in the other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties … and are not conducted for the purpose of determining the rights or liabilities of any person" (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)).

For more detailed background information on this report, visit the NTSB Case Analysis and Reporting Online (CAROL) website and search for NTSB accident ID RRD22MR007. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting –

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