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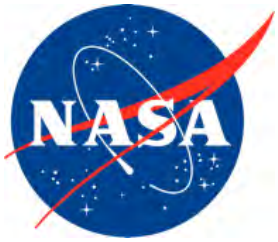

# Positive Train Control (PTC) Study: An Analysis of PTC-Related Reports Submitted to the Confidential Close Call Reporting System ($C^3RS$)

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August 2021

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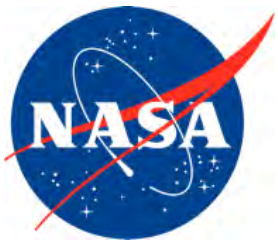

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C³RS 2021-1

# PTC

## Positive Train Control Study:

An analysis of PTC-related reports submitted to the Confidential Close Call Reporting System (C³RS)

August 2021

CONFIDENTIAL CLOSE CALL REPORTING SYSTEM

Contact: Becky Hooey, C³RS Director, Becky.L.Hooey@nasa.gov

# EXECUTIVE SUMMARY

The Rail Safety Improvement Act of 2008 (RSIA) mandated the implementation of Positive Train Control (PTC) systems on Class I railroads' main lines, which consist of over five million gross tons of annual traffic, transportation of certain hazardous materials, and intercity / commuter rail passenger transportation. After two extensions by Congress, full implementation was required by December 31, 2020. PTC technology is designed to prevent:

- Train-to-Train Collisions
- Over-Speed Derailments
- Incursions into Established Work Zones
- Movements of Trains through Switches Left in the Wrong Position

The purpose of this Confidential Close Call Reporting System ($C^3RS$) study was to learn about the potential operational risks associated with PTC focusing on the integration and operation of PTC systems. Studying the reported $C^3RS$ close-call events regarding PTC was expected to yield information about the risks that may be present in the operation of PTC systems. Generally, this research set out to accomplish three things:

- Demonstrate the usefulness of $C^3RS$ data analyses
- Define a process for determining safety issues derived from data
- Outline specific strategies to identify and help mitigate operational risks of PTC

### *Technical Approach*

A Supplemental Question Set (SQS) was developed in collaboration with the FRA and the NASA $C^3RS$ team. The SQS was a dynamic set of questions adapting to the responses of the participants. A total of up to 45 questions were asked when applicable. The SQS focused on following five topics:

- PTC Close-Call Event
- General PTC Experience and Training
- PTC Failures and Faults
- Human-System Interaction
- PTC Acceptance

The SQS was conducted during telephone callbacks to reporters who submitted a qualifying PTC-related report. Participants invited to answer the SQS were identified by $C^3RS$ Expert Analysts after submitting a qualifying report. Qualifying reports were identified during the $C^3RS$ screening process. A qualifying close-call event was identified as including an 'On Board System' anomaly with PTC being the primary cause. The report was then assigned to the Expert Analyst to process and conduct a callback. During the callback, the reporter was invited to participate in the PTC SQS. Like the $C^3RS$ program, the SQS was voluntary and a reporter could refuse to participate. A total of 40 reporters completed the SQS.

### *Findings*

After the completion of the callbacks and SQS, the NASA $C^3RS$ team analyzed the data and identified four areas that may merit further investigation by FRA and rail carriers:

- System/Paperwork Synchronization
- Training
- PTC Acceptance
- Display/Alerts

The four themes are discussed in the conclusion section of the study. The findings in this report provide insight into PTC implementation issues, which, if addressed, may help ensure the continued safe use and implementation of PTC within the rail industry.

# TABLE OF CONTENTS

# 1.0 INTRODUCTION

## 1.1 Confidential Close Call Reporting System ($C^3RS$)

The Confidential Close Call Reporting System ($C^3RS$) is a partnership between the National Aeronautics and Space Administration (NASA) and the Federal Railroad Administration (FRA), in conjunction with participating railroad carriers and labor organizations. The program is designed to improve railroad safety by collecting and analyzing reports that describe close-call events in the railroad industry. Employees are encouraged to report safety concerns or "close calls" voluntarily and confidentially. NASA $C^3RS$ Expert Analysts disseminate safety alerts, newsletters, and bulletins to communicate safety concerns to railroad carriers.

While individual reports submitted to $C^3RS$ are confidential, the information from these reports are analyzed by $C^3RS$ Expert Analysts to provide the railroad community insights into system-wide safety issues that can be proactively addressed. This report describes the results of a study conducted by NASA $C^3RS$ to understand the operational risks associated with the introduction of Positive Train Control (PTC) technology and help ensure safe implementation industry wide.

## 1.2 Positive Train Control Background

The Rail Safety Improvement Act of 2008 (RSIA) mandated the implementation of PTC systems on Class I railroads' main lines, which consist of over five million gross tons of annual traffic, transportation of certain hazardous materials, and intercity / commuter rail passenger transportation. After two extensions by Congress, full implementation was required by December 31, 2020. PTC technology is designed to prevent:

- Train-to-Train Collisions
- Over-Speed Derailments
- Incursions into Established Work Zones
- Movements of Trains through Switches Left in the Wrong Position

PTC systems must also provide for interoperability in a manner that allows for equipped locomotives traversing other railroad's PTC-equipped territories to communicate with and respond to that railroad's PTC system, including uninterrupted movements over property boundaries.

PTC systems require FRA approval prior to implementation. According to the FRA's website, there are 10 types of PTC for which railroad operators can seek approval. Of the carriers participating in $C^3RS$, only four types of PTC are in use:

- **ACSES / ACSES II –** Transponder-based train positioning system. It is a vital overlay used to support 150 MPH operations and is used by multiple northeast commuter agencies. ACSES II is an upgraded ACSES system with integrated Realtime Temporary Speed Restrictions and Radio Communication data transfer.
- **ITCS –** Communication-based signaling system overlay used to support 110 MPH operation. ITCS uses GPS-based train positioning.

- **E-ATC –** A system that uses an underlying automatic train control (ATC) system, in conjunction with other "enhanced" features or systems to achieve the core required functionalities of PTC. These systems are often integrated with underlying cab signal systems (CSS) and centralized traffic control (CTC) systems, in addition to other signal or train control system enhancements the railroad elects to make, to meet the full requirements of PTC.
- **I-ETMS –** GPS and communication-based system that communicates with the wayside signal system, as well as back-office systems. I-ETMS supports up to 90 MPH operation and allows for GPS-based train positioning. The system also provides a freight train braking algorithm based on actual consist.

## 1.3 Study Objectives

The objective of the special study was to learn about the potential operational risks associated with the introduction and use of PTC technology. Studying the reported close calls regarding PTC can yield information about the risks that may be present in the operation of PTC systems.

Generally, this research set out to accomplish three things:

- Demonstrate the usefulness of $C^3RS$ data analyses
- Define a process for determining safety issues derived from data
- Outline specific strategies to identify and help mitigate operational risks of PTC

# 2.0 METHOD

To augment the submitted $C^3RS$ report, a Supplemental Question Set (SQS) was developed and implemented via a telephone call-back with qualifying $C^3RS$ reporters. The purpose of the SQS was to determine potential safety issues related to the integration and operation of PTC systems, which if mitigated may potentially prevent an incident or accident in the future.

## 2.1 Supplemental Question Set Development

The SQS was developed in conjunction with FRA and subject matter experts to query railroad employees that submit close call reports to NASA. It was developed collaboratively with input from FRA Human Factors Research Division, Rail Safety Partnerships Division, and Signal and Train Control PTC Division; as well as NASA $C^3RS$ Expert Analysts and Human Factors, and input from participating carriers.

The SQS was dynamic, with questions adapting based on responses and up to a total of 45 questions in length. The PTC SQS addresses the following topics (see full SQS in **Appendix A**).

- PTC Operation at the time of the Close-Call Event
  - PTC Status
  - PTC Initialization
  - PTC Event

        - Failures, Recovery, Alerting, Violation of Restrictions
    - PTC Training
        - Amount, Timeliness, Adequacy
    - PTC Failures and Faults
        - Frequency, Source of Failure/Fault, Recovery
    - Human-System Interaction Issues
        - Confusion, Distraction, Effectiveness
    - PTC Acceptance
        - Train Handling, Reliance, Workload, Improvement Areas

## 2.2 Supplemental Question Set Implementation

In September 2020, C$^3$RS began conducting the SQS. Implemented by telephone and conducted by a C$^3$RS Expert Analyst, the SQS was completed following standard C$^3$RS callback procedures. The SQS was a dynamic question set, with questions adapting based on responses, with a potential of 45 questions in total. The SQS required approximately 30 minutes to complete. Any Engineer or Conductor who submitted a C$^3$RS report regarding a PTC-related incident was invited to participate in the SQS. Conductors were included only on a case-by-case basis depending on operational experience with PTC. Repeat reporters to C$^3$RS were only eligible to participate in the SQS once.

In total, 95 qualifying reports were submitted to C$^3$RS between September 14, 2020 and March 31, 2021. Of these 95 qualifying reports, a total of 40 reporters agreed to complete the SQS, 8 declined, and 47 did not return the Expert Analyst's call.

## 2.3 Data Caveats

Before presenting the findings of this study, it is important to note that SQS participation was voluntary and thus subject to reporting biases. Study participants were selected based on qualifying submissions to C$^3$RS. Since reports are voluntarily submitted, they cannot be considered a random sample of the full population of like events.

Not all railroad carriers participate in C$^3$RS. To date, there are 19 carriers participating. The majority are passenger operations and there are no Class 1 carriers in the program. Of the participating carriers, not all employees are equally aware of the C$^3$RS program or may be equally willing to report. Also, not all PTC system types are equally represented in the data set.

Reporting biases, which are not fully known or measurable, may influence C$^3$RS information. Experience and exposure to PTC may influence willingness to participate and responses. One may be more, or less, inclined to participate if they have had a particularly negative or positive experience with PTC. With these statistical limitations in mind, the real power of C$^3$RS data is the qualitative information contained in report narratives and SQS responses.

C$^3$RS reports may be clarified by further contact with the individual who submitted them, but the information provided by the reporter is not investigated further. Such information represents the perspective of the individual who is describing their experience and perception of a safety related event.

# 3.0 FINDINGS

The findings presented in the following sections include a summary of the C$^3$RS Expert Analyst Full Form Analysis data, as well as responses to the SQS questions.

## 3.1 Full Form Analysis / Coding Form Data

The Full Form Analysis data include data reported by the individual at the time the original C$^3$RS report was submitted, as well as additional values selected by the C$^3$RS Expert Analyst during full form processing of the C$^3$RS report. C$^3$RS Standard Operating Procedure (SOP) definitions for the fields selected in this study can be found in **Appendix B**.

The following coding form data fields are highlighted below:

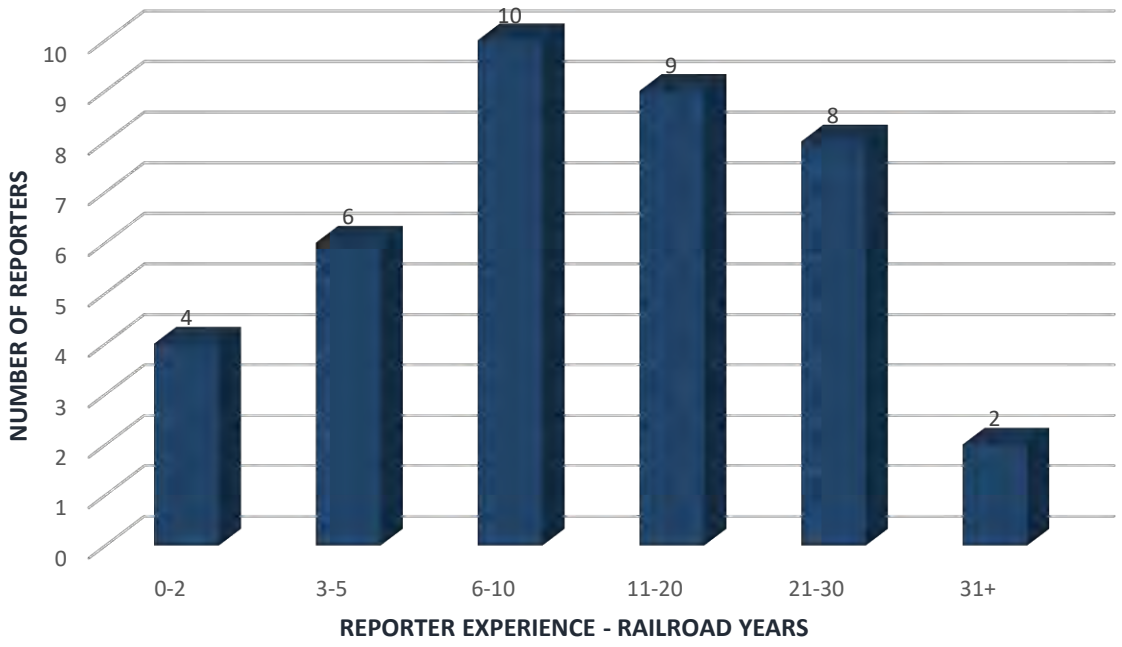
- Demographic Information: Experience, Shift, Reporter Location
- Anomaly or Event Type
- Contributing Factors
- Human Factors

The coded data provide a better understanding of the close-call events that qualified the reporters for the PTC SQS.

## Reporter Experience – Railroad Years

The majority (74%) had between 6 and 31 years of railroad service. A small percentage (10%) had two or less years of experience (see **Figure 1**). The reporter experience in railroad years is provided on the report form by the reporter when submitting the original $C^3RS$ report. The reporters who provided responses to the SQS demonstrated a broad distribution of railroad experience.

**Figure 1:** ***Reporter Experience - Railroad Years***




Note: n=39. One reporter did not provide railroad experience.

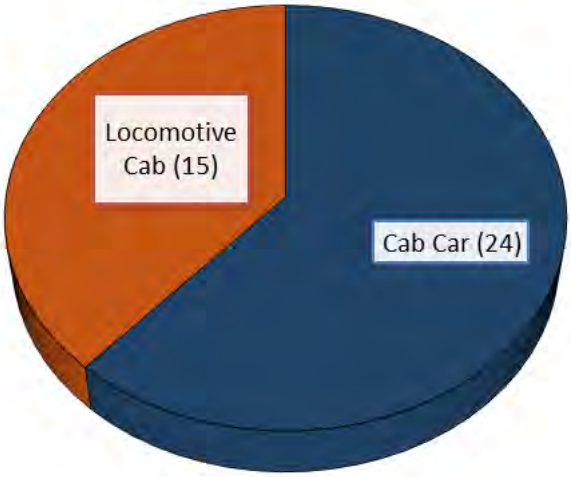
## Reporter Shift / Reporter Location

PTC SQS participants were operating on their regular start job at the time of the reported event in 70% of the 40 records (see **Figure 2**). Additional data provided by the reporters show that 62% (24) of the reporters were in a cab car controlling situation versus 38% (15) were operating the train from the actual locomotive (see **Figure 3**).

**Figure 2: *Reporter Shift***


Note: n=40

**Figure 3: *Reporter Location***

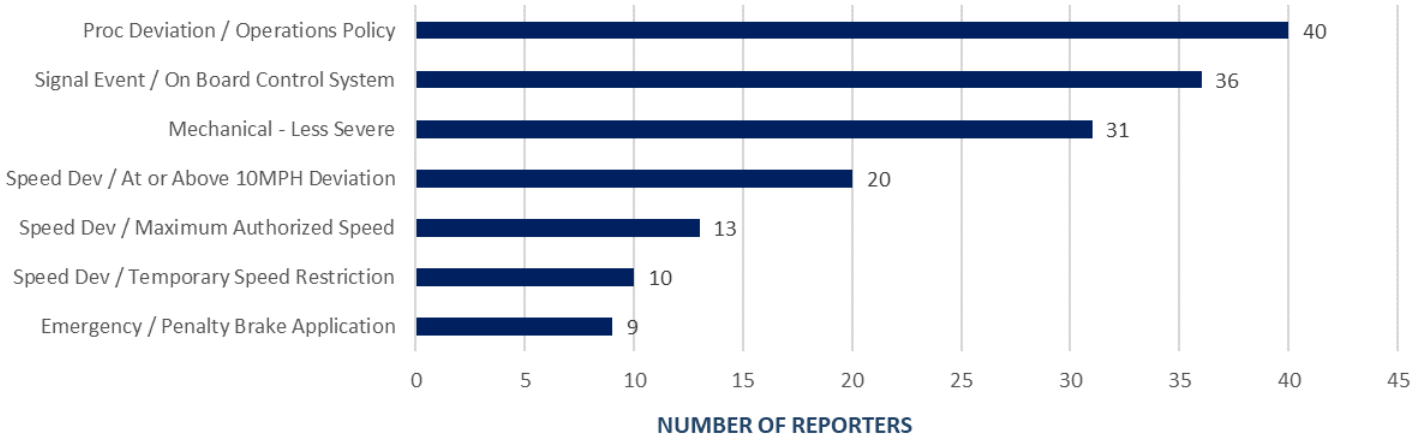



Note: n=39. One reporter did not provide location information.

## Anomaly / Event Type

The anomaly or event type is coded by C[3]RS Expert Analysts during Full Form analysis using a defined taxonomy of event types (See **Appendix B**). The majority of the incidents reported in this data set were coded as Signal Event / On Board Control System events (90%), (see **Figure 4**). Of these, 31 of the 36 Signal Events were also coded as Mechanical – Less Severe. Half of the events involved a speed deviation of at or above 10 MPH. Emergency / Penalty Brake Applications were coded in conjunction with Mechanical – Less Severe events 8 out of 31 times.

