Why do train drivers pass red signals? Understanding the immediate and underlying causes of SPAD events

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SUMMARY

An accident investigation framework has been introduced into the GB rail industry's safety management intelligence system (SMIS) to understand the immediate and underlying causes of SPAD events. This paper will show the process of reporting detailed causes, the challenges of introducing this framework into operational environments and an analysis of the causes of SPAD events.

KEYWORDS

Human performance, underlying causes, rail accident and incident investigation, SPADs

Introduction

The Office of Rail and Road (ORR) describe a signal passed at danger (SPAD) as an event that occurs when a train passes a stop signal when not allowed to do so (ORR, 2023). Over the past 100 years there have been several significant SPAD accidents including Harrow and Wealdstone (1952), Southall (1997) and Ladbroke Grove (1999). These events led to the introduction of train protection systems such as the Train Protection Warning System (TPWS) (RSSB, 2018).

The driver of the train involved in the SPAD at Purley in 1989 was prosecuted as they were blamed for the event. Years later the driver was acquitted after new evidence showed that there had been 4 previous SPADs at that signal so there was something about the design of the infrastructure that made errors more likely (RSSB, 2018). This highlights that the human and system failures need to be understood to effectively manage SPAD risk. Harrison et al., 2022 compared data on how many SPADs occurred on the mainline network per year with data on red aspect approaches (RAATs) (RSSB, 2023c) to show that train drivers have a SPAD event on average 1 in every 43,000 red aspect approaches. When compared to the human error probability for this type of task in the rail action reliability assessment tool (RARA) (RSSB, 2019), it showed that train drivers are performing close to the limit of human performance. System improvements will therefore be key in reducing the number and risk of SPAD events.

The number of SPADs each year and the risk from SPAD events decreased following the introduction of TPWS but has now plateaued at 250-300 events per year. According to the GB rail industry's Safety Risk Model (RSSB, 2022c), SPADs account for a low percentage of overall risk on the railway (RSSB, 2022b), however there is still the potential for catastrophic harm where trains pass a signal at danger and reach a point where conflict with another train is likely.

Human performance factor and 10 incident factor framework

A framework was initially developed to classify the range of causes of operational events. This original framework was based on the Generic Error Model for Rail to capture human performance failures and the 10 incident factors for identifying system related failures (Smith and Lowe, 2012). It was called the Incident Factor Classification System (IFCS) (Cynk et al., 2017). The IFCS was used by the Human Factors team at RSSB to classify a sample of industry operational events each month. The data were used to create special topic reports on areas such as SPADs and safety critical communications.

The Safety Management Intelligence System (SMIS) is an online health and safety reporting and business intelligence software. All GB mainline railway undertakings and infrastructure managers input and extract safety data from the system (RSSB, 2023a). SMIS collects information on thousands of safety events each year. When SMIS was updated, there was an opportunity to integrate the IFCS framework into the system and to refine the classification categories so that they could be entered by industry accident investigators. This would mean there was an industry wide mechanism for capturing the immediate and underlying causes of adverse events. The use of a framework for identifying accident causes also creates a common language in accident investigations and encourages a fair culture in investigations by classifying system failures as well as the human failures.

The IFCS was refined by conducting:

- A review of the 6,800 lines of IFCS data to understand categories not used or used reliably.
- Interviews with users of the IFCS (n = 11) including Human Factors specialists and industry incident investigators to gather feedback on their experiences using the IFCS.
- A review of 28 classification systems from other safety critical industries (including Human Factors Accident and Classification System (Wiegmann and Shappell, 2003) and Cognitive Reliability and Error Analysis Method (Hollnagel, 1998)).
- Three rounds of trials with human factors specialists and potential users (n = 51) to test the proposed changes
- A mapping exercise so that the existing IFCS data could be transferred into SMIS.

