A STRUCTURED INCIDENT ANALYSIS OF HUMAN PERFORMANCE IN FREIGHT TRAIN PREPARATION

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ABSTRACT

The condition of rail freight vehicles entering the network is a concern for the freight community. Human performance failures may be a significant source of operational risk. An analysis was performed of 31 freight preparation incident and accident reports. These reports were analysed using the Rail Safety and Standards Board (RSSB) Human Factors Framework. 27 of 31 reports included a significant human performance failure, identifying 45 human performance factors across the incidents, including 39 occurrences classified as a slip / lapse or decision-making failures. These were generally omissions of checks or actions to release brakes. 137 underpinning Incident Factors played a causal or contributory role. This included 'infrastructure, vehicles, equipment and clothing' (n = 43), including maintenance and equipment failure issues – primarily related to wagon condition - and design / usability issues related to a range of assets. Teamworking (8) and resourcing (17) issues were also present, which included factors related to inter-agency working. The paper discusses the implications of these results for improving rail freight safety performance, and emphasises the importance of a systems view of human performance to deliver safe, efficient rail freight.

BACKGROUND

Rail freight is a key function of the economy, moving bulk goods such as aggregates and fuel, intermodal containerised goods, dangerous goods such as nuclear fuel, and providing supplies and train movements for the build and repair of the railways itself. In Great Britain (GB), the total economic and social benefits of freight are valued at £2.5bn annually and removes the equivalent of 7 million heavy goods vehicles from the roads. Therefore, the continued success and growth of rail freight is a cornerstone of transport decarbonisation, nationally and globally (e.g. UNESCAP, 2021).

Rail freight needs to be reliable. Incident-free rail freight is essential to ensure existing freight customer confidence while attracting new customers. Delays to freight trains can be costly, with minor incidents costing thousands of pounds in delay costs, through to accidents that might involve the loss of the freight load, damage to infrastructure or potentially weeks of disruption to both passenger and freight services (e.g. RAIB 2022).

Most importantly, the carriage of freight needs to be safe, ensuring the integrity of the load, and safety and staff and public.

In Great Britain, the 2020 Rail Safety and Standards Board (RSSB) Annual Health and Safety Report highlighted that in the previous two years, there had been a rise in the number of potentially higher risk train accidents for freight, a trend that is driven by an increase in derailments. Further, over this period, over 350 trains were stopped on the network due to issues with vehicles, importing safety risks and delays to the network. The GB railway's National Freight Safety Group (NFSG) has identified that the condition of vehicles entering the network is the highest priority risk for the freight community, and is currently sponsoring a project to understand why freight vehicles may enter the rail network in an unsafe condition. RSSB is supporting the work undertaken in this project. This involves developing a better understanding of the processes prior to a vehicle entering the network and the underlying causes that may be a precursor to vehicles entering unsafely.

OBJECTIVE

People are critical to the safe, efficient delivery of freight. At an operational level, people load trains, couple and uncouple wagons, prepare trains for the network, drive trains, and control the movement of switches and signals that allow the trains to move (Ryan et al, 2021). However, from a human factors perspective, freight functions such as the management of wagons in yards are one of the most under-researched areas of rail operations. Also, it is critical to understand that human performance failures are rarely isolated, but are instead the product of the competence and abilities of the individual, the conditions of the work environment and technology, and of the wider organisational and regulatory environment (Wilson and Sharples, 2017).

An important step towards identifying and addressing failures of freight train preparation, and diagnosing risk, is to conduct a structured, cross-organisational analysis of human performance failures relevant to freight train preparation and inspection. This kind of analysis has been used in other aspects of rail (Baysari et al., 2009; Madigan et al., 2017) to understand patterns of accidents, as well as causal and contributory factors that may lead to human performance failures. The objectives of the work presented in this paper were therefore

1) Identify adverse events (accidents and incidents), relevant to freight preparation, where human performance played a role

2) Identify and classify the types of human performance failures that led to adverse events

3) Identify and classify the factors underpinning human performance failures that subsequently lead to an adverse event

4) Use the analysis to identify future research and risk-reduction actions.