**Figure 4: *Anomaly***

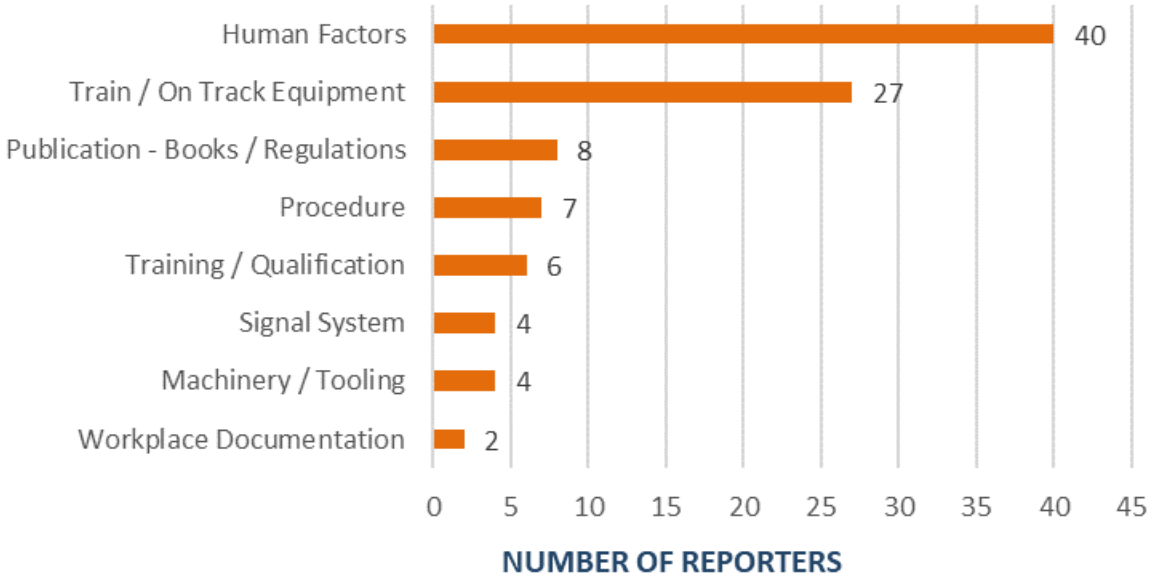



Note: n=40. Not Mutually Exclusive.

## Contributing Factors

As shown in **Figure 5**, Human Factors were coded as a contributing factor in all 40 records. This can be expected as C[3]RS Expert Analysts select more than one Contributing Factor and the majority of reports relate to human factors / mistakes. Train / On Track equipment was also coded in 27 of the events. Other contributing factors included: Publications - Books/ Regulations, Procedure, Training/Qualification, Signal System, Machinery/Tooling, and Workplace Documentation**.**

**Figure 5: *Contributing Factors***



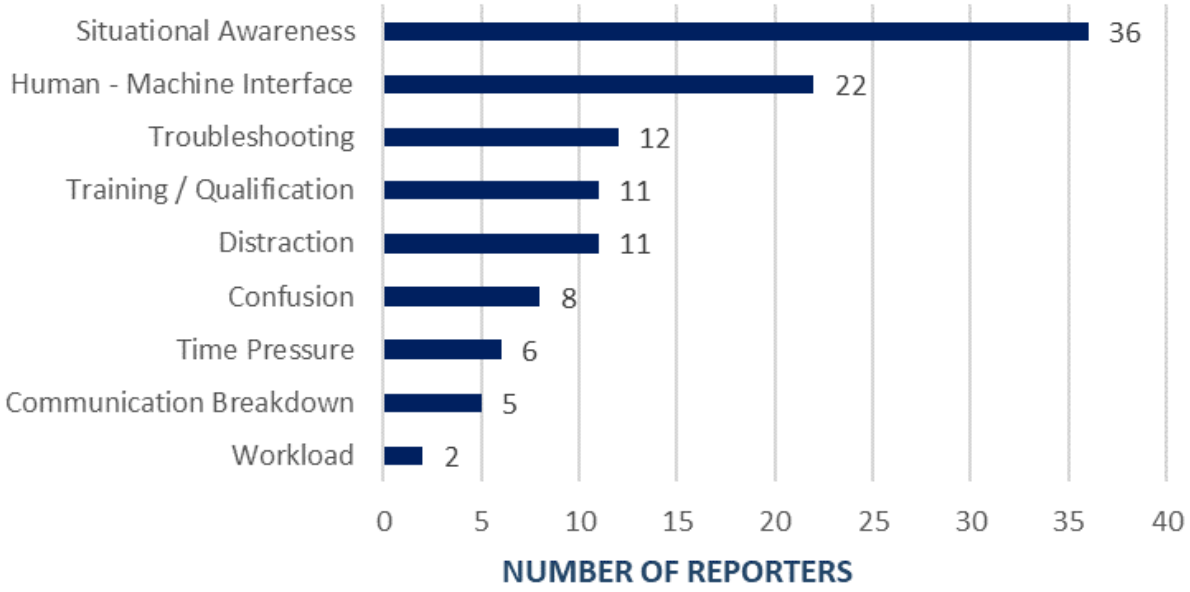

Note: n=40. Not Mutually Exclusive.

## Human Factors

With human factors being coded in all 40 records, it is important to further understand what is included in this category. Nine human factors were coded by the C$^3$RS Expert Analysts when reporters reference one or more human factors in their narrative (see **Figure 6**). The majority of these reports relate to Situational Awareness issues which include being aware of what is happening around them and understanding how information, events, and the reporter's own actions will impact his or her goals and objectives, both now and in the near future.

Over half of the reporters mentioned problems in their interaction with hardware and / or software while operating the train. An Expert Analyst selects this when a reporter references issues with equipment design, ergonomics, or interaction with computers or controls.

**Figure 6: *Human Factors***




Note: n=40. Not Mutually Exclusive.

## 3.2 Supplemental Question Set Results

The SQS Results section provides a summary of the additional questions (up to 45 if relevant) asked of the reporters during the SQS callback. The following results are broken down into the following main topics:

- PTC Operation at the time of the Close-Call Event
- PTC Training
- PTC Failures and Faults
- Human-System Interaction Issues
- PTC Acceptance

### PTC Operation at the Time of the Close-Call Event

Questions 1-16 in the SQS included a series of questions that specifically had to do with PTC operation at the time of the close-call event reported to $C^3$RS.

#### *Q1. What was the PTC related close-call event?*

In addition to the Anomaly selected by the Expert Analyst (**Figure 4**), the reporter was asked to describe the PTC event during the SQS. These events are presented in **Tables 1** and **2** and grouped by System Factors (PTC system acted differently than expected) and Human Factors (human took an action while manipulating PTC). As shown below, the majority of events were PTC System related issues.

**Table 1. PTC System Related Events**

| |
|---|
| PTC dropped out and failed to enforce speed restriction. |
| PTC-related switches were not properly sealed causing a system malfunction. |
| PTC dropped out and put train into penalty. |
| PTC system did not acknowledge TSR due to system error. |
| PTC system did not acknowledge TSR (scheduled outage per bulletin); overspeed in a TSR. |
| PTC went into penalty when making a shoving movement. |
| PTC system applied a penalty for crossover. After recovering, PTC showed Max Speed of X MPH; however, train still was in a Y MPH speed restriction. |
| PTC system would not allow train to blow horn through road crossing. |
| Cab Signal failure caused a related PTC failure. |
| PTC malfunctioned during a speeding event. |
| PTC failed to enforce a stop indication at an interlocking. |
| PTC wouldn't reset from unknown penalty; had to cut-out PTC en route and may have over sped through curve. |
| PTC did not return to the proper mode after leaving specified area. Engineer had to stop and recycle the breaker. Engineer may not have run a departure test. |
| PTC display not working as intended when entering PTC Territory and was overspeed. |

| |
|---|
| Engineer cut out PTC on territory due to audible indicator and display showing incorrect mode. |
| PTC failed when departing the initial terminal. Crew was ordered to depart without active PTC, which is against the rules. |
| Engineer cut out PTC en route due to malfunctioning PTC. |
| Train Crew cut out PTC en route due to a failure. |
| Engineer cut out PTC en route due to system “dropping out” constantly. |
| PTC failed en route and had to be cut out. Engineer was unsure what the correct cut-out rule was. |
| PTC didn't accurately pick up a speed restriction. |
| Engineer cut out PTC en route (2). |
| PTC would not recognize the proper speed limit and put train into penalty. Engineer couldn't reset the penalty and had to cut out PTC. |
| PTC did not pick up a Temporary Speed Restriction. |
| PTC system malfunctioned and prevented system from working as intended; system was cut out. |
| PTC system failure en route required a cut out. |
| PTC failure; Engineer cut out en route. |
| Train was overspeed in a TSR; PTC malfunctioned. |
| Malfunctioning PTC caused a distraction for Engineer. |
| PTC dropped out and had an unknown failure. Engineer had to disengage system (not cut out). Train went overspeed in a restriction. |
| PTC system dropped out (disengaged) during a TSR and caused a distraction. PTC failed to enforce a TSR. |

**Table 2. Human Factors Related Events**

| |
|---|
| Train Crew did not realize that Lead controlling cab was PTC equipped and did not operate with system initialized. |
| Engineer did not disengage PTC system the correct way. This caused PTC to not operate correctly when re-engaging the system again. System stayed in “non-active” mode. |
| Engineer did not select correct location on PTC system when entering PTC territory. |
| Train reported going overspeed while testing PTC system. |
| PTC was cut out on territory due to a failure; train went overspeed. |
| PTC system did not engage and operate as intended while in a terminal. |
| Engineer did not realize PTC was cut out by Mechanical Department. Company rules required PTC to be in effect. |
| After experiencing malfunctioning PTC, Engineer improperly cut out PTC system. |

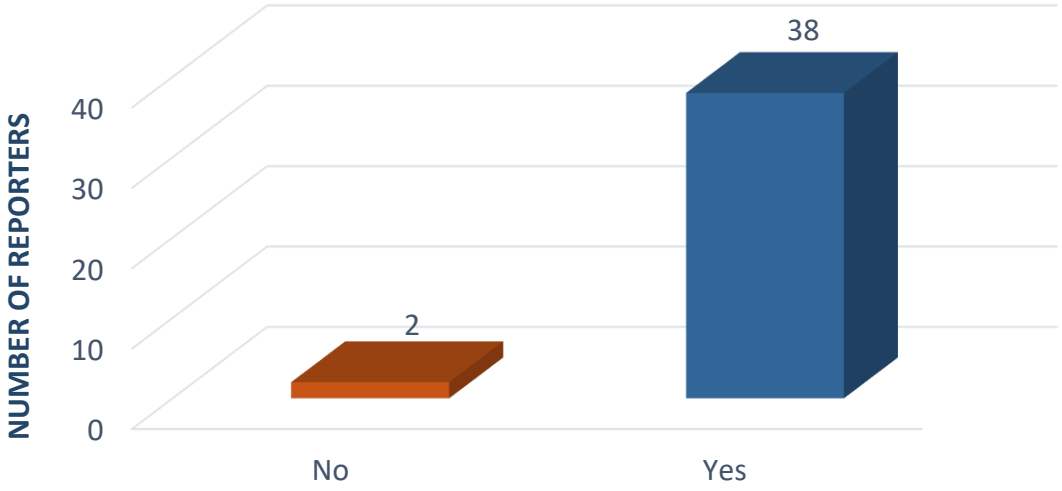
*Q2. Was PTC in effect on your territory?*

On the day of the C$^3$RS-reported event, all 40 participants stated that PTC was in effect and working on the territory they were operating. It should be noted that C$^3$RS began conducting callbacks for the PTC study on September 14, 2020 and concluded callbacks on March 31, 2021. Participants in the PTC study prior to December 31$^{st}$ were not required to have PTC active on their trips, while participants after December 31$^{st}$ were required to have PTC active when departing initial terminals. This was due to the FRA deadline of December 31, 2020 that required all Class 1 and passenger railroads to have a PTC system fully implemented and active on all trains departing initial terminals.

*Q3. Was PTC in effect / cut-in on your train and working to your knowledge?*

The majority of reporters (95%) responded "yes" when asked if PTC was in effect / cut in and working to their knowledge as shown in **Figure 7**. Two reporters answered that PTC was not in effect / cut in at the time of the reported event. This was due to a scheduled outage that was covered in their bulletins and Job Safety Briefing. Both reporters stated they were relying on PTC to alert them of a Temporary Speed Restriction; however, they never received the alert since the restriction was within the planned outage limits (see Examples of "No" scenarios provided below).

**Figure 7*: Was PTC in effect / cut in on your train and working to your knowledge?***




Note: n=40.

*Q4. What type of PTC were you using?*

The majority of participants in the SQS used the ACSES/ACSES II system (35), while a smaller number used I-ETMS at the time of the event.

*Q5. On the day of your reported event, did your Onboard System initialize as expected?*

All 40 participants stated "yes" when asked "did your Onboard System initialize as expected"; therefore, the participants **skipped questions 6-8** which were the following:

- Question 6: What initialization issues did you have?
- Question 7: Did you have enough time to troubleshoot and resolve it?
- Question 8: Did you have to depart prior to initialization?

There were no reported issues with initialization when asked if the Onboard System initialized as expected. Initialization depends on the PTC system used (not all require it) and the process determined by each carrier. Some of the participants stated that the carrier's mechanical department handles the initialization prior to the crew boarding the train.

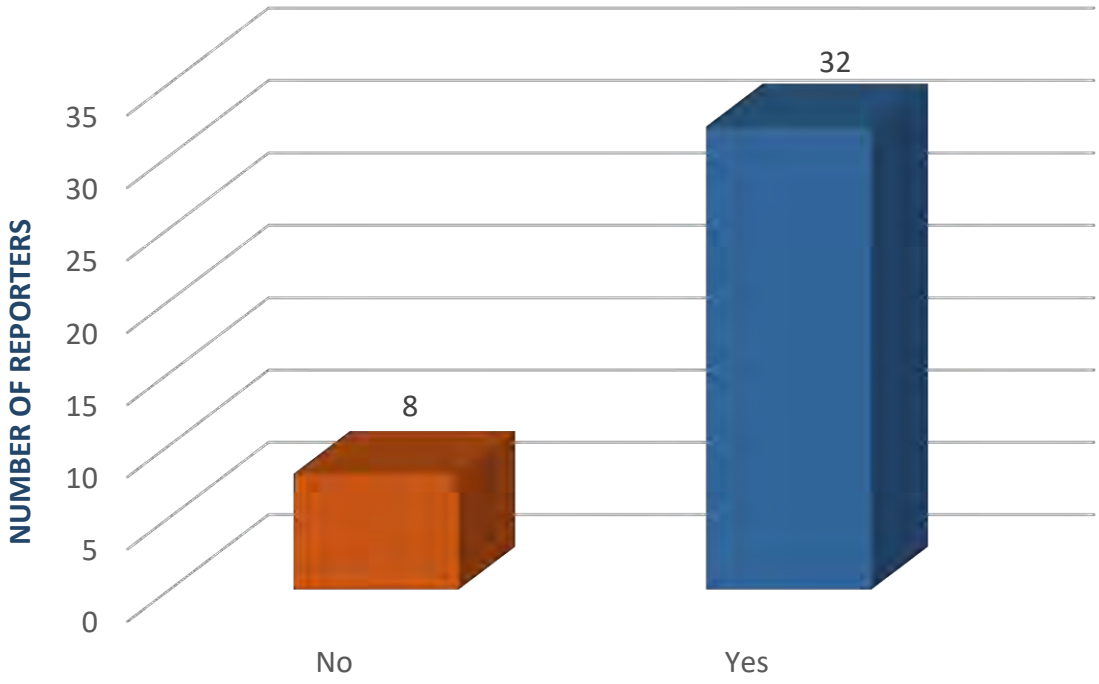
*Q9. Did restrictions in PTC Accurately reflect your paperwork?*

As seen in **Figure 8**, 32 participants responded that the restrictions in PTC did accurately reflect the paperwork and 8 said that they did not match. It should be noted that not all PTC systems have the capability of previewing restrictions for crews to compare against their paperwork. Crews would not be aware of any inconsistencies until they were en route to their destination and at the location of a known restriction.

The reporters who answered that the PTC did not accurately reflect their paperwork provided the following explanations:

- "Speed restrictions did not match actual locations."
- "The system is more like Cab Signals; you can't compare restrictions. The system doesn't cover TSRs."
- "Train [PTC system] showed X MPH when [restriction] was actually Y MPH."
- "Phantom restrictions that aren't on paperwork appear."
- "PTC system enforces alternate track restrictions."
- "[PTC] system was missing a TSR in effect."
- "[PTC system] doesn't show restrictions."
- Final reporter was unable to recall what was wrong with the paperwork.