The human performance factor (HPF) and 10 incident factor (10IF) framework (renamed from the IFCS) was built into SMIS in 2019. This framework has been incorporated into the Railway Industry Standard, RIS-3119-TOM Accident and Incident Investigation (RSSB, 2022) and so is considered industry best practice. The framework is presented in Figure 1 below. Each of these categories have subcategories and supporting qualitative descriptions to understand the causes being classified in more detail.

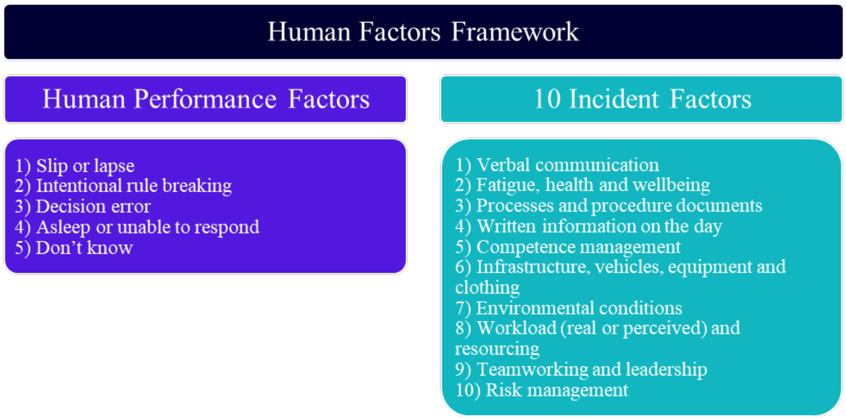

Figure 1: RSSB's Human Factors Framework

When a SPAD event occurs, the initial event details are entered by the infrastructure manager. An investigation is then completed by either the operator of the driver involved in the event or by the infrastructure manager. The detailed causal information is then entered into SMIS using an online form called the 'causes form' (which includes the HPF and 10IF framework) by the investigating company once the investigation has been completed. This means that the causal data is entered 3-9 months after the event depending on the length of time it takes to complete the investigation.

SPAD causes

The following data has been exported and analysed directly from SMIS and shows the human performance and system level failures identified through the causes form over the last three years. Since April 1st, 2021, there have been 690 SPADs across the GB rail network; 525 passenger and 165 freight. 308 cause forms have been entered over the same period with 885 causes, meaning that we are able to understand the human performance and system failures for approximately 45% of the SPADs that have occurred.

Exploring this further we can see that of the 308 cause forms submitted, there have been 488 human performance factors and 339 10 incident factors identified. When reviewing the human performance factors for train drivers involved in SPAD events over the last 3 years, the most frequent immediate cause of train drivers going through red signals is slip or lapse errors (73%) closely followed by decision errors (22%) (Figure 2).