METHOD

While a number of accident analysis approaches have been used in the past in the rail context (e.g. HFACS [Baysari et al., 2009]) the approach taken in this study was to use the Rail Safety and Standards Board (RSSB) Human Performance and Incident Factors Classification System (Gibson et al, 2015**)**. The latest version of the classification is presented in RSSB (2022).

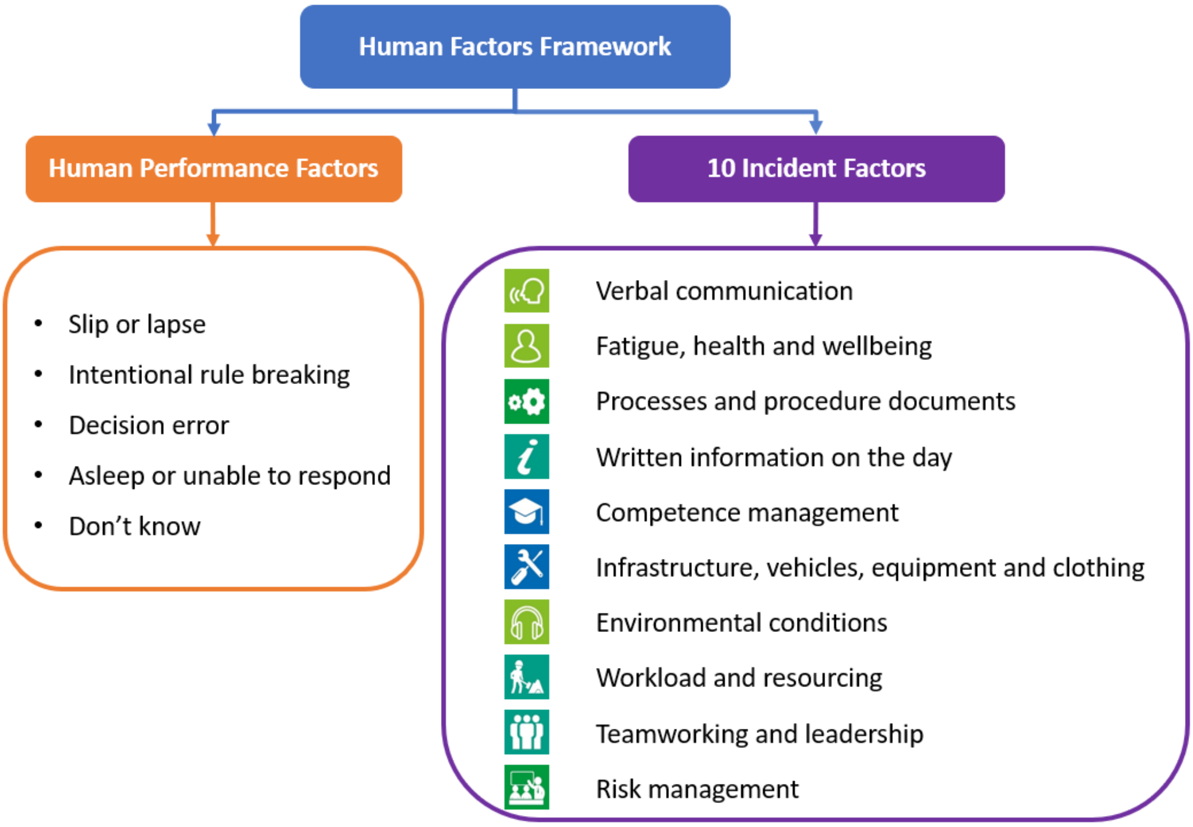

Figure 1: Human Factors Framework (RSSB, 2022)

This is a systemic approach that acknowledges the multiple types of event that might constitute a human performance factor. It also acknowledges that one or more of user, workplace, and organisational factors may cause or contribute to an adverse event.