**Figure 8*: Did the restrictions in PTC accurately reflect your paperwork?***

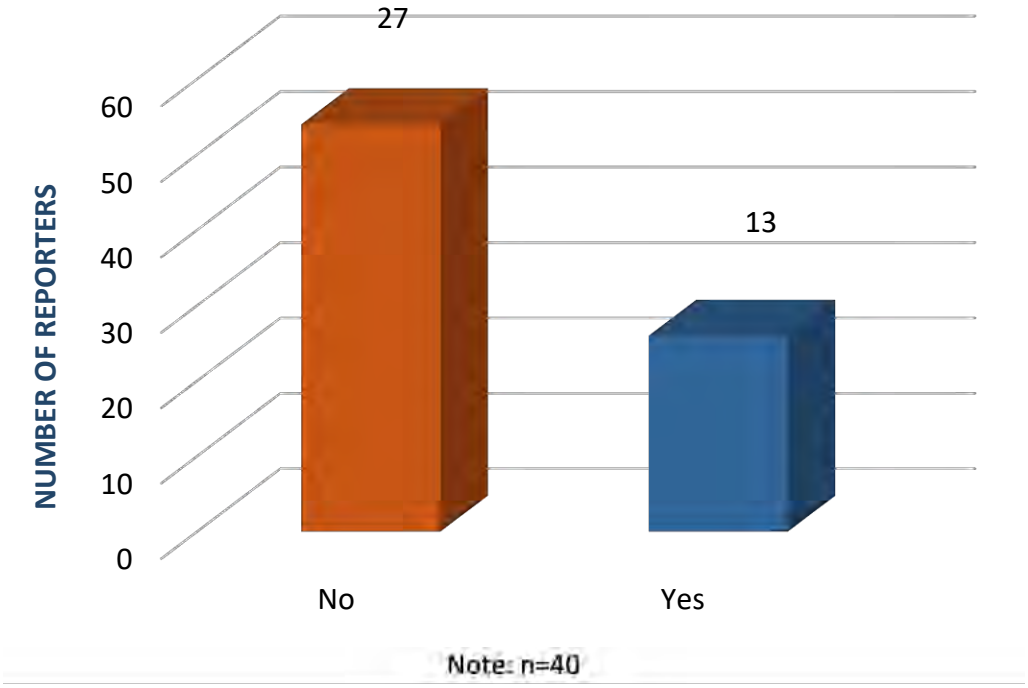



**Note: n=40**

*Q10. Did PTC Work as intended?*

Although PTC was in effect and initialized, 68% of respondents still noted that PTC did not work as intended (see **Figure 9**). The issues ranged from PTC not picking up transponders to the audible alert system not working and getting unknown penalties. The most concerning example was that PTC failed to enforce a stop indication, which is a fundamental requirement for PTC systems.

**Figure 9*: Did PTC work as intended?***



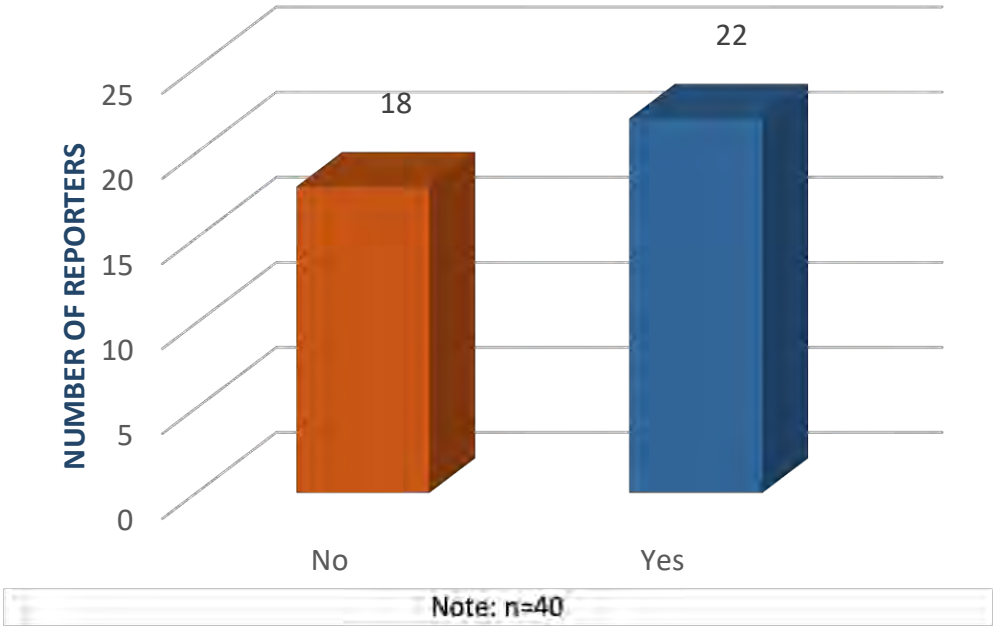

Reporters provided the following explanations for why PTC did not work as intended:

- "PTC wasn't picking up transponders…"
- "PTC failed to enforce stop indication."
- "…PTC didn't pick up the restriction correctly."
- "No; In and out of construction mode, kept dropping out."
- "Multiple faults and failures...."
- "PTC went into unknown penalty and couldn't be reset."
- "Unknown penalty and PTC wouldn't let system recover."
- "PTC acted as if it had a stop indication at every signal even if it was a proceed."
- "Audible alert system did not work as intended, kept going off."
- "System disengaged en route in a TSR."

*Q11. Did you experience a PTC failure? If yes, respond to Q12-16.*

Reporters were asked if the close-call event also included a PTC failure. Out of 40 participants, 22 stated they experienced a PTC failure, requiring that PTC be cut out. Almost half of the reporters (45%) said the reason for the failure was unknown but mentioned the PTC system would not recover from the penalty. Engineers do not always understand the reasons for a PTC failure and may be told to cut the system out in order to proceed (see **Figure 10**).

**Figure 10*: Did you experience a PTC failure?***

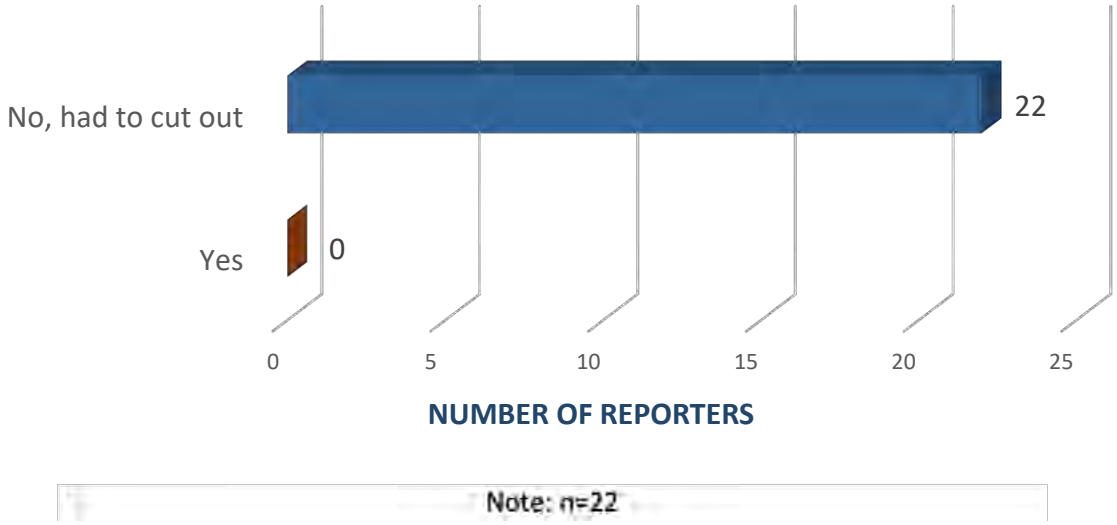


*Q12. Did you recover from the PTC failure?*

While completing SQS callbacks, it was determined that the terms fault and failure were defined and interpreted differently between carriers and Engineers. Some carriers considered a fault as a reason for PTC to be cut out, while other carriers required multiple consecutive faults for PTC to be cut out. It was also found that Engineers interpreted the two terms as the same and considered them interchangeable depending on their knowledge and experience with PTC. In addition, participants who operated on foreign carrier territories mentioned a foreign carrier may define faults and failures differently, and the reporters were unaware of the differences or how to handle those situations. For the purposes of the study, if PTC was cut out and could no longer be used for the operation of the train, this was deemed a failure. Any occurrence from which an Engineer could recover, would be considered a fault since PTC was allowed to remain cut in and operational.

All participants that experienced a PTC failure in Question 11 (n=22) were next asked "did you recover from the PTC failure?". All 22 participants reported that they were required to cut out PTC to continue operating the train (see **Figure 11**).

**Figure 11: *Did you recover from the PTC failure?***




Note: n=22

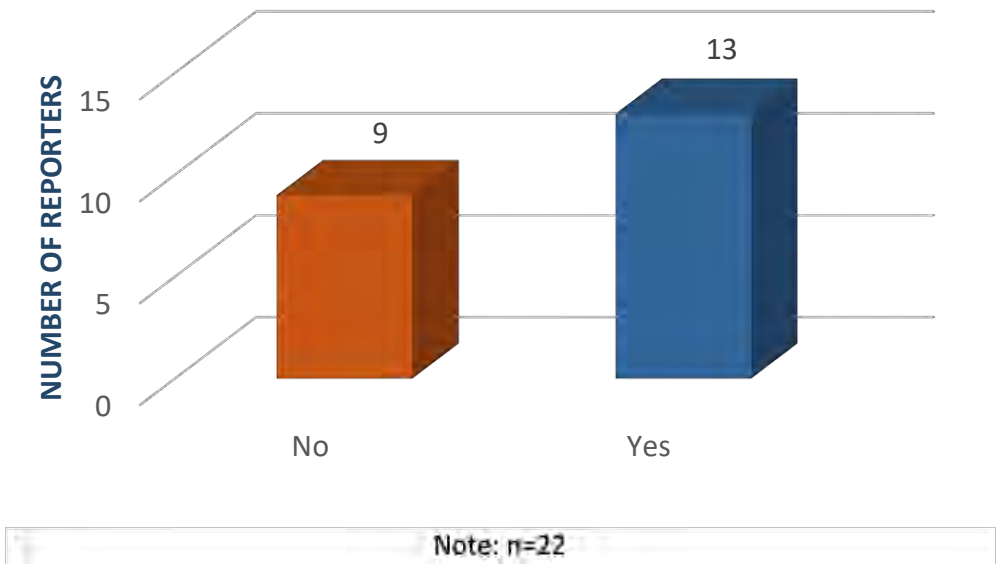
*Q13. Did PTC provide an understandable alert (visual or audible tone) prior to incident?*

PTC systems are designed to give the operator an audible and/or visual alert when there is a change required by the system. Of the 22 reporters who experienced a PTC failure (Q11), the majority of participants (59%) responded "yes" that they did receive an understandable alert prior to the failure. However, 2 of the 13 mentioned that although it was understandable, the alert was *not correct* for the situation.

Nine reporters stated they did not receive an understandable alert and PTC enforced a restriction without any alerts or prior warning.

In two incidents, the reporter only received audible alerts, while in another incident the reporter only received a visual alert. These three participants were included under "yes" – PTC provided an understandable alert (see **Figure 12).**

**Figure 12*: Did PTC provide an understandable alert prior?***

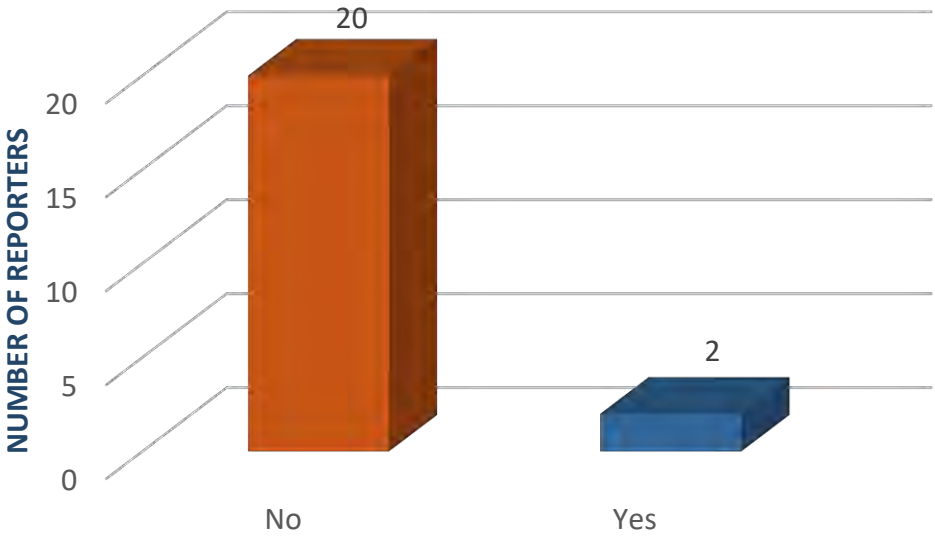


*Q14. Was there a violation of a speed restriction or work zone limits before PTC enforced a penalty? If yes, answer Question 15.*

Of the 22 reporters who reported a failure in Question 11, the majority of participants (91%) already had PTC cut out; therefore, the reporters responded "no" to "was there a violation of a speed restriction or work zone limits before PTC enforced a penalty?" (see **Figure 13**).

Two reporters answered there was a violation of a speed restriction or work zone limits. Both reporters stated that PTC was active and cut in at the time of the incident; however, the system failed to enforce a penalty or provide any type of alert and the train operated through the entire restriction. The incident led to PTC subsequently being cut out and considered a failure.

**Figure 13*: Was there a violation of a speed restriction or work zone limits before PTC enforced a penalty?***



*Q15. How far into the restriction did you operate before PTC enforced a penalty?*

The two reporters who answered that there was a violation of a speed restriction or work zone limit in Question 14 were asked how far they operated into the limits before PTC enforced a penalty. Those two participants stated that the PTC System failed to enforce a penalty or provide any alert for a known speed restriction and they operated the train through the entire restriction. As a result of the incident, the reporter's PTC was considered failed and cut out.

*Q16. Did you bypass any PTC functions without permission during this event?*

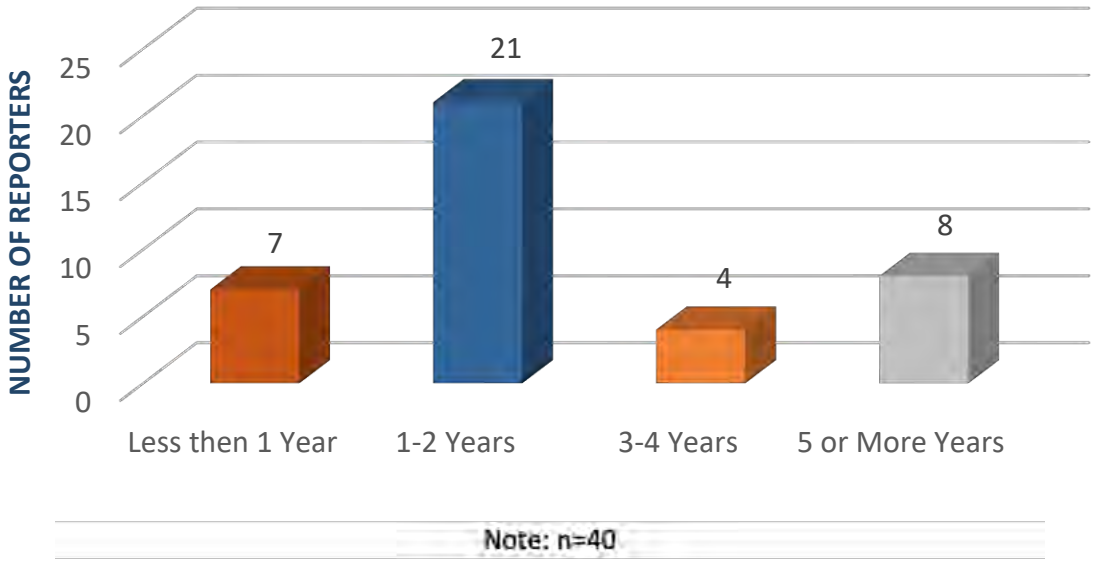
All SQS participants answered "no" when asked if they bypassed any PTC functions without permission during their event.

## PTC Training

*Q17. How long have you been using PTC?*

The original date for implementation of PTC was December 31, 2015. Two extensions pushed the date until December 31, 2020. Carriers have been implementing PTC at their own pace allowing for various lengths of experience with use. As shown in **Figure 14**, seven participants had been using PTC for less than a year; however, 82% had been utilizing a form of PTC for one to two years or longer.