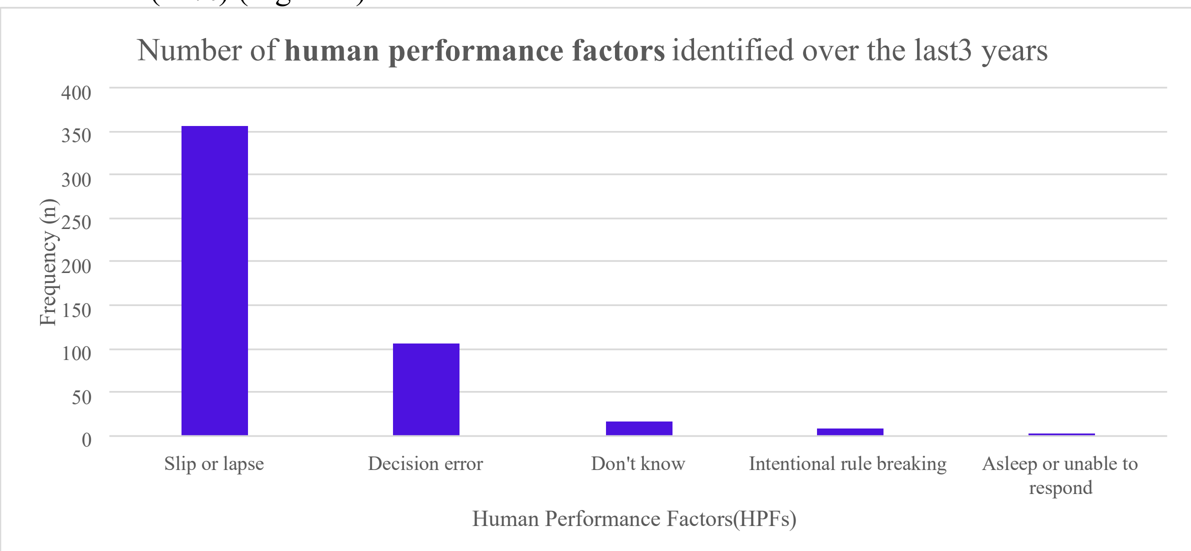

Figure 2. Number of HPFs identified over the last 3 years

Slip or lapse errors are divided into 9 sub-categories (Figure 3). Slip or lapse errors tend to happen in routine tasks that people are doing without much conscious thought (for example, on autopilot). These happen when people know what to do in the situation but do something wrong without realising. This includes slips or lapses in seeing, hearing, speaking, doing (physical actions) and remembering (RSSB, 2022d). For example, the factor description of one incident read: *" The driver boarded the north end cab, reset his DRA and started to move the train from a stand half way along the platform. He believes he may have been distracted by the people on the platform but did not check his signal which had not been cleared. As he passed it he received a SPAD indication on ATP display and a red light illuminated on TPWS. The train was brought to a stand approximately half a coach length past the signal. The driver reset the driver reminder appliance (DRA) without checking the aspect of the starting signal."* The immediate cause was cited as a slip or lapse error, 'distracted or not paying attention' in addition to 'forgot something, mis-remembered something or missed something out'.