Figure 1 lists the four types of human performance factor, along with the 10 incident factors. The Human Factors Framework is a standard approach to incident investigation in the GB rail sector, as well as being linked to industry training in accident causation. The analysis of adverse events seeks to identify both human performance factors, and the underpinning incident factors. It thus provides a common framework that has a shared understanding across stakeholders and organisations, and allows comparison and trends analysis such as the one reported in this paper.

In practice, the Human Factors Framework was applied as follows

1. A set of candidate incident reports was identified and filtered for relevance (see Results)
2. A sample of three reports were analysed by the first author [DG]. This involved reviewing each report and noting HPFs and IFs against tables in an Excel spreadsheet. This analysis also included
    a. Type, source and date of report
    b. Freight type (e.g. intermodal, bulk etc.)
    c. Failure type (i.e. what was the technical outcome of the failure [e.g. wagon brake left on])
    d. Point of identification (i.e. where the failure was first recognised and raised)
    e. Outcome (i.e. the type of damage that occurred)

f. High level causal pathway (i.e. was the event primarily mechanical and exacerbated by human performance factors, or purely human performance)

3. This analysis was shared with second author [JL] and an RSSB expert in the Human Factors Framework for discussion on how the method was being applied, misconceptions, gaps etc.
4. Based on this consensus on the use of the Human Factors Framework, all reports were analysed by first author [DG]
5. The whole analyses was shared amongst the author team both in raw form (Excel spreadsheet) and draft report for comment on gaps, omissions and clarifications.
6. The report was revised and a final version of the analysis was confirmed with all authors.

RESULTS

Initial filtering and analysis

31 incident reports were initially considered relevant to the analysis. These were reports that covered freight incidents or accidents where there was potential human involvement that contributed in some way to the event, and where that contribution was in some way at the freight train preparation phase. This comprised

- 11 detailed internal investigations– these were more significant events but had not involved, or had to the potential to lead to, significant injury or physical damage
- 10 brief reports – these were deemed minor events that had only received brief internal investigation
- 10 Rail Accident Investigation Branch (RAIB) reports, including 2 bulletins – these are significant events, that have led to, or with the potential to lead to, significant injury or damage. Such events are investigated by the Rail Accident Investigation Branch – an independent body with the authority to make industry-wide recommendations.

On closer inspection one internal investigation report covered two similar incidents. As these incidents could be clearly distinguished, with separate causal investigations, they were treated as two separate incidents. One incident was covered twice (first as a brief report and then as a more detailed investigation). Only the detailed investigation was analysed as this included a greater range of information. Four of the brief reports contained no information regarding any human performance factor and appeared to be solely related to mechanical causes. This left a total sample of 27 incidents for further analysis – 11 detailed internal investigations, 6 brief reports, and 10 RAIB reports. These 27 incidents were classified broadly as follows

Freight type - 13 incidents included intermodal loads, 8 were bulk / aggregate loads, and 6 miscellaneous (1 each of car transport, biomass loads, stock move, engineering train plant (e.g. High Output Plant System) and non-bulk engineering supply (e.g. sleepers on flat bed wagons)).

Failure type - 14 were issues associated with wagon handbrakes, 3 were locomotive air brake left applied events, 2 were some other form of brake issue, 7 were non-brake issues with wagons (wagon doors failing to secure, wagons not being fully unloaded, wrong container height), and 1 was a SPAD due to issues in train planning process leading to incorrect line speed.

Point of identification - For 4 incidents, the failure came to light when in the freight preparation / area before departure or while stabled, 5 incidents were identified on arrival at their destination, and 18 failures were identified when the train was out on the network.

Outcome - 14 resulted in either no specified damage or wheelset damage (these were all brake related), 4 resulted in derailment, 3 resulted in collision, 3 resulted in runaways, 2 resulted in SPADs and 1 issue with wagon doors did not specify any damage.