**Figure 14*: How long have you been using PTC?***

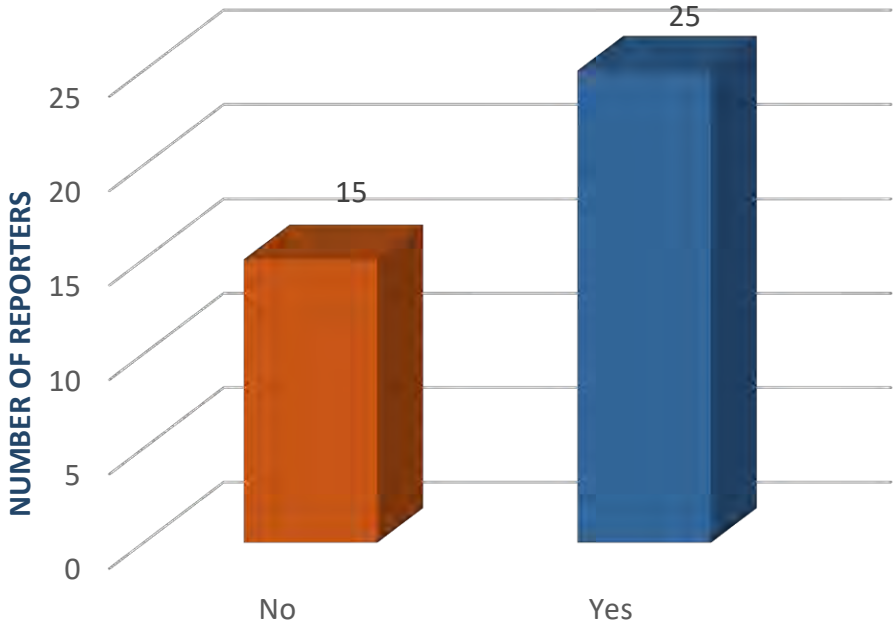


*Q18. Was the PTC Training you received adequate?*

**Figure 15** reflects the answers of the reporters who were asked if they received adequate PTC training. The majority (25) stated "yes"; however, 15 felt it was inadequate. Reporters mentioned that a gap in their training was how to handle faults and anomalies (reference Question 23). Real world and simulator application, in addition to classroom training, with off-nominal type scenarios may be helpful for the future. The following examples were provided by reporters who responded that their training was inadequate:

- "No, not enough training, especially for Conductors."
- "No, training was rushed."
- "No, PTC was rushed out to meet FRA PTC mandate, it could have been more in depth, relied too much on General Notices to give PTC training information."
- "No, only an hour to two-hours. Class is rushed."
- "No, classroom isn't enough. More visuals and video presentations of what to expect."
- "No, does not cover the issues and failures you experience. New to everyone so each issue is being experienced as you go."
- "No, system has so much information and not enough training. Very hard to get practical experience without risk of failure or penalty."

***Figure 15: Was the PTC training you received adequate?***

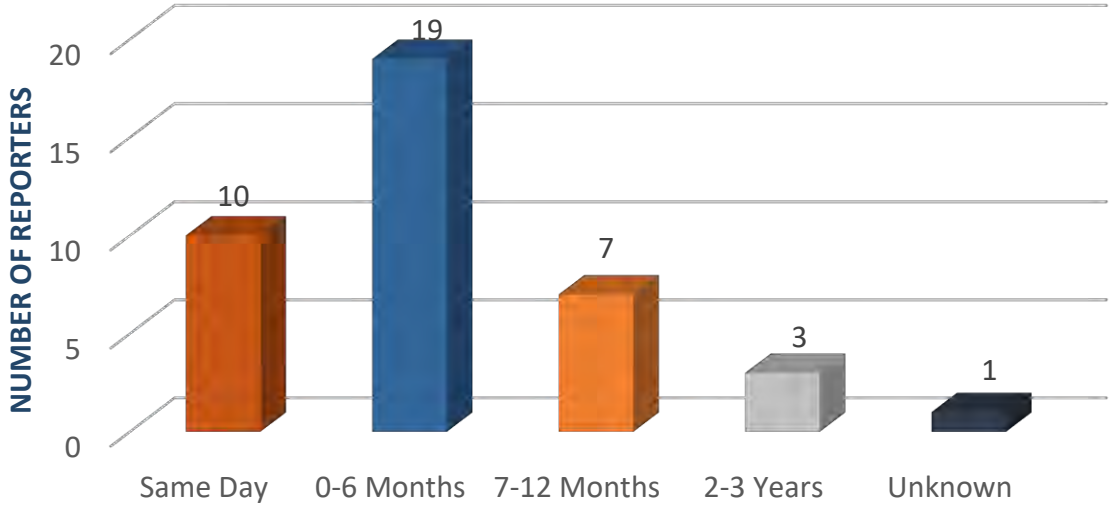



Note: n=40

*Q19. How long between initial training and your first use of PTC?*

The majority of reporters (73%) received their initial PTC training within six months of their first "over the road" use. Some reporters (10) mentioned they received their initial training the same day they used PTC for the first time (see **Figure 16**).

**Figure 16*: How long between initial training and your first use of PTC?***

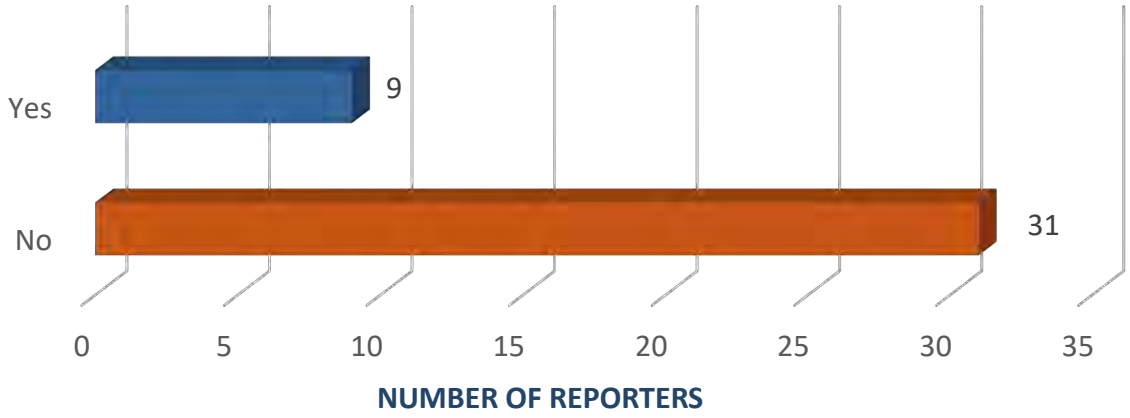



Note: n=40

*Q20. Did you receive any refresher training prior to your first use of PTC?*

About a quarter of the reporters (23%) responded "yes" to receiving refresher PTC training prior to their first use. Refresher training came in the form of additional management training or Annual Rules Training (see **Figure 17**). It should be noted that since 10 participants stated they began using PTC the day they received initial training (Q19), they would not have needed refresher training prior to their first use.

**Figure 17*: Did you receive any refresher training prior to your first use of PTC?***

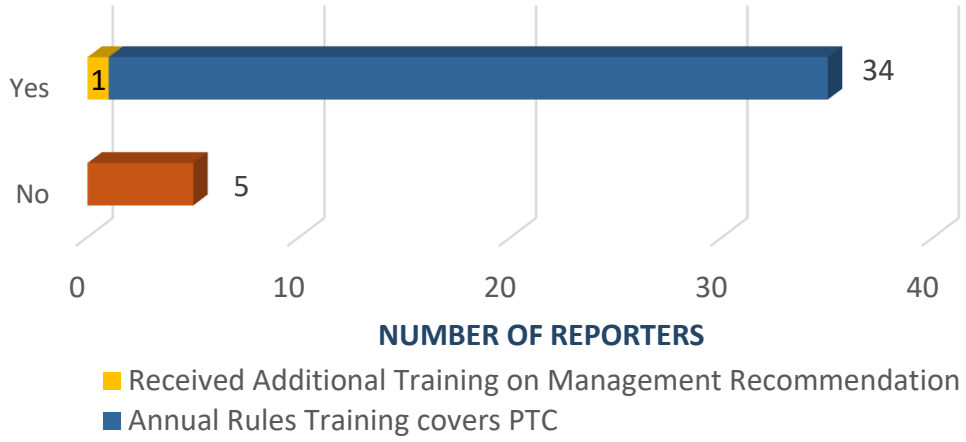



Note: n=40

*Q21. Did you receive any refresher training after your first use of PTC?*

The majority of reporters (88%) stated that they received refresher training after their first use of PTC and most of them (34) said it was covered in their Annual Rules Training. One reporter received additional training on management recommendations (see **Figure 18**).

**Figure 18*: Did you receive any refresher training after your first use of PTC?***



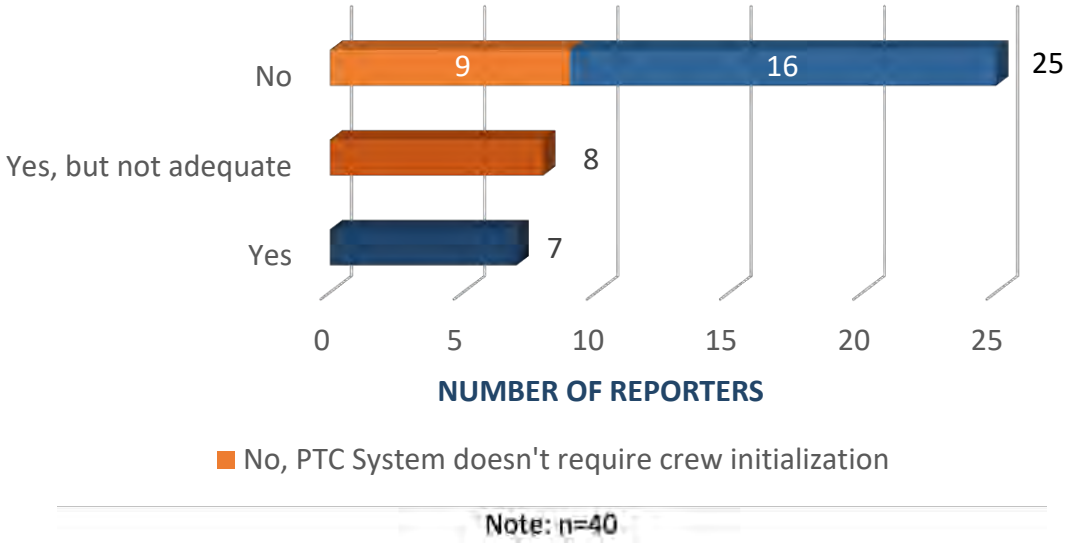

Note: n=40

*Q22. Did your training cover the following: "What steps to take when initialization fails"?*

When asked if the reporter's training covered the handling of initialization failures, 63% of respondents said "no". However, 16 of those who responded "no," stated that their PTC system did not require a crew to initialize prior to departure. It was mentioned that mechanical employees are tasked with initializing PTC when trains are being prepared for outbound crews.

Eight of 15 participants who responded "yes," stated that the training was inadequate. Some examples cited by reporters were that they were just trained to contact mechanical or only given pamphlets to use for trouble shooting (see **Figure 19**).

**Figure 19*: Did your training cover the following: "What steps to take when initialization fails"?***




Note: n=40

*Q23. Did your training cover the following: "What to do after a PTC failure"?*

**Figure 20** reflects the respondents' answers when asked if their training covered what to do after a PTC failure: 23 responded "yes" and 17 responded "no". Some reporters provided additional comments to both the "yes" and "no" responses that demonstrate there is room for improvement for this type of training. When asked if training covered what to do after a PTC failure, 58% (23/40) responded "yes". However, 10 of these respondents explained that while they did receive some training, they did not feel it was adequate. Reasons provided included:

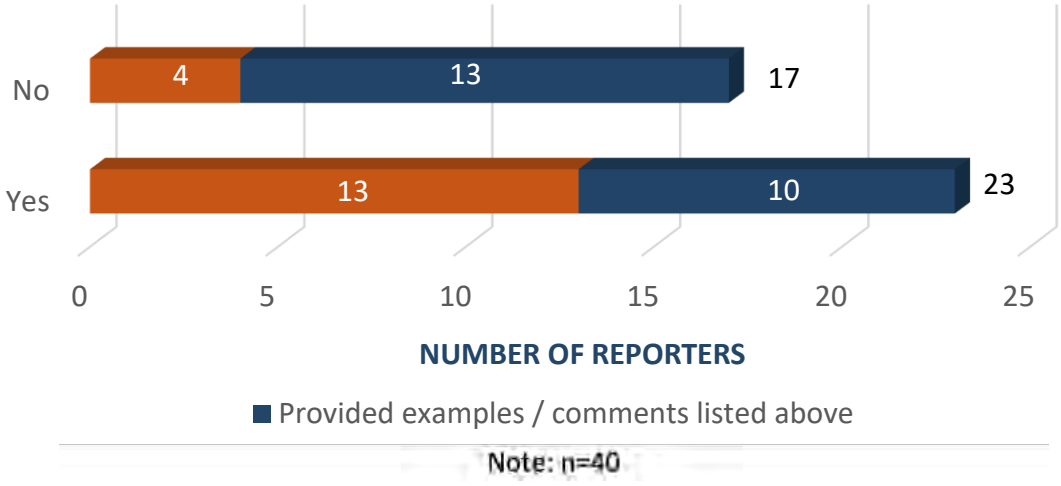
- Yes, but info only given in a pamphlet.
- Yes, but not adequate. Trained to just cut system out.
- Yes, but not adequate; Told to call helpdesk/mechanical. (2)
- Yes, but just to call Dispatcher. (4)
- Yes, but not what to do with total failure.
- Yes, but training was not adequate.

Seventeen reporters responded that they did not receive training that covered what to do after a PTC failure. Of these, 13 reporters provided further explanation including the following:

- No, unknown.
- No, unknown, but don't remember. Different railroad systems cause this confusion.
- No, training was only on a simulator.
- No, trained to contact mechanical or company "tech". (4)
- No, trained to just cut out. (4)
- No, just send out General Notices when things change.
- No, just told to reduce speed and call dispatcher.

Overall, six respondents (yes and no's) mentioned they were trained to just cut out PTC in the event of a failure, rather than trained on how to troubleshoot the failure.

**Figure 20*: Did your training cover the following: "What to do after a failure"?***



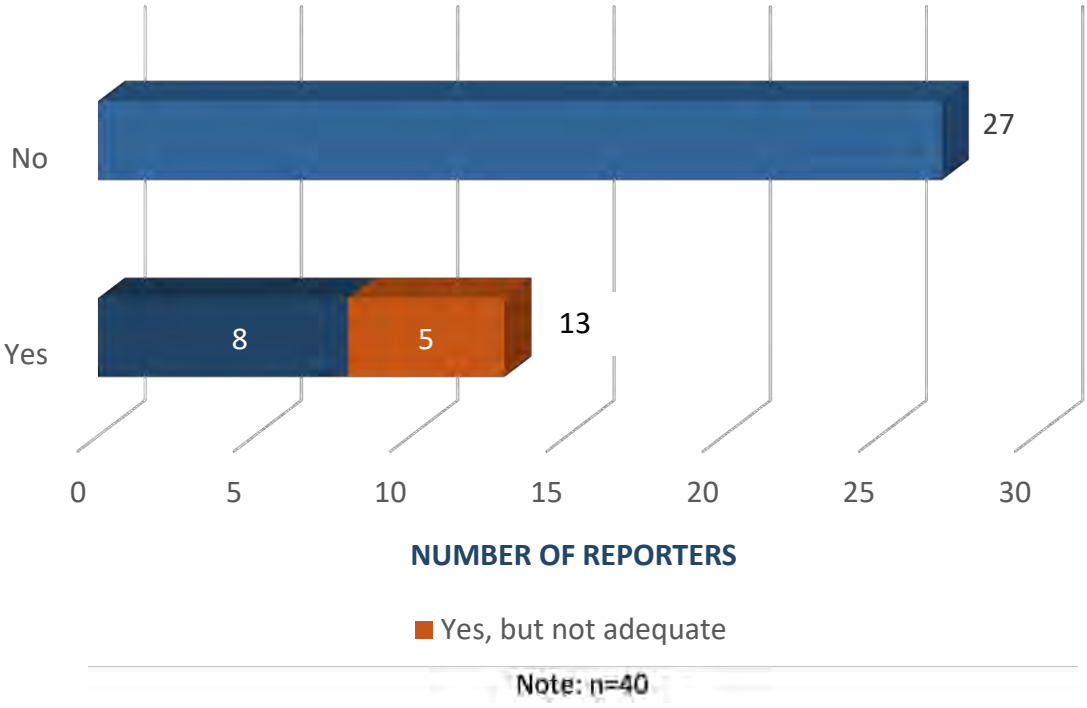
*Q24. Did your training cover the following: "Territory-specific exceptions"?*

Reporters were also asked if their training covered Territory-Specific exceptions (see **Figure 21)**. The majority (68%) stated they did not receive any training for territory-specific exceptions. Respondents mentioned that training was not that in-depth and didn't include where known issues were or what to expect. Of the 13 participants who responded that they did receive training for territory-specfic exceptions, five participants stated that this training was not adequate. Reasons for inadequate territory-specific exceptions training mentioned by reporters included:

- No, [company] tells you where there are issues, but not what to expect.
- No, not covered.
- No, training isn't that in-depth.
- No, training was only on a simulator.
- Yes, but not adequate. No issue is explained in-depth and where they are.

Due to the various PTC rollout timelines territory-specific exceptions may not have been known at the time of training. This brings up the need for possible refresher training as PTC updates are made or implementation changes occur.