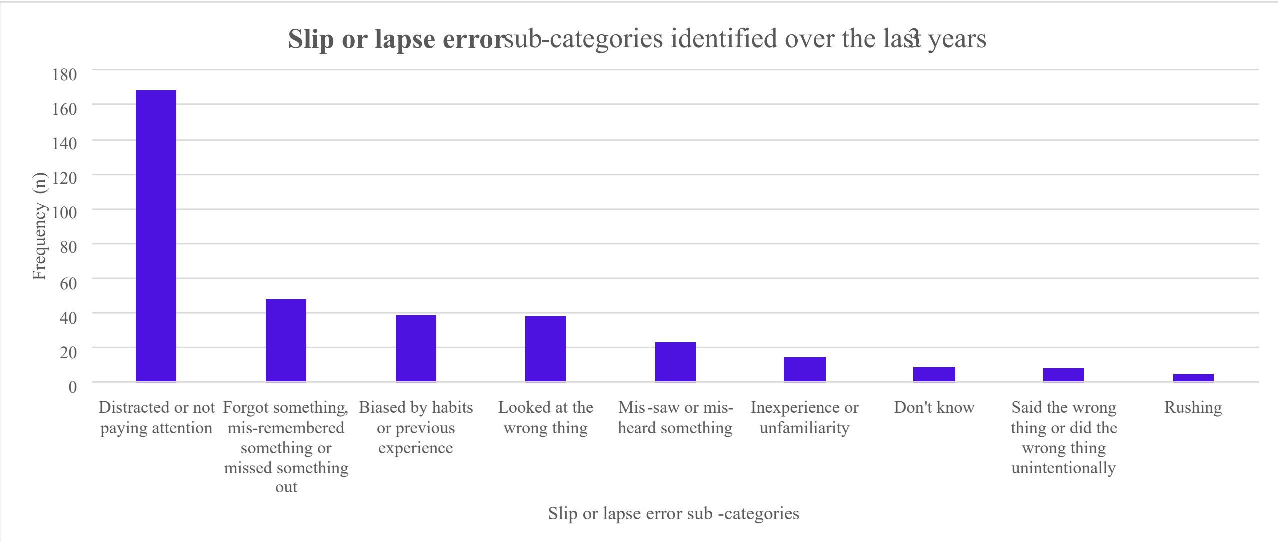

Figure 3: Slip or lapse error sub-categories identified over the last 3 years

Decision errors are divided into 7 sub-categories. Decision errors are errors in conscious judgements, decisions or strategies. These happen when people are aware that they are making a decision, a choice or adopting a strategy, but they are not aware that it is somehow 'wrong'. This includes errors due to lack of knowledge and from mis-understanding a situation. Over the last 3 years, the leading cause for drivers passing signals at danger due to a decision error is 'misunderstanding of a situation or wrong assumptions made' (35%), followed by 'distracted or not paying attention' (22%). For example, the factor description of one incident read: *"The driver commenced a train movement when he observed the correct route indication displayed in the miniature indicator but did not observe that the signal aspect remained at danger, directly resulting in a SPAD. The driver's unfamiliarity with the shunt movement could be a source of distraction upon changing ends as discovered by 2 calls to the Signaller querying about the shunt movement to be carried out."* The immediate cause was cited as a decision error, 'mis-understanding of situation or wrong assumptions made' in addition to 'distracted or not paying attention'.

When reviewing the 10 incident factors over the last 3 years, we can see that the most frequent underlying system cause of drivers going through red signals is 'infrastructure, vehicles, equipment and clothing' (IVEC) closely followed by 'verbal communications' and 'competence management' (Figure 4).

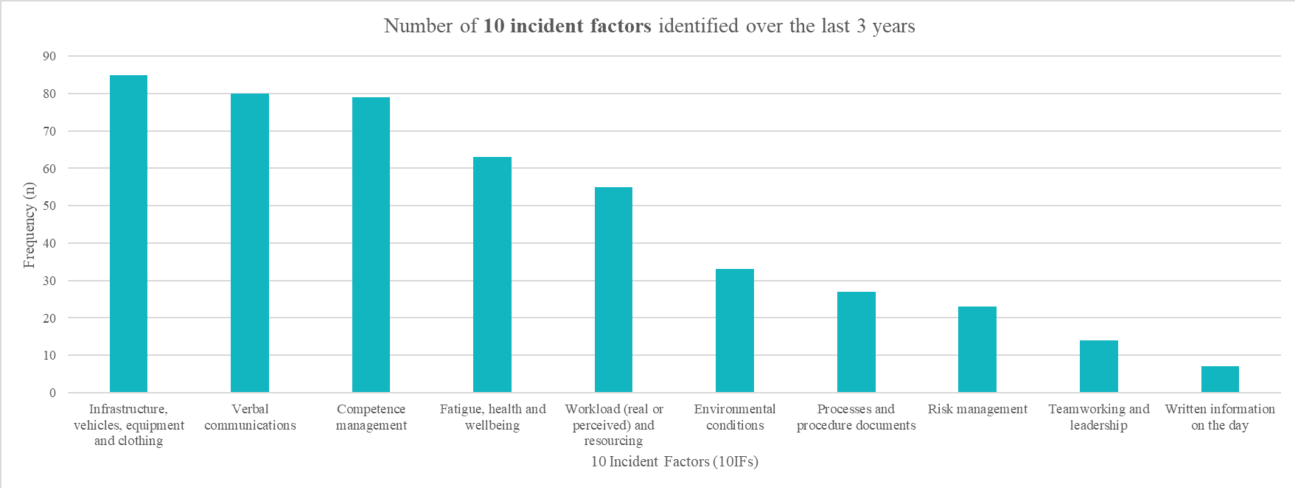

Figure 4: Number of 10IFs identified over the last 3 years

IVEC is divided into 5 sub-categories (Figure 5) and covers any equipment used to undertake or support an activity on the operational railway. This includes but is not limited to railway signals, train brakes, automatic warning system (AWS), train protection warning system (TPWS), controls and displays in cabs, signal boxes or control centres, route drivability, and personal protective equipment (PPE).