High-level causal pathway - 16 incidents were primarily human performance failures, but with underpinning non-mechanical incident factors. However, there was no existing contributory mechanical fault or failure. 11 incidents involved some kind of mechanical failure. These include events that were primarily mechanical/ maintenance faults, but with a human performance element that enabled or exacerbated the incidents (e.g. where a handbrake had failed, but poor risk assessment had led to a runaway), or where the mechanical failure had contributed to a human performance factor (e.g. where a handbrake was stiff through poor condition, and therefore staff had though it had been fully applied). It should be noted that maintenance and mechanical failures refers to failures of rolling stock rather than infrastructure, though it is noted in some of the RAIB reports that railhead condition and maintenance were also factors.

Human Performance Factor Analysis

The analysis identified 45 Human performance issues across 27 incidents. A high number of human performance factors that are either slip / lapse (n = 16), decision making (13), or something between the two (not clear from the incident report) (10). These 39 HPFs were generally omissions of checks, or actions to release brakes, but it was often not clear whether these were simply forgetting or whether they were shaped by conscious decision making. There is no evidence of intentional rule breaking type events.

Further detail on the Human Performance analysis is presented in Table 1.

Incident Factor Analysis

The analysis identified 137 Incident factors. The largest incident factors group was Infrastructure, Vehicle, Equipment and Clothing (n = 43), with a high number of maintenance and equipment failure issues – primarily related to wagon condition. There were also a number of design / usability issues related to a range of assets. There were also a high number of teamworking issues (8) and resourcing issues (17) both of which included factors related to inter-agency working.

Across all categories of Incident Factor there were indications of issues with yard / site complexity – in terms of physical layout and condition (e.g. vegetation) but also what that meant for operational conditions (e.g. having to conduct multiple moves to split / fit trains into the length of the yard). Each additional move increases the number of times brakes are applied and released, thus increasing risk. There were a range of issues with processes not covering specific instances or configurations, and with risk management processes that were inadequate or incomplete.

Further detail on the Incident Factor analysis is presented in Table 2.

Human performance factor	Sub-categories	Commentary and examples
Slip or lapse (16)	Forgot, misremembered or missed out (12) Misheard or mis-saw something (3) Said wrong thing or did wrong thing unintentionally (1)	Several of these refer to the failure to remember to release handbrakes or, in some cases, air brakes. Also refers to inspections where issues such as unreleased handbrakes were missed, or drivers failing to detect issues when out on the network.
Decision error (13)	Misunderstanding, wrong assumptions (10) Lack of knowledge (2) Don't know (1)	This mostly comprised decisions on the part of staff (usually a train preparer-type role) not to apply a brake, or in case of drivers, not to check brakes during service. This was often due to a misunderstanding of either the condition of the vehicle, or local conditions (e.g. gradients in the yard).
Don't know (10)	N/A	These were situations where an action (usually related to the brakes) had not been performed but where it was not possible to tell from the investigation whether this was a slip/lapse or a conscious decision on the part of the staff, based on expectation and misunderstanding.
Biased by habits or previous experience (4)	N/A	Two were handbrake application errors, and two related to an unknown performance failure (due to deleted text in investigation report documentation)
Rush (3)	N/A	Two train drivers rushing because of signals clearing and having a shunter waiting; one train preparer rushing to get to train and to prep
Distracted (1); Inexperience or unfamiliarity (1)	N/A	Train preparer avoiding other vehicles; not trained in the appropriate procedure

Table 1 – human performance factors – frequencies with example

Incident factors	Sub-categories	Commentary and examples
Infrastructure, vehicles, equipment, clothing (43)	Poorly designed (15) Unreliable (11) Poor maintenance (10) Not available (4) Don't know (2)	Poorly designed covered poor usability (11), doesn't work as it should or in range (3), and don't know (1). Across all Poorly Designed, 7 related to site arrangements (e.g. needing to split trains, location of loading or viewing points), 5 related to wagons (door closures, brake indicators), 2 related to locos (brake indicators for multiple loco configurations) and 1 related to a software human-computer interface. Unreliable covered wagon brakes (7), other wagon issues (3) and track condition (1) Poor maintenance covered wagon brakes (6), other wagon issues (3) and site maintenance related to vegetation (1) Not available (4) included handbrake tags (2), site messroom facilities, and height detection device for intermodal