**Figure 21*: Did your training cover the following: "Territory-specific exceptions"?***



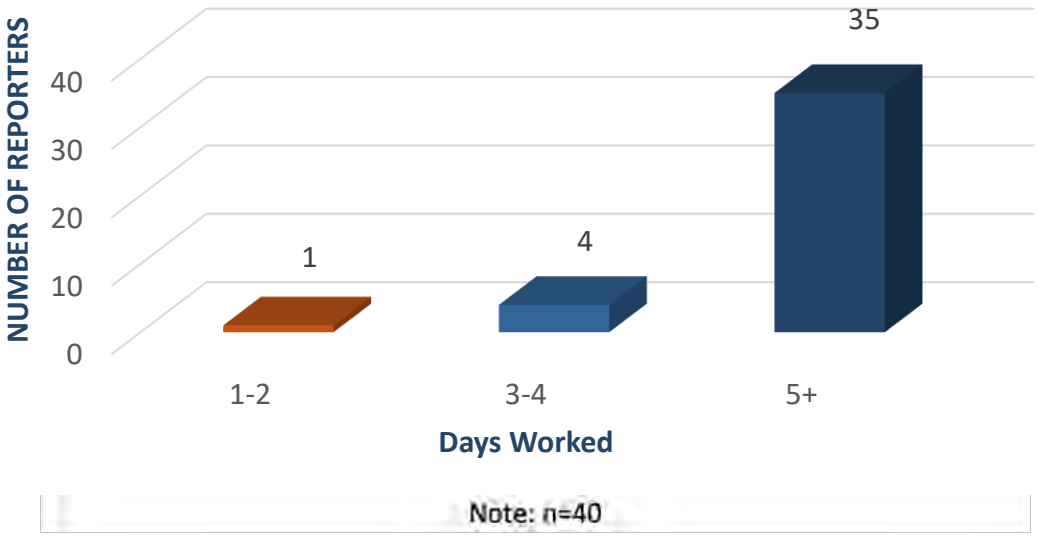
## Failures and Faults

For this study, failures were defined as any instance PTC failed completely and the system was cut out; the system was no longer operational. PTC faults were defined as a PTC or related system error that prevented PTC from working as intended; the PTC could be recovered via a reset or acknowledging the fault (see **Appendix C** for key terms). Reporters were asked about their experiences with failures and faults over the span of the previous *three months*. It should be noted that PTC failures and faults can be defined differently from carrier to carrier and reporters may not use the two terms in a consistent manner.

*Q25. In the last three months, how many days per week do you operate trains?*

To provide context for the following questions, which ask participants to estimate frequency of event occurrence over the last three months, participants in the SQS were asked how frequently they operated trains during a given week. The majority of the reporters (88%) answered they work at least five days a week. Only one of the SQS participants worked less than three days in a week, shown in **Figure 22**.

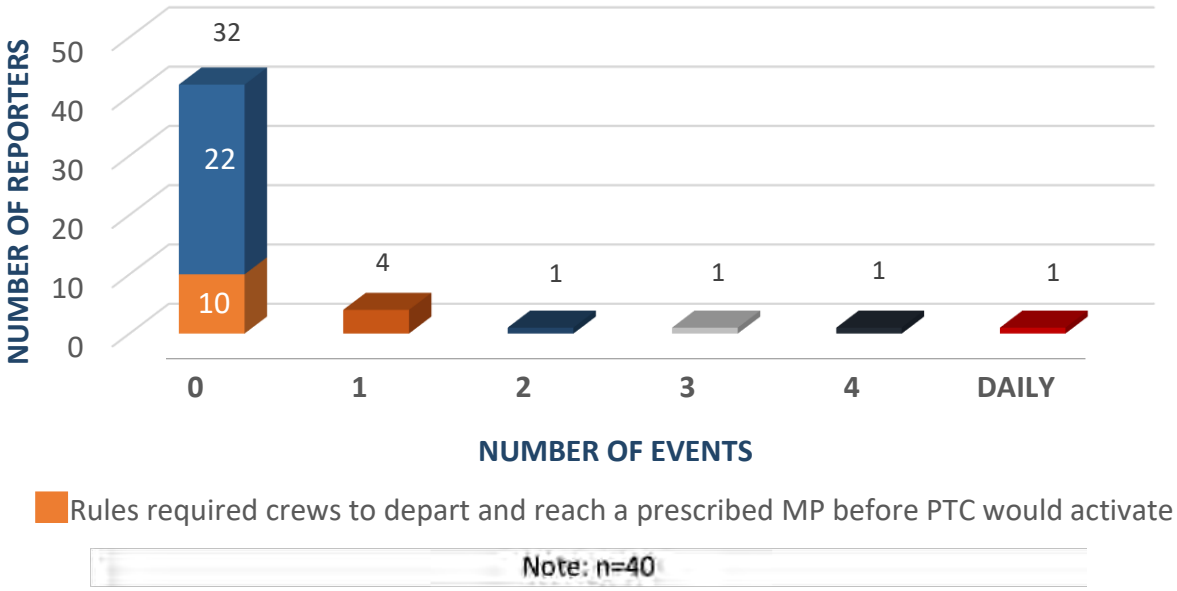
**Figure 22*: In the last three months, how many days per week do you operate trains?***



*Q26. In the last three months, how many times have you departed your initial terminal with PTC cut out?*

When asked how many times they departed their initial terminal with PTC cut out, 8 of 40 participants answered that they departed in this state at least once in the last three months. As shown in **Figure 23**, one reporter answered they departed daily with PTC cut out. Since January 1, 2021, only one reporter responded that the train departed the initial terminal with PTC cut out. In the three-month time-period, 10 participants answered that they departed the initial terminal with PTC cut out, because territory-specific rules required trains to reach a prescribed milepost before activating PTC for the first time.

**Figure 23*: In the last three months, how many times have you departed your initial terminal with PTC cut out?***




Note: n=40

*Q27. In the last three months, how many times did you experience a PTC failure en route?*

Participants responded with the number of times they experienced a PTC failure en route in the last three months. The data represent only instances in which the PTC system completely failed and had to be cut out. **Figure 24** shows that 78% of reporters experienced a failure en route (inside the blue dashed line), and 22% did not experience a failure in the last three months. Nearly half of the participants experienced PTC failures two or more times, in the last three months.

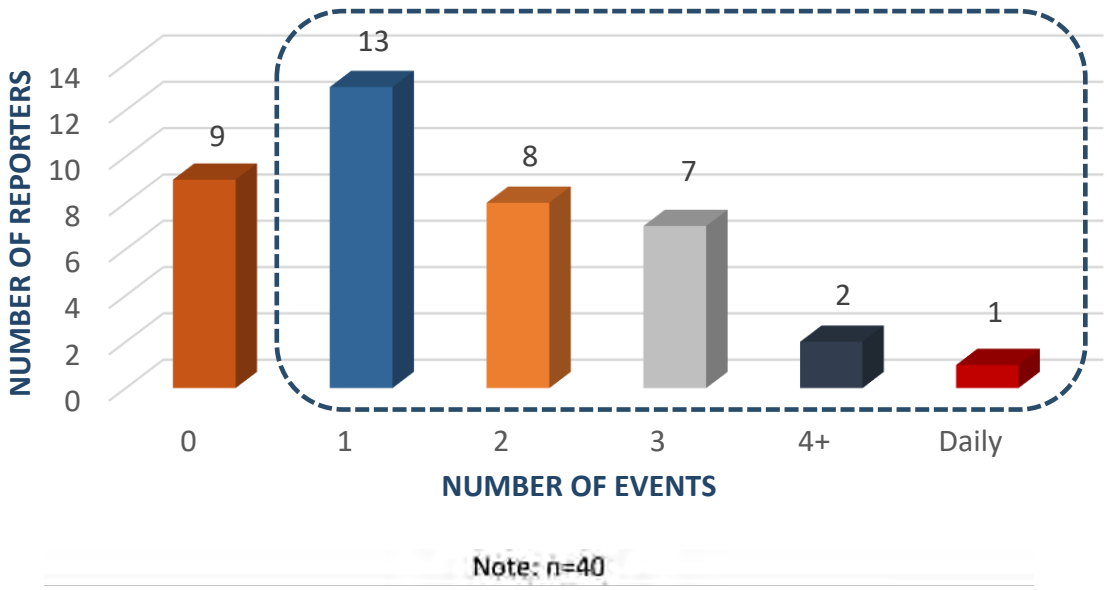
**Question 28** asked if PTC needed to be cut out en route, but that overlapped with this question and is not shown. **Questions 29 and 30** asked the reporter to further explain whether the failures they experienced were due to a mechanical issue or other type of failure. Examples of failures classified as Mechanical (cited 20 times) included:

- PTC antenna issues
- No visual display working as intended
- Cab signal related failures

Examples of factors classified as due to 'Other' factors (cited 7 times) included:

- GPS-related failure
- Foreign railroad compatibility failures
- PTC failures from back-end programing or related issues

**Figure 24*: In the last three months, how many times did you experience a PTC failure en route?***

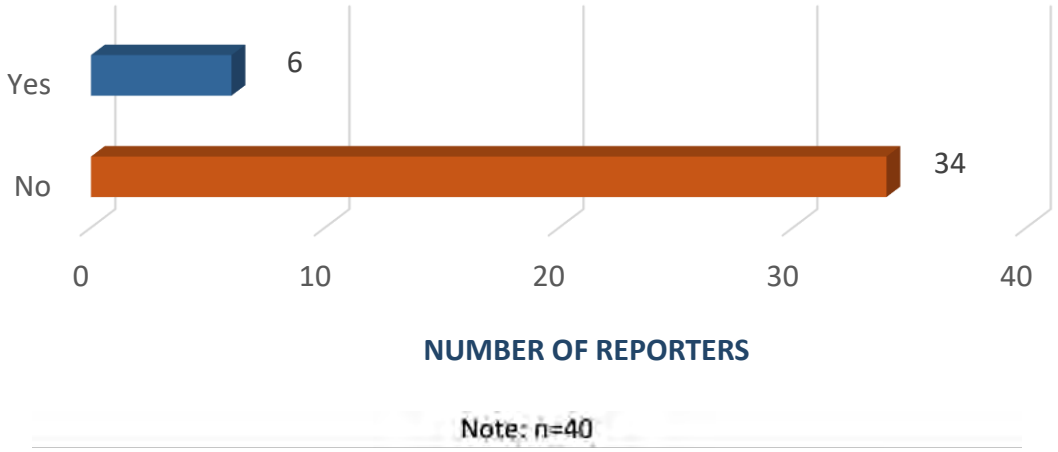



Note: n=40

*Q31. When PTC failed, did you need time to readjust to operating without PTC?*

Participants were asked if they needed time to adjust to operating without PTC when the system failed en route. Out of the 40 reporters, 85% responded "no," they did not need any time (see **Figure 25**). Those that answered "yes" (only 15%), mentioned time was needed to go over operating rules and to perform a job safety briefing.

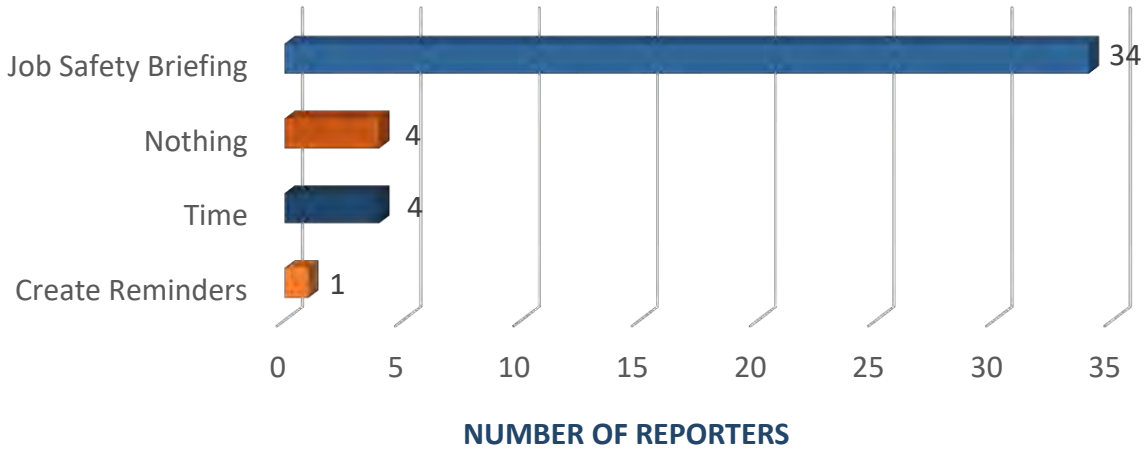
***Figure 25: When PTC failed, did you need time to readjust to operating without PTC?***



*Q32. What do you need to do to readjust to operating your train when PTC fails?*

When PTC fails and is cut out, the reminders and assistance are absent, so operators need to return to a less automated way of operating. Most reporters (95%) mentioned that they mainly needed time for a Job Safety Briefing when PTC failed en route (**Figure 26**). With the addition of PTC, new operating rules have been added. One of those new rules is the Maximum Authorized Speed of a train with and without PTC. With mandatory implementation and success of PTC, crews get used to operating at a higher speed with PTC active. When PTC fails and requires the train to operate at a lower Maximum Authorized Speed, crews often have to rely on their memory or look up the new speed. This finding is consistent with C$^3$RS Expert Analysts' observations of a recent increase in reports where PTC is cut out and the Engineer did not remember a change to the Maximum Authorized Speed. One participant suggested creating a "check speed" reminder to help crews remember the new Maximum Authorized Speed for their train when PTC fails and is cut out.

***Figure 26: What do you need to do to readjust to operating your train when PTC fails?***

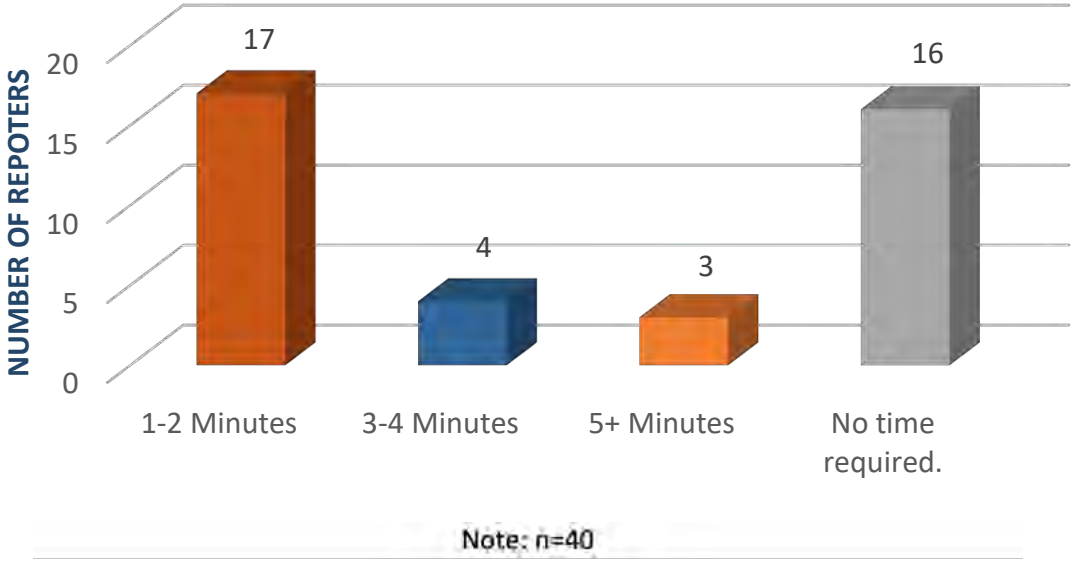



Note: n=40. Mutually Exclusive

*Q33. How long does it take to readjust to operating your train when PTC fails?*

As shown in **Figure 27,** 93% of participants stated they needed between zero minutes to four minutes to readjust to operating the train after a PTC failure en route. The majority of the time needed was to conduct a job safety briefing and reset the operating cab.

***Figure 27: How long does it take to readjust to operating your train when PTC fails?***



*Q34. Are you given the appropriate time to readjust to operating your train when PTC fails?*

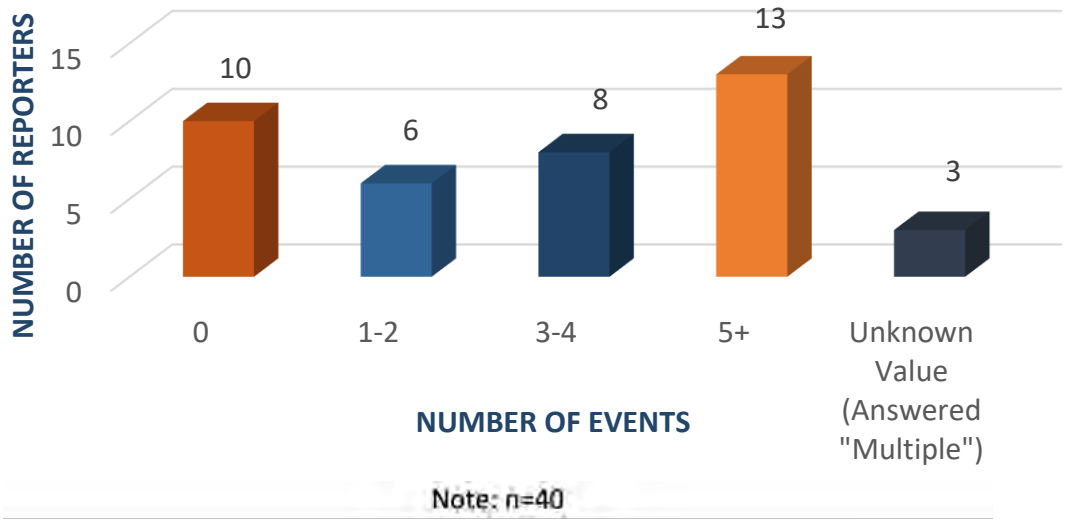
All 40 participants felt they had an appropriate amount of time from the train dispatcher to readjust to operating the train after the PTC failed en route.