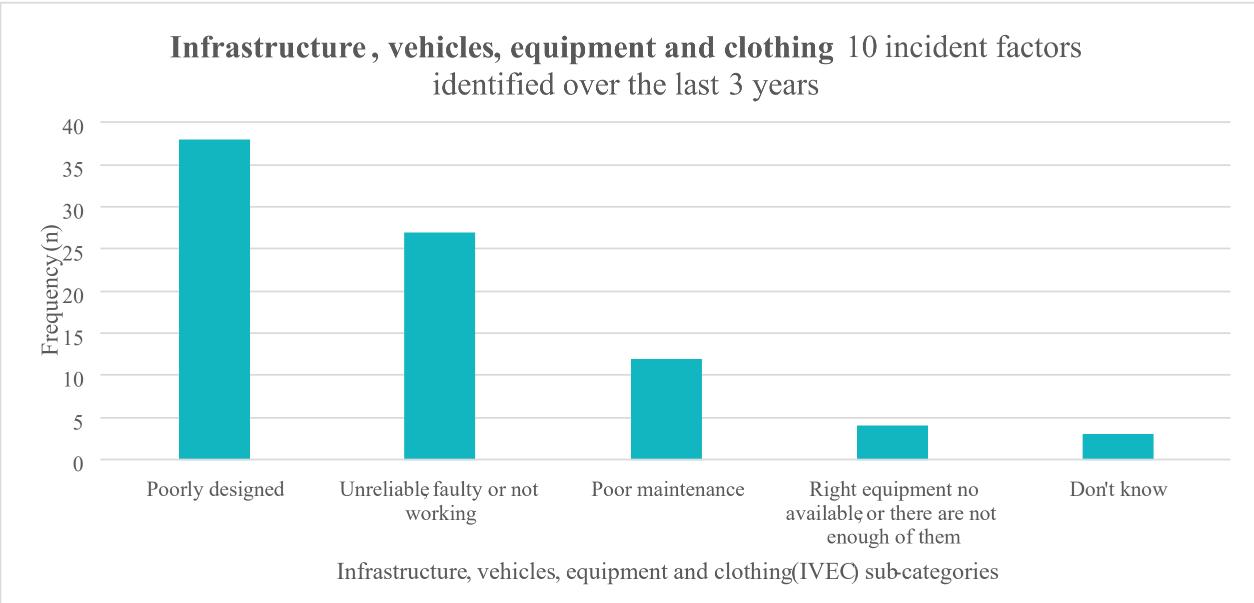

Figure 5: Infrastructure, vehicles, equipment and clothing 10IFs identified over the last 3 years

The 'poorly designed' sub-category within IVEC can be broken down into further sub-factors. 'Poor usability' is the leading cited underlying cause of drivers passing signals at danger, over the last 3 years. For example, the factor description of one incident read: *"The layout of the signals at this location lend themselves to being misread, with a relatively unusual right-hand signal being placed on the same signal gantry as left-hand signals."* Another example of poor usability as a contributory underlying system failure to a SPAD is: *"The column next to the driver's window could potentially obstruct the view of the signal, particularly if the train wasn't stopped accurately alongside the board. Additionally, the 10 car stop board is placed at a height of approximately 2-3 feet. The Company instruction to drivers is to stop the train with the car stop board in the quarter light* *window. This could not be done with any accuracy at this station as the 10 car board was not placed at a sufficient height to be viewed from the driver's position in the quarter light window."*

This data has primarily been collected for SPAD events (n = 379); however, some operators use the causes form to enter data for other operational events such as train derailments (n = 55) and railway operating incidents (which include station stopping incidents and handbrakes being left on in depots) (n = 179). Each of these event types have a different 10IF profile as shown in Figure 6. For example, train derailments have a higher percentage of IVEC classifications (especially relating to depot maintenance) compared to other event types and risk management. Railway operating incidents have a higher percentage of processes and procedure document classifications and SPADs have a higher percentage of fatigue, health and wellbeing classifications.