*Q35. In the last three months, how many times did you experience PTC not enforcing known restrictions such as not picking up speed restrictions, not displaying a crossing warning, or not picking up working limits?*

The majority of reporters (30) stated that PTC did not enforce known restrictions at least once in the past three months (see **Figure 28**). The reporters were asked to elaborate on this question and examples include:

- Daily issues because of territorial failures.
- When going into the next calendar day, restrictions change, and PTC may not pick them up.
- Not picking up a 60 mph Temporary Speed Restriction.
- The [PTC system] will throw incorrect speed limits, multiple tracks; the system can't figure out which track you're on, causing system confusion.
- PTC appears to pick up speed restrictions from alternate tracks.
- Incorrect speed.
- Incidents where PTC picks up wrong track and the prescribed restrictions.
- PTC will give you unknown Temporary Speed Restriction messages and makes you reset train, all while there is no Temporary Speed Restriction.
- PTC wouldn't allow train to enter a work zone.

***Figure 28: In the last three months, how many times did you experience PTC not enforcing known restrictions such as not picking up speed restrictions, not displaying a crossing warning, not picking up working limits?***

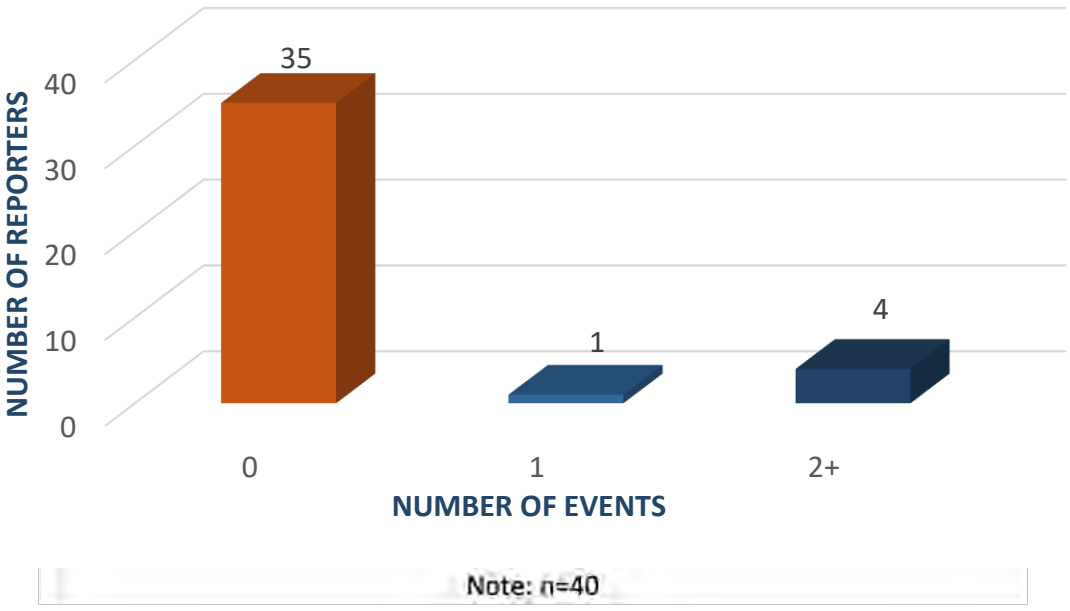


*Q36. In the last three months, how many times did you experience PTC issues that you can attribute to data entry on the Dispatcher side or back-end programming?*

Most reporters (88%) did not report experiencing any Dispatcher data entry or back-end issues related to the PTC system (see **Figure 29**). The five reporters who experienced issues gave the following examples:

- Expired or new restrictions not picked up.
- Received Temporary Speed Restriction but system wasn't updated right away to reflect it; possible that Dispatcher forgot.
- Speed restriction picked up from adjacent track, phantom speed restrictions.
- Speed Restrictions appear in the wrong location, like interlockings, from what limits Dispatcher sent.
- Dispatcher authorized a track warrant but did not send it to the PTC System.

***Figure 29: In the last three months, how many times did you experience PTC issues that you can attribute to data entry on the Dispatcher side or back-end programming?***

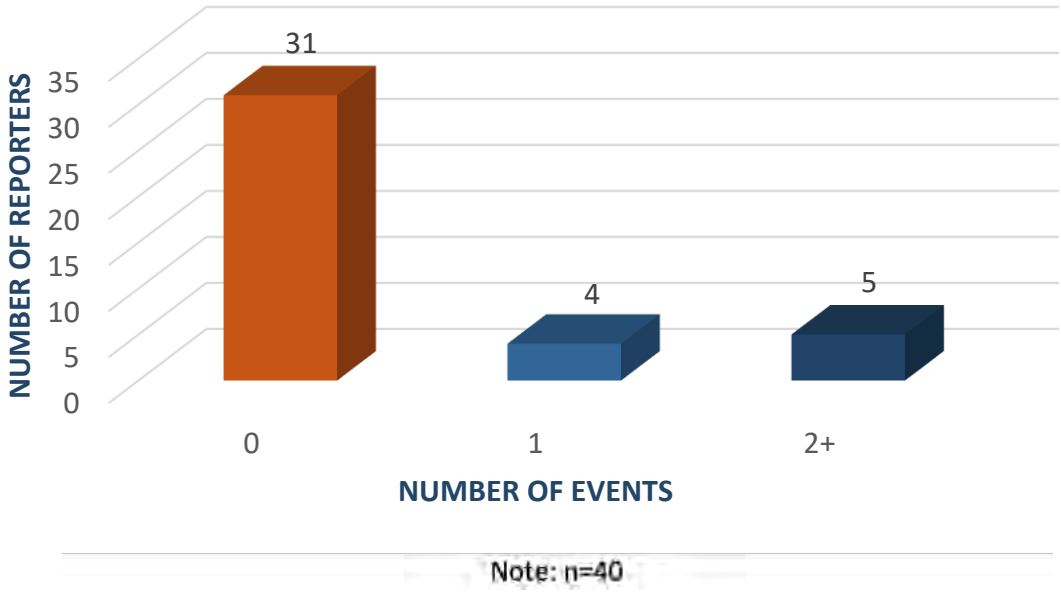


*Q37. In the last three months, how many other types of PTC-related issues have you experienced, but not mentioned?*

When asked if there were any other types of PTC-related issues a reporter experienced, 78% reported no other PTC-related issues (see **Figure 30**). This is compared to the 23% that did experience other PTC issues. Some examples provided included:

- No consistent advance warnings (audible or display) when approaching Temporary Speed Restrictions and work zones.
- PTC not allowing for Max Authorized Speed when approaching Interlockings.
- PTC display turns off and on for no reason while in operation.
- Some systems do not work well with other systems when diverging over to other railroads. Too much information on the PTC display bogs system down.

***Figure 30: In the last three months, how many other types of PTC related issues have you experienced, but not mentioned?***



## Human Systems Interaction

*Q38. In the last three months, can you think of any times when the PTC display was confusing?*

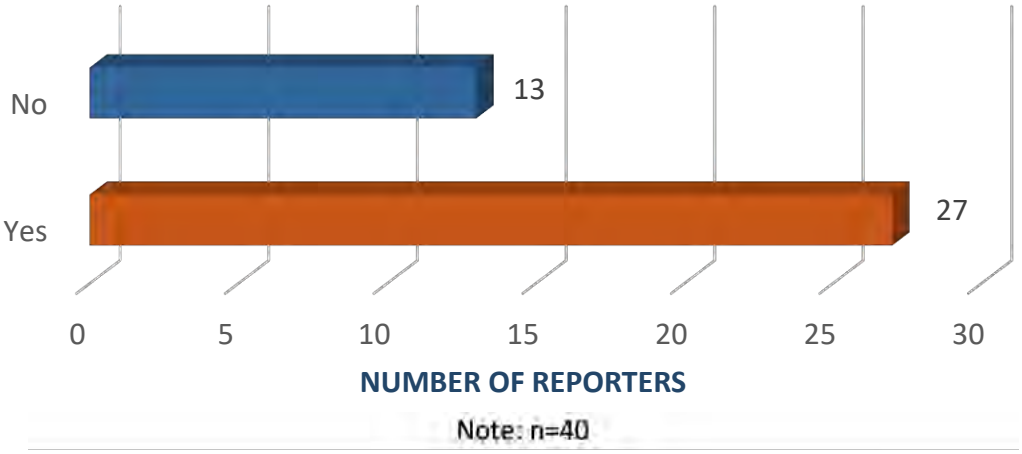
As shown in **Figure 31**, 27 of the 40 participants (68%) responded that in the last three months, they could think of times when the PTC display was confusing.

The most frequently cited reason for confusion was audible alerts that coincided with the display. Other sources of confusion included PTC software updates, prompts jumping around, and multiple advance warnings at the same time. Examples of the confusion experienced by the participants are provided below and demonstrate the uniqueness of each person's experience with PTC:

### Reporter Excerpts – Found PTC Confusing

- When attempting to update PTC software.
- Multiple, no consistent advance warnings (audible or display) when approaching TSR, work zones, etc.
- Secondary alarms and audible alarms.
- Other railroad carriers' messages appear on screen that aren't necessary.
- Whole system is confusing cause audible alerts for all occurrences (at speed, under speed, overspeed).
- Next target prompt causes confusion, prompts jump around and go to next prompt too quick.
- When PTC doesn't pick up "transponder" you have to keep acknowledging system but system would accept it.
- Multiple times because display of wrong information causes distraction.
- One from this incident from unknown restriction.
- PTC mistakes alternate track's restriction and causes confusion.
- Lack of consistent alerts.
- When display jumps from different modes.
- Audible alerts and incorrect speeds make it confusing and distracting.
- When the system is required to be cut out and isn't working. Audible alerts are confusing.
- Audible alerts are confusing.
- PTC doesn't pick up correct restrictions.
- The system is giving audible alerts for no reason.
- New updated system has changed and now you are looking for where info is located.
- TSR on multiple main track shows incorrect speed from other track.
- Audible alerts for no reasons make no sense and are distracting.
- The system screen doesn't always work.
- The PTC screen counts down to restrictions that aren't there.
- System doesn't display correct locations of restrictions.
- Every time it has an issue its confusing. No one knows what to do and have to wait for system to fail.
- Audible alerts for no reason constantly cause confusion.
- System gives unwanted PTC and can't figure out why. Really confusing.
- When the system doesn't work properly, it adds so much confusion.

***Figure 31: In the last three months, can you think of any times when the PTC display was confusing?***




Note: n=40

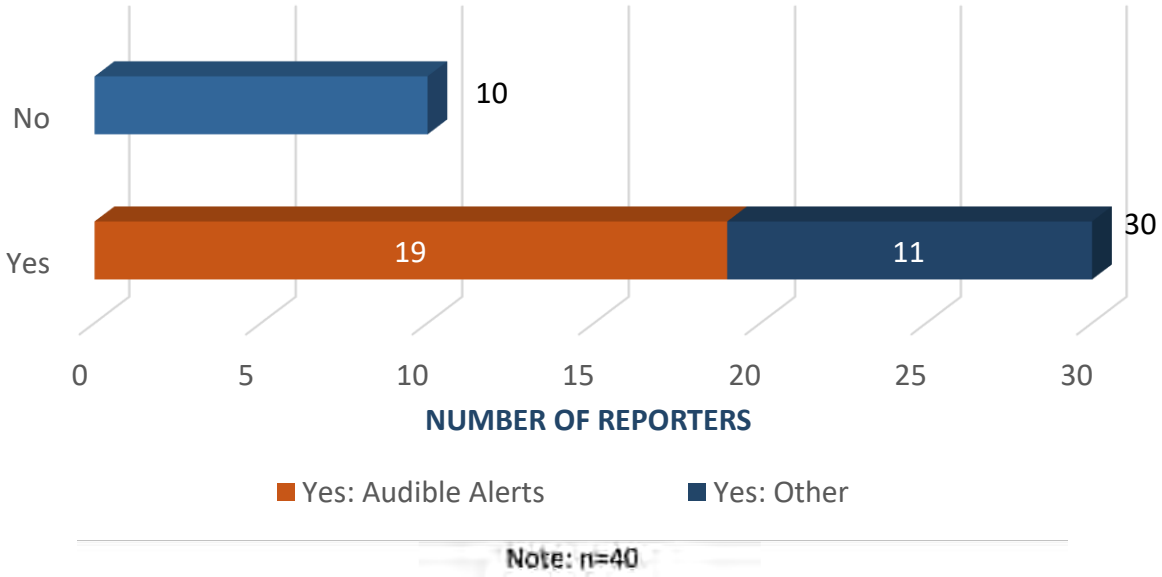
*Q39. In the last three months, can you think of any times when you were distracted by the PTC system?*

Most reporters (75%) reported that they had been distracted by the PTC system in the last three months as shown in **Figure 32**. PTC adds another system to monitor and can be distracting while performing other essential tasks. Almost half (48%) of the participants mentioned that the audible alerts were the cause of the distraction. Other examples of distraction included when the display showed incorrect information, when the system location was incorrect, or when it required the operator to multitask. Excerpts from the reporters' comments are provided below:

**Reporter Excerpts – Found PTC Distracting**

- Audible alerts cause distractions: Trying to acknowledge the alarm causes distraction when attempting to operate the train.
- The audible alerts [beeping] are annoying.
- When attempting to complete multiple tasks, system can be distracting.
- PTC every day is frustrating; audible alerts for no reason. Loud and can't focus. Audible alerts aren't for negative issues. [Other] PTC systems are better.
- Display and sounds are distracting with constant alerts.
- Too many alarms both visual and audible.
- Visual display [is distracting].
- The whole system is confusing; causes audible alerts for all occurrences [at speed, under speed, overspeed].
- The horn feature sometimes doesn't blow at right spot, causing distraction.
- Train speed on the speedometer and PTC speed aren't matching, causes additional distraction.

**Figure 32*: In the last three months, can you think of any times when you were distracted by the PTC system?***

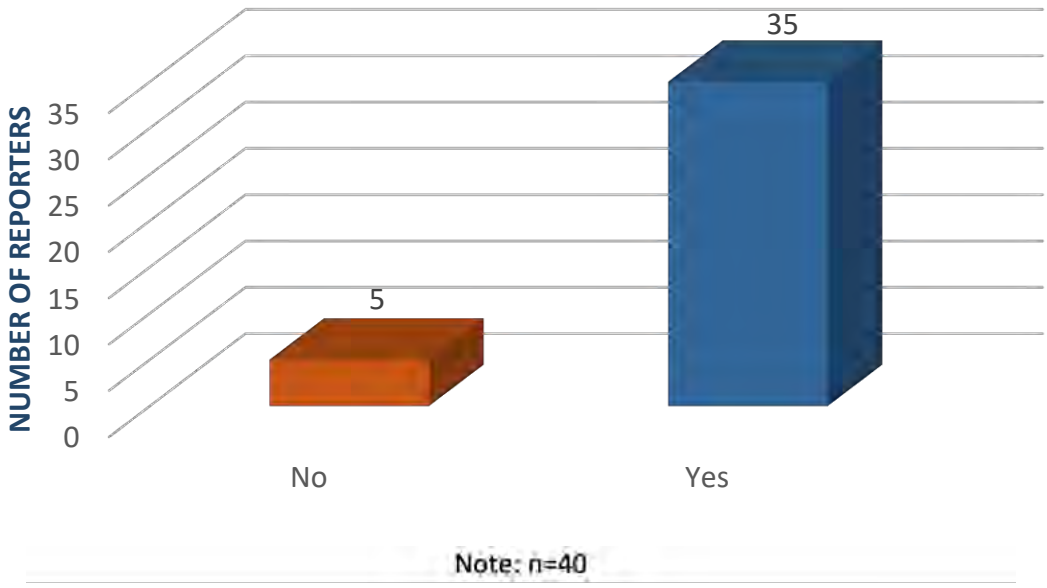


*Q40. Do you consider PTC warnings / alerts effective in helping direct your attention and give you information on what actions to take?*

Most reporters (88%) stated that the warnings and alerts directed their attention and provided good information on what actions to take (see **Figure 33**). Even though the warnings and alerts were mostly effective, the reports did provide some additional information on the alerts. Examples include:

- Yes, but the sound [of audible alert] is too loud.
- Yes, but too much attention is focused on the PTC.
- No, system doesn't always give the proper warning alerts [audible and visual].
- No, system is constantly giving audible alerts that are just for...faults that you can't tell when it's for real events.
- No, system is oversaturated with audible alerts and it isn't effective.

***Figure 33: Do you consider PTC alerts effective in helping direct your attention and give you information on what actions to take?***



## PTC Acceptance

Operator acceptance is an important factor in determining the successful integration of any new technology. An operator's level of acceptance may depend on many factors such as the degree to which the system is consistent with the operator's expectations, and the degree to which the technology is believed to support the operators' job functions in a natural and meaningful way, without increasing workload. When these factors are absent, operators often look for ways to work-around, or even disable, the technology, thus defeating the intended safety benefits.

*Q41. Has PTC changed the way you handle your train?*

The majority of participants (26 of 40) answered "yes" when asked if PTC implementation has changed the way they handle their train. Of those, 23 participants referenced tending to run more cautiously or conservatively (responses listed below). This included braking or slowing earlier, not running as "hot" or aggressively, approaching stops differently, and being prepared for penalties or failures. One Engineer mentioned that PTC has standardized how all Engineers run trains on the territory.

"Yes" Responses to Operating More Cautiously / Conservatively (23)

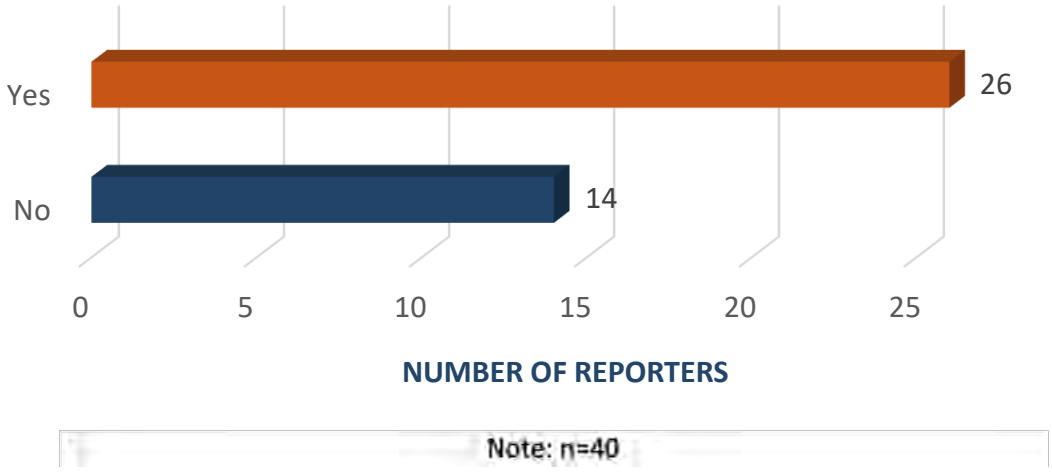
- ❑ Have to be more cautious. (4)
- ❑ Has to operate more cautiously.
- ❑ Have to be way more cautious of the PTC failure.
- ❑ More cautious and slower.
- ❑ Have to adjust how train is operating due to how the train approaches speed restrictions.
- ❑ You now have to operate the train with more operating restrictions.
- ❑ You have to operate more conservative, can't run "hot".
- ❑ PTC requires you to slow down earlier for speed restrictions due to the conservative nature of the PTC System.
- ❑ Requires you to operate slower, conservative, to prevent PTC Penalty.
- ❑ Requires you to change how you approach stops.
- ❑ System requires you to brake sooner.
- ❑ System requires you to be conservative coming up to speed restrictions.
- ❑ PTC requires longer braking distance.
- ❑ When working, have to go slower.
- ❑ More conservative operating.
- ❑ Have to be more conservative and slower.
- ❑ Have to approach speed restrictions less aggressively.
- ❑ More aggressive with braking and more conservative.
- ❑ Have to be more cautious. Has standardized how all Engineers run train on the territory.
- ❑ Have to now be prepared for train to go into penalty.

Some additional comments included:

- Yes, feel like the PTC handles the train and I'm just complying.
- Yes, because of constant attention to false PTC alarms and alerts, it is easy to be distracted and this causes unnecessary slower operations.
- Yes, for this PTC system you have to operate more in advance than other PTC systems I have used.

The remaining 14 participants responded "no" to whether PTC changed the way they handled their train as shown in **Figure 34**.

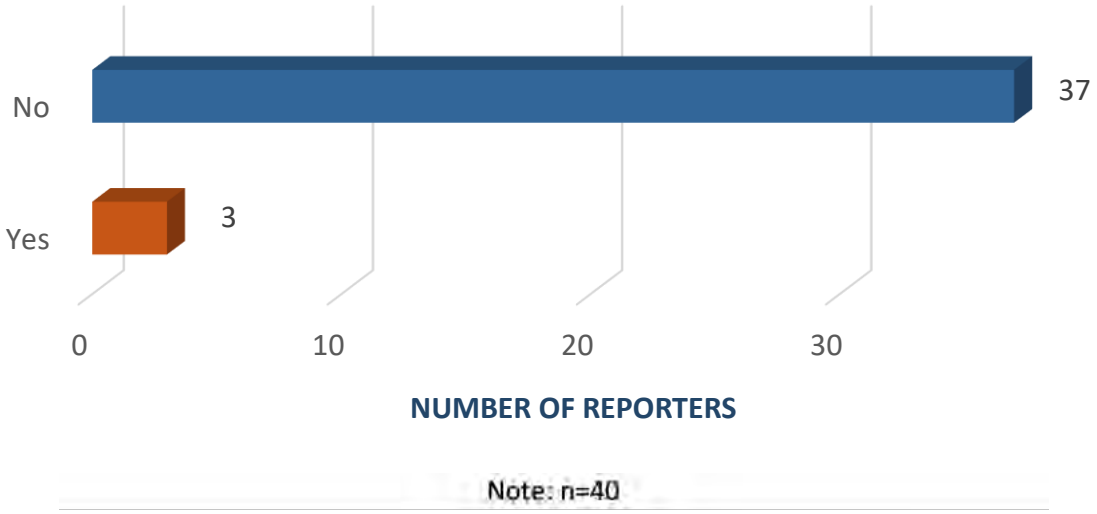
**Figure 34*: Has PTC changed the way you handle your train?***



*Q42. Do you tend to rely on PTC for train handling?*

**Figure 35** reflects the responses when participants were asked "Do you tend to rely on PTC for train handling?" Nearly all responses (93%) were "no". Three participants stated that they did tend to rely on PTC for train handling including approaching speed restrictions, and one stated that PTC handles the train and the Engineer is "just complying" (Note: same respondent as in Q41).

**Figure 35*: Do you tend to rely on PTC for train handling?***



*Q43. When operating with PTC, would you say that your workload has increased or decreased?*

When asked if PTC has increased or decreased their workload, all reporters stated that their workload increased or remained the same (see **Figure 36**). Alerts, glitches, and failures were mentioned by reporters as being root causes of their perceived workload increase. Zero participants mentioned that it decreased. It is expected that workload might increase with the introduction of any new technology as there is a learning curve. It is possible that the perceived workload responses may go down as people become more experienced with the system. However, 82% of the respondents have been using PTC for at least one year. This may be something to monitor over time. There were some common themes that could be identified for the reasons why participants experienced an increase in workload and some examples are provided below:

**Don't trust PTC System (1)**

- I don't trust the PTC system, so I operate like it wasn't there.

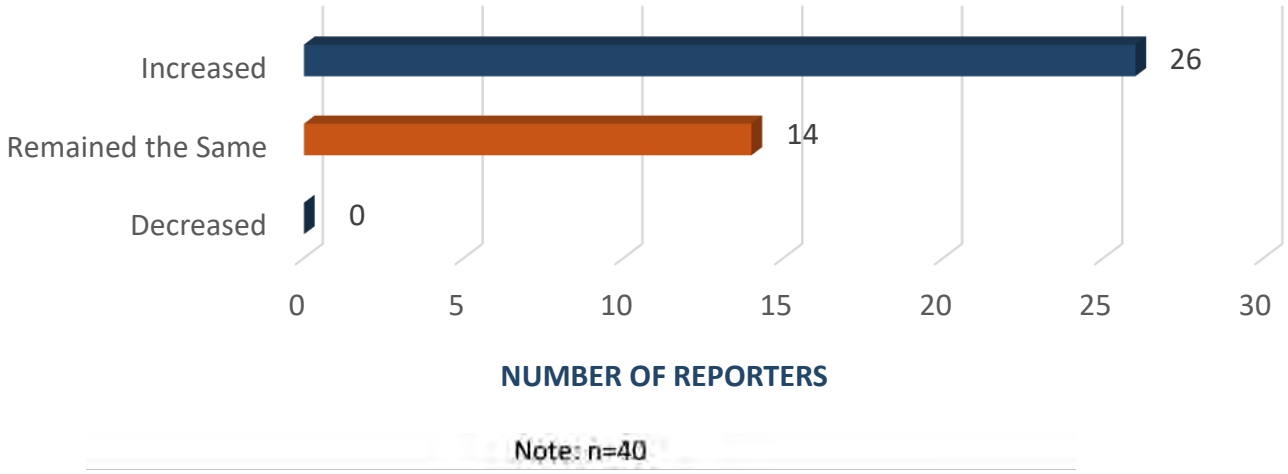
**More Work Troubleshooting (10)**

- Audible alerts cause distractions.
- Added distractions cause more work.
- The glitches make it more work.
- Watching the PTC system and waiting for it to fail causes added work.
- When it doesn't work right, it adds distractions. This is more work.

**Requires Extra Focus (15)**

- More distractions to focus on.
- You have to focus more on the system as well as your normal task.
- Extra attention is needed while operating.

**Figure 36*: When operating with PTC, would you say that your workload has:***

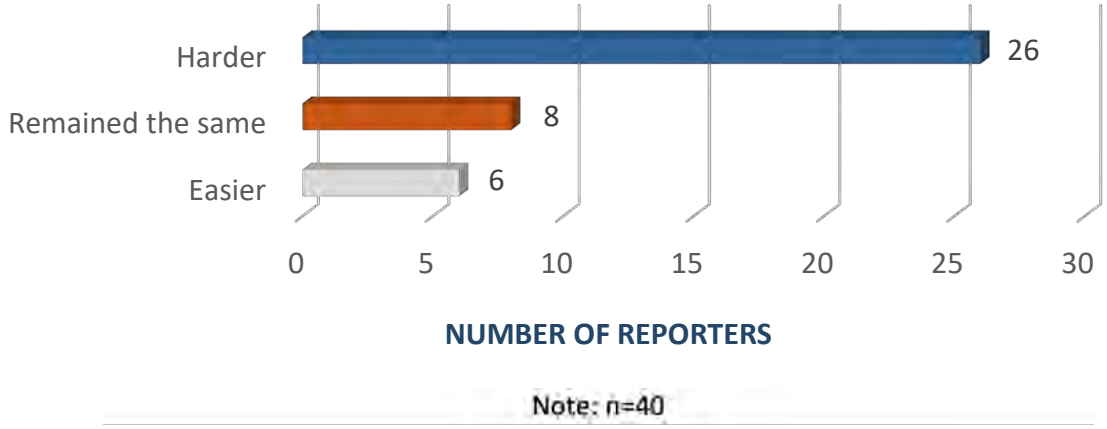



Note: n=40

*Q44. Has PTC made operating your train easier or harder?*

Participants were asked if PTC has made operating their train easier or harder. The majority answered harder (65%), but the remaining 14 said it remained the same or was easier (see **Figure 37**). Some excerpts from reporter's answers can be found below.

**Figure 37*: Has PTC made operating your train easier or harder?***




**Examples of "Easier" Scenarios**

- [It is a] safety net that makes job less stressful.
- Helps with remembering signals and restrictions.
- If you are distracted, it allows for you to regain focus on things like TSRs. It allows the Engineer to be reminded about those restrictions.

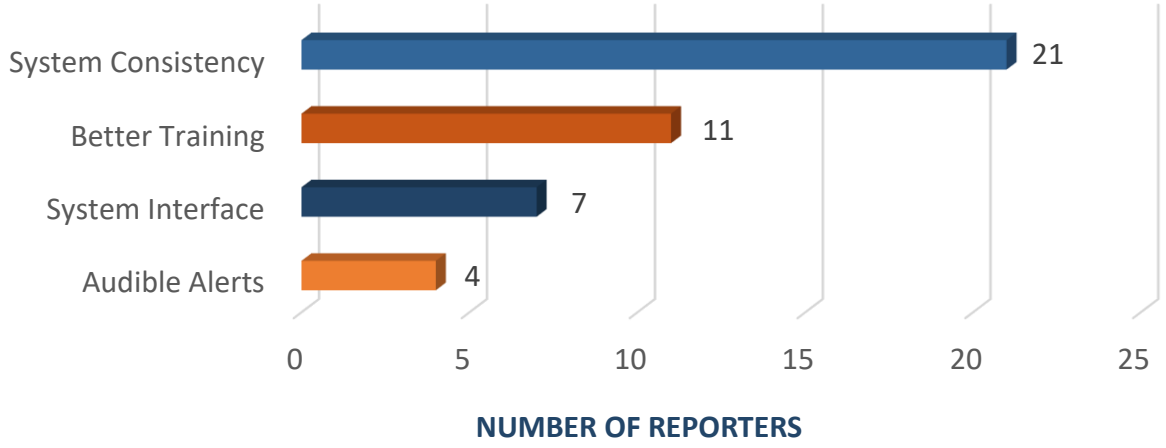
**Examples of "Harder" Scenarios**

- It questions how you operate your train; it questions your braking approaching a restriction. This makes you have to adjust.
- PTC requires more steps in pre-departure, crew members not as knowledgeable to it, audible alerts.
- You have to wait for the PTC to catch up before you can operate your train properly like departing a station but having to wait for PTC to acknowledge your location before you can pick up speed.
- Have to re-learn how to operate based on how PTC requires trains to be ran.
- Just not used to the system, more work.
- Extra attention needed.

*Q45. How can PTC be improved?*

The last question of the SQS offered the opportunity for the participants to provide suggestions for areas of improvement (see **Figure 38**). Four common themes emerged; 1) Engineers suggested the need for increased system consistency, improved training, improved system interface, and reduction and / or prioritization of audible alerts. Reporter suggestions are highlighted below by category.

**Figure 38*: How can PTC be improved?***




Note: n=40. Not Mutually Exclusive

## System Consistency

- "It needs accurate enforcement. A better connection between system and transponders. The countdown needs to be adjusted, it stops you too soon when you need to pull up tight on signals or stations."
- System needs to be more accurate: Speeds need to be correct, the TSR should be in the right spot, braking points need to be accurate to allow you to operate the system as normal as possible.
- Foreign PTC system doesn't work as well as home system, wish they were the same...

## Better Training

- It needs a better training process; add more training for Conductors.
- Training needs to be improved. [Current] training only teaches to cut system out after contacting [dispatcher] and getting approval.
- More training to keep up with constant changes. Do all the updates at one time and then teach. More in-depth training.
- With so many new software updates, tell crews about [updates process] and let them be part of it. More in-depth training on what to do when faults and failures occur.

*Q45. How can PTC be improved? (continued)*

## System Interface

- ❑ You can't input TSR through a work zone given by a foreman on the system, [Engineer] should be able to enter the speed given.
- ❑ Need to make it easier to acknowledge alerts and alarms, especially when blowing for road crossings.
- ❑ The alerts take too long for the system to acknowledge your acknowledgement.

## Audible Alerts

- ❑ Audible alerts are used too much.
- ❑ PTC system shouldn't make audible alerts when the train picks up speed.
- ❑ The audible alerts are way too loud. Why do we need to have a loud and [unnecessary] alert telling me to increase speed?

# 4.0 CONCLUSION

Implementation of PTC technology is constantly changing the field for all railroads. The PTC Supplemental Question Set went forward with a goal of understanding how PTC is affecting day to day railroad employees when it comes to safe and effective operation of trains throughout the United States. Completion of the SQS, with the participation from multiple railroads and PTC systems, demonstrated that the growing pains of these PTC systems is not an individual person or specific carrier issue. In reviewing the data from the PTC SQS, $C^3$RS Analysts focused on four topics of interest that were commonly mentioned throughout the SQS.

- System / Paperwork Synchronization
- Training
- PTC Acceptance
- Displays / Alerts

## 4.1 System / Paperwork Synchronization

Synchronization between the PTC System and paperwork is one of the most important requirements for a PTC system. For a PTC system to work as intended, it must be able to synchronize with the train's route and crew's paperwork. Each PTC system differs in how an operator can review the restrictions in the PTC system and compare to the crew's paperwork. Most reporters (80%) confirmed their paperwork was accurately reflected in the PTC system they were using. However, 18% of participants noted that PTC did not accurately reflect their paperwork. In these cases, participants reported that Temporary Speed Restrictions were missing, speeds were incorrect, and speeds did not match actual locations, among others. These discrepancies can become a distraction to the operator if PTC is enforcing unknown restrictions, etc. Paperwork and PTC route accuracy is vital for the system to be successful. In certain PTC systems, train operators have no way to cross-check and catch any potential errors prior to departure. Giving the crews this ability to compare and cross-check their PTC system against their paperwork could add a layer of redundancy to catch inaccuracies and errors and increase system transparency.

## 4.2 Training

The majority of reporters (63%) felt their initial training was adequate, 37% did not. Follow-up or refresher training was mentioned as an ongoing issue. Better training was also suggested by 11 participants when asked for their suggestions to improve PTC. When asked if participants received any refresher training after their first use, 88% responded they did receive training; however, they mentioned that it is mostly conducted during an Engineer's Annual Rules Training and limited to classroom instruction only. Other reporters mentioned that training mainly covered PTC when it is working as expected.

Training on PTC failures and territory-specific exceptions were also identified as not adequate by reporters. Most reporters (68%) stated they received inadequate or no training at all with regards to handling PTC failures. The same number of reporters (68%) also stated they did not receive any training on territory-specific exceptions. Reporters mentioned that PTC system updates / fixes were not being communicated out to operators by carriers in a consistent way.

Reporters stated the frequency and location of system updates in their documentation was confusing and added to their frustrations. Some updates were provided in daily bulletins, various types of notices, or other types of communication. Updates / fixes were completed at unknown frequencies, so operators had to constantly search for new communications to stay current on new or updated PTC instructions. With constantly changing PTC system updates, increased communication and education regarding what is expected from operators could alleviate confusion. It appears that training covering "off-nominal" types of events in various modalities such as classroom, simulations, and practical trainings in the field, would be beneficial.