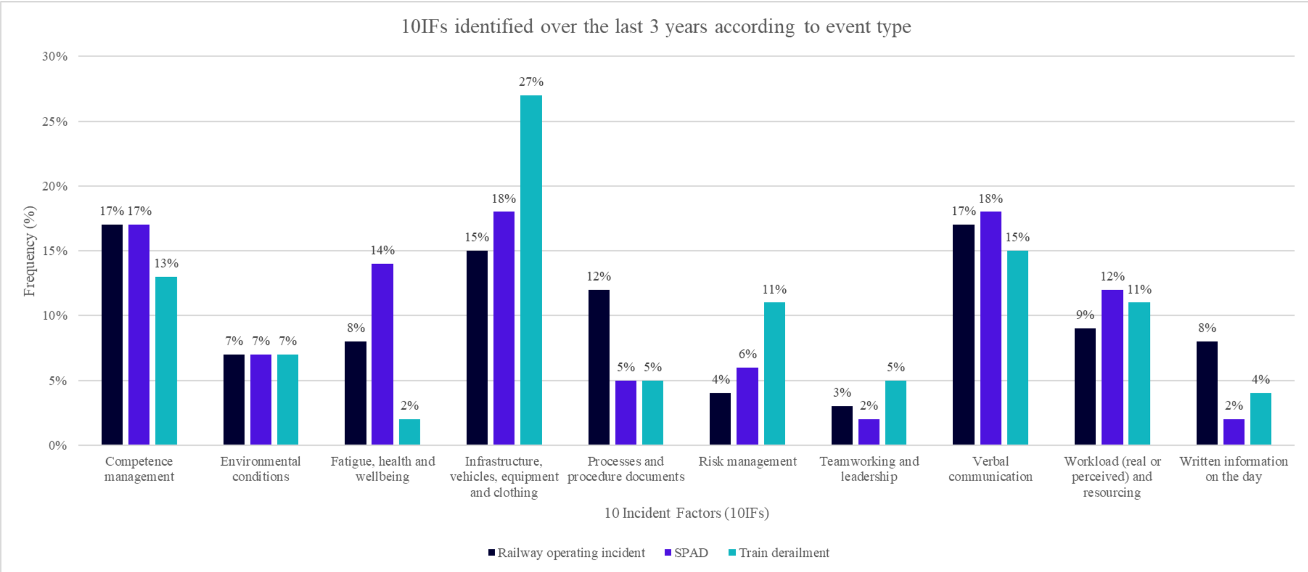

Figure 6: 10IF profile comparison for SPADs, railway operating incidents and train derailments

How underlying cause data can be used to make safety improvements

The data generated by the causes form is now being used by industry to strengthen their defences against SPAD events. For example, a passenger operator has amended the way investigations are completed to include a preliminary investigation review. In this meeting they look at each 10IF and whether that contributed to the event to ensure that the full range of factors were considered in their investigations. This company have also used the causes form data to make immediate changes to documentation such as yard safety plans but also to make more complicated changes such as train turnaround times. At the end of a journey, sometimes there is a short amount of time for the driver to take a comfort break and change ends of the train and they may also be approached by customers. The collection of this data in SMIS means that data is collated in one place and therefore evidence from a number of events can be used to make the case for extending the turnaround time which although is compliant with industry requirements, was impacting on driver performance. Investigators previously may not have included this in their investigations because it wouldn't have led to a change but now contributes to an evidence base to make change (RSSB (2023d).