## 4.3 PTC Acceptance

With regards to PTC acceptance, 65% of participants stated the implementation of PTC increased their workload (Q43). This is perhaps not surprising as the introduction of any new technology and form of operation can be expected to increase workload in many situations. This increase in workload made train operations harder according to 65% of reporters (Q44). When asked if PTC changed the way Engineers operate their train (Q41), 65% of participants affirmed that PTC has changed the way they operate. Among the responses received, reporters stated PTC requires more attention from the Engineer, which could potentially be a source of distraction.

Monitoring PTC is an additional task in a job that requires constant situational awareness. While PTC is important in its function as a safety device, the additional attention and work required can limit an operator's ability to focus on other tasks that are also important. This is especially true when the PTC system is not functioning consistently or in a manner consistent with the operator's expectations. System accuracy is crucial to train operations and the inconsistencies are making the operation of trains more difficult for operators. Reporters suggested that increased system consistency would be beneficial. Participants mentioned more in-depth training would also help with PTC consistency. They mentioned a better understanding of how PTC systems work and how to troubleshoot system issues would help operators resolve problems during operations.

## 4.4 Display / Alerts

Displays and audible alerts are different with each PTC system. The results of the SQS suggest that PTC displays and audible alerts can be distracting at times. The majority of participants (75%) reported being distracted by the PTC system in the last three months (Q39). In the same amount of time, 68% found PTC to be confusing at times (Q38). The system did help in alerting operators with 88% of participants answering that PTC effectively directed their attention and provided information on what actions to take (Q40).

Along with the PTC display, the audible alerts were the most frequently mentioned reason for confusion by participants (Q38). Participants suggested adjusting the volume, improving accuracy (limiting false positives), more consistent advance warnings, and reducing unnecessary audible alerts when asked how to improve PTC. From a human factors perspective, the use of alarms or alerts can be addressed from a variety of perspectives such as perceived usefulness, prioritization, frequency, accuracy, and timing—allowing the operator enough time to troubleshoot prior to the same or another alert sounding. Possible improvements may exist here with possible lessons learned from other domains.

# Appendices

## 5.0 APPENDICES

Appendix A: Supplemental Question Set (SQS)

Appendix B: Coding Form / SOP Definitions

Appendix C: Key Terms

Appendix D: $C^3$RS Analyst Synopses

# Appendix A

## Supplemental Question Set

# Related to the Event Reported

**1. What was the PTC related close-call event?**

- (Specify): _____

**2. Was PTC in effect on your territory?**

- Yes
- No (Specify): _____

**3. Was PTC in effect/cut in on your train and working to your knowledge?**

- Yes
- No (Specify): _____

**4. What type of PTC were you using?** Clarify reporter is talking about PTC and not something else.

- ACSES
- ACSES II
- ITCS
- E-ATC
- I-ETMS
- Other (Specify): _____

# Initialization

**5. On the day of your reported event, did your Onboard System initialize as expected?**

- Yes – Skip to Question 9
- No (Specify): _____

**6. What kind of initialization issues did you have?**

- Specify: _____

**7. Did you have enough time to troubleshoot and resolve it?**

- Yes
- No (Specify): _____

**8. Did you have to depart prior to initialization?**

- Yes (Specify): _____
- No

**9. Did the restrictions in PTC accurately reflect your paperwork?**

- Yes
- No (Specify): _____

## PTC-Specific Event

**10. Did PTC work as intended?**

- Yes
- No (Specify): _____

**11. Did you experience a PTC failure?**

- Yes (Specify): _____
- No -Skip to Question 17

**12. Did you recover from the PTC failure?**

- Specify: _____

**13. Did PTC provide an understandable alert (visual or tone) prior to incident? (If alert was provided, but not understandable, capture the nature of the alert and how it was confusing)**

- Yes
- No (Specify): _____

**14. Was there a violation of a speed restriction or work zone limits before PTC enforced a penalty?**

- Yes (Specify): _____
- No -Skip to Question 16

**15. How far into the restriction did you operate before PTC enforced a penalty?**

- Specify: _____

**16. Did you bypass any PTC functions (no code, stop override, soft cutout) without permission during this event?**

- Yes (Specify): _____
- No

## Training and Experience with PTC

**17. How long have you been using PTC? (Please clarify any outlying numbers)**

- _____MONTHS

- _____YEARS

**18. Was the PTC training you received adequate?**

- Yes
- No (Specify): _____

**19. How long between initial training and your first use of PTC?**

- _____MONTHS

**20. Did you receive any refresher training prior to your first use of PTC?**

- Yes (Specify): _____
- No

**21. Did you receive any refresher training after your first use of PTC?**

- Yes (Specify): _____
- No

**22. Did your training cover the following: "What steps to take when initialization fails?"**

- Yes
- No
- Yes, but training was not adequate. Please explain

**23. Did your training cover the following: "What to do after a failure?"**

- Yes
- No
- Yes, but training was not adequate. Please explain

**24. Did your training cover the following: "territory-specific exceptions?"**

- Yes
- No
- Yes, but training was not adequate. Please explain

# Faults and Anomalies – General

**25. In the last three months, how many days per week do you operate trains?**

- _____

**26. In the last three months, how many times have you departed your initial terminal with PTC cut out?**

- _____

## Faults and Anomalies – PTC Failures

**27. In the last three months, how many times did you experience a PTC failure en route?**

- _____
  - Please describe the failure types

**28. How many times have you had to cut out PTC en route?**

- _____

**29. How many failures were due to mechanical issues?**

- _____
  - Please describe each failure, and were you trained to handle the specific failures

**30. How many failures were due to other issues?**

- _____
  - Please describe each failure, and were you trained to handle the specific failures

**31. When PTC failed, did you need time to readjust to operating without PTC?**

- Yes (Specify): _____
- No

**32. What do you need to do to readjust to operating your train when PTC fails?**

- (Specify): _____

**33. How long does it take to readjust to operating your train when PTC fails?**

- (Specify): _____

**34. Are you given the appropriate time to readjust to operating your train when PTC fails?**

- Yes
- No (Specify): _____

# Faults and Anomalies - Other Issues (Non-Failures)

**35. In the last three months, how many times did you experience PTC not enforcing known restrictions such as not picking up speed restrictions, not displaying a crossing warning, not picking up working limits?**

- _____
    - Please explain each occurrence

**36. In the last three months, how many times did you experience PTC issues that you can attribute to data entry on the Dispatcher side or back-end programming?**

- _____
    - Please explain each occurrence

**37. In the last three months, how many other types of PTC related issues have you experienced, but not mentioned?**

- _____
    - Please explain each occurrence

# Human Machine Interface

**38. In the last three months, can you think of any times when the PTC display was confusing?**

- Yes (Specify): _____
- No

**39. In the last three months, can you think of any times when you were distracted by the PTC System?**

- Yes (Specify): _____
- No

**40. Do you consider PTC alerts effective in helping direct your attention and giving you information on what actions to take?**

- Yes
- No (Specify): _____

# PTC Acceptance

**41. Has PTC changed the way you handle your train?**

- Yes (Specify): _____
- No

**42. Do you tend to rely on PTC for train handling?**

- Yes (Specify): _____
- No

**43. When operating with PTC, would you say that your workload has:**

- Increased (Specify): _____
- Decreased (Specify): _____
- Remained the same

**44. Has PTC made operating your train easier or harder?**

- Easier (Specify): _____
- Harder (Specify): _____
- Remained the same

**45. How can PTC be improved?**

- (Specify): _____

# Appendix B

## Coding Form / SOP Definitions

## Coding Form Data: Definitions of Values

The following definitions are used by the C$^3$RS Expert Analysts during Full Form Analysis.

### Anomaly / Event Type

C$^3$RS Expert Analysts code the Anomaly / Event to reflect what happened at the point at which those involved became aware of the problem. Multiple Anomalies can be selected.

| Term | Definition |
|---|---|
| **Procedural Deviation / Operations Policy** | A procedural or operational event that includes non-compliance with a published operational policy or procedure. This is often coded in conjunction with other anomalies. |
| **Signal Event / On Board Control System** | A signal event that involves the failure of a signal-based system on a locomotive. Cab Signals, PTC, or any other type of system that relies on the track signal system. |
| **Mechanical / Less Severe** | A mechanical event that involves an equipment problem that does not incapacitate a train and can be bypassed to allow the continued operation of the train (i.e., Cab signals or PTC system cut out). |
| **Speed Deviation / At or Above 10 MPH Deviation** | A speed deviation event involving a train that is operating at or above 10 MPH over the required speed. |
| **Speed Deviation / Maximum Authorized Speed** | A speed deviation event involving a train that is operating above the maximum speed of a train or track. |
| **Speed Deviation / Temporary Speed Restriction** | A speed deviation event involving a train that is operating above a temporarily reduced speed restriction that is put in place often due to track defects or track work. |
| **Emergency / Penalty Brake Application** | Any event involving an emergency brake application - desired or undesired. May be initiated by a crewmember in a locomotive by activating the End of Train Telemetry Device (EOT) by a Remote-Control Operator or a penalty brake application. |

## Contributing Factors

C$^3$RS Expert Analysts can select more than one contributing factor during Full Form Analysis.

| Term | Definition |
|---|---|
| **Human Factors** | Human performance deficiency or breakdown among train crew, engineering, supervisors, maintenance, etc. |
| **Train/On Track Equipment** | Issues with Train/Equipment. |
| **Publications-Books/Regulations** | Information or instructions contained within any publication (i.e. rule books, timetables). |
| **Procedure** | Procedure / Process in place to prevent incident and not followed. This may also include if a reporter suggests there is a gap or need for a new procedure to be put in place. |
| **Training/Qualification** | Lack of experience or need for further education and/or training. |
| **Signal System** | A mechanical or electrical device erected beside railway line to pass information relating to the state of the line ahead to operators in trains or on-track equipment, which contributed to the incident. |
| **Machinery/Tooling** | Mechanical and maintenance-related issues. |
| **Workplace Documentation** | Supplemental documentation to publication books/regulations that are specific to a designated workplace or location (general orders, bulletins, carrier notices). |

## Human Factors

C$^3$RS Expert Analysts can select more than one human factor during Full Form Analysis.

| Term | Definition |
|---|---|
| **Situational Awareness** | Issues involved in being aware of what is happening around you to understand how information, events, and your own actions will impact your goals and objectives, both now and in the near future. |
| **Human-Machine Interface** | Problems or issues associated with the interface between human and system (hardware and software). This includes locomotive computer integration, remote control operation devices, control panels, mechanical malfunctions, and other controls. MUST involve a human and a machine (computer or otherwise) and not the entire train/locomotive, equipment itself. Includes design of equipment, ergonomics (e.g., control stand design). It does not include issues between humans. |
| **Troubleshooting** | Isolating a fault often will be related to maintenance, signal systems, or machinery. |
| **Training/Qualification** | Problems or issues arising as a result of, or in connection with, an on-the-job training/examination or check rides. Also includes issues with experience, qualifications, and knowledge. |
| **Distraction** | Reporter states distraction, or narrative suggests being distracted from a task. |
| **Confusion** | Loss of orientation (ability to place oneself correctly in the world by time, location, and personal identity) and often memory (ability to correctly recall previous events or learn new material). |
| **Time Pressure** | Time pressure, whether self-imposed or imposed by others, as related to train crews, dispatchers, manager, train schedule, etc. |
| **Communication Breakdown** | Human communication issues, which may involve either spoken or visual signals (or both). Interactions between people such as coordination, phraseology, receive or repeat transmissions or instructions, language barriers, interpersonal conflicts, job briefings, and supervision. Not to be used for human and equipment interaction. |
| **Workload** | Workload in terms of task demands and the ability to cope with task demands; workload management. |

# Appendix C

Key Terms

## Key Terms

The following definitions were used in this PTC Study to provide consistency in the data collection process.

| Term | Definition |
|---|---|
| **PTC** | Positive Train Control. May also be referred to as an Onboard System. |
| **PTC Failure[1]** | Any instance in which PTC fails completely; system cut out and no longer operational. |
| **PTC Fault[1]** | PTC or related system error that prevents PTC from working as intended. Examples include synchronization error, GPS error, acknowledgement error. System can be recovered via reset or acknowledging fault. |
| **Back-end Programing** | Coding or PTC data entered into a train's PTC system from a remote location. |
| **Initialization** | Activating the Onboard System.<br>Note: Initialization may be conducted by the human or the system as is the case with ACSES/ACSES II which may be initialized by mechanical forces prior to crew boarding the train. |
| **Cut out** | The crew turning the PTC System OFF via bypasses, breakers or logging off. |
| **Territory-Specific Exceptions** | Any territory features such as tunnels, bridges, and mountains that may cause PTC faults or failures. |

[1]PTC Failure/Fault can be defined differently from carrier to carrier and may not be distinguished by a reporter. For this study, Failure/Fault will use definition above.

# Appendix D

## $C^3$RS Analyst Synopses

**ACN 21957**

An Engineer reported improperly cutting out Positive Train Control after receiving numerous penalty brake applications.

**ACN 21898**

An Engineer was overspeed in a Temporary Speed Restriction citing malfunctioning Positive Train Control and lack of Speed Signs as contributing factors.

**ACN 21856**

An Engineer was overspeed in a Temporary Speed Restriction, citing malfunctioning Positive Train Control as a contributing factor.

**ACN 21846**

A Train Crew was instructed to depart the yard with malfunctioning Positive Train Control.

**ACN 21796**

An Engineer was overspeed in a Permanent Speed Restriction citing malfunctioning Positive Train Control as a contributing factor.

**ACN 21748**

An Engineer reported malfunctioning Positive Train Control en route, resulting in having to proceed at reduced speed

**ACN 21649**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control failed en route.

**ACN 21639**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control failed en route.

**ACN 21589**

An Engineer entered a Temporary Speed Restriction overspeed but returned to compliance within the restriction.

**ACN 21588**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control malfunctioned en route.

**ACN 21551**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control failed en route.

**ACN 21526**

An Engineer was overspeed in a Temporary Speed Restriction, citing malfunctioning Positive Train Control as a contributing factor.

**ACN 21490**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control failed en route.

**ACN 21473**

An Engineer was overspeed in a Temporary Speed Restriction, citing malfunctioning Positive Train Control as a contributing factor.

**ACN 21457**

An Engineer may have exceeded Maximum Authorized Speed after the cab signals and Positive Train Control failed en route.

**ACN 21446**

An Engineer was overspeed in a Temporary Speed Restriction after Positive Train Control failed en route.

**ACN 21367**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control failed en route.

**ACN 21327**

An Engineer, after cutting out PTC, was overspeed in a Temporary Speed Restriction. Immediately after realization, the Engineer returned to compliance.

**ACN 21319**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control failed en route.

**ACN 21271**

A Train Crew thought they had violated an operating rule when Positive Train Control failed en route. It was later determined the rule was not in effect.

**ACN 21226**

An Engineer experienced a Positive Train Control malfunction, resulting in an overspeed event.

**ACN 21201**

An Engineer did not retest the Positive Train Control after resetting the circuit breaker.

**ACN 21184**

An Engineer exceeded Maximum Authorized Speed after Positive Train Control was cut out en route.

**ACN 21144**

An Engineer was overspeed in a Permanent Speed Restriction citing troubleshooting malfunctioning Positive Train Control as a contributing factor.

**ACN 21141**

An Engineer did not stop at an interlocking with a dark signal present, citing Positive Train Control as a contributing factor.

**ACN 21106**

An Engineer departed with Positive Train Control cut out on the cab car.

**ACN 21007**

An Engineer did not operate Positive Train Control correctly while operating out of the yard.

**ACN 20806**

An Engineer reported malfunctioning Cab Signals and Positive Train Control en route.

**ACN 20699**

An Engineer exceeded Maximum Authorized Speed, resulting in a Positive Train Control penalty brake application.

**ACN 20674**

An Engineer reported operating overspeed in a Temporary Speed Restriction, citing malfunctioning Positive Train Control as a contributing factor.

**ACN 20633**

An Engineer did not activate Positive Train Control while traversing territory with Positive Train Control. Immediately after realization, the Engineer activated the Positive Train Control.

**ACN 20627**

An Engineer used the Positive Train Control stop bypass without verbal permission from the Dispatcher.

**ACN 20605**

An Engineer, after completing a station stop, was overspeed in a Temporary Speed Restriction.

**ACN 20598**

An Engineer did not perform the proper horn sequence at a road crossing at grade due to a constant malfunctioning alerter warning. The Engineer reported that multiple alerts while operating a train is a safety concern.

**ACN 20585**

An Engineer was overspeed in a Temporary Speed Restriction after completing a station stop; Positive Train Control did not enforce the Temporary Speed Restriction.

**ACN 20580**

An Engineer reported not performing a Positive Train Control test after cutting it out and back in trying to reset a fault.

**ACN 20481**

An Engineer reported a train rolled backward within an interlocking after recovering from a unwarranted penalty brake application by Positive Train Control.

**ACN 20460**

An Engineer reported not checking Positive Train Control seals prior to departing.

**ACN 20421**

A Conductor reported not logging into the Positive Train Control system prior to departure, citing an overlooked Bulletin Order item as the contributing factor.

**ACN 20340**

An Engineer was overspeed entering a Permanent Speed Restriction curve due to Positive Train Control dropping out without warning.