SMIS cause form data has also been used in other areas of the rail industry such as workforce/ occupational safety (RSSB, 2023b). In 2023, the Infrastructure Safety Leadership Group (ISLG) for GB rail commissioned work into assessing an emerging risk of engineering objects being left on the line following possessions and engineering works. As part of this work, which included observations within work sites and possessions, interviews with frontline staff and managers, and workshops; the RSSB human factors team performed a review of incident and accident data in SMIS to understand the immediate and underlying causes of engineering objects being left on the line. The findings were synthesised and presented to several Leading Health and Safety on Britain's Railway (RSSB (2022) groups, which are the GB rail industry's risk groups, to drive change in providing understanding and associated recommendations and solutions to address the issue of objects being left on the line to industry. The framework has also been applied proactively to identify potential human and system failures for the machine/crane controller task (RSSB, 2022a).

Challenges of collecting underlying cause data in the rail industry

The causes form is currently completed for approximately 45% of SPAD events and has increased year on year. However, challenges remain in getting this data into SMIS including (but not limited to):

Quality of the investigation: the data in SMIS is entered by inputters from each operator and therefore the quality of it is only as good as what is inputted. The investigation itself needs to identify the range of immediate and underlying causes so that it can be entered. Many operators do not have specific accident investigators and it is instead an addition to another role. This means that they have a high workload and may not have advanced knowledge/skills on how to extract these causes as part of their investigation. The target entry time for the causes form is 90 days after the event date and, it often takes longer for this information to be entered because of the workload of investigators.

Role of the inputter: the SMIS inputters are individuals that enter the information into SMIS. This is usually a dedicated role. However, the SMIS inputters are not part of the investigation or involved in day-to-day operations. The information to be entered into the causes form therefore needs to be provided to the SMIS inputter in a way that it is easy to identify and enter. The structure of some investigation reports does not make this task simple, and the SMIS inputter would not have the time to search reports for causes. There are inputters who have company specific incident reporting systems and so SMIS is the second system that they need to enter information into. This means that data has to be entered twice into two different systems.

Data quality: to ensure data is inputted consistently between companies, the RSSB team reviews each entry to ensure the framework has been correctly applied. However, the SPAD data shows that HPFs are still more commonly identified than 10IFs and a comprehensive support package is needed to help both investigators and those inputting the data to understand how to identify these types of factors in accident investigation and correctly classify them.

Frameworks: the HPF and 10IF framework for identifying immediate and underlying causes is included within the rail industry standard for accident investigation and is therefore considered best practice. However, use of the framework or entry of cause form data is not currently mandated and therefore some operators have developed an alternative framework.

Conclusion

The HPF and 10IF framework was incorporated into SMIS in 2019. This framework has been used to collect data across the rail industry and is inputted by industry. There are challenges to implementation of this type of framework in a real-world operating environment, but the data from SPADs has reached a level where it can be used to make changes within organisations and across industry. For example, the data shows that slip/lapse type errors are the main human performance failure for this type of event and that a large proportion of these errors have a distraction subcategory classification. The qualitative descriptions that accompany these classifications show that the most common distractions are work related (station stopping duties, out of course movements). Therefore, personal protection strategies and task/equipment design changes could be considered. Improvements could also be made in the drivability of the signalling system, standard of verbal communications and in the provision of training in competence management systems.

The future activities for this project are to:

1. Develop and broaden the range of resources for accident investigators and SMIS data inputters. This includes the accident investigation training (RSSB, 2023e) and special topic videos on investigation hot topics (such as situation awareness and fatigue).
2. Improve data quality by promoting the use of the 10IFs to identify system failures.
3. Expand use of the causes form so that it is consistently used by operators for other event types beyond SPADs.
4. Use technology to make the data entry process more efficient. This includes the use of artificial intelligence (AI) models to extract causes data directly from investigation reports and technology that will automatically extract data from an organisations safety reporting system directly into SMIS (RSSB 2023f).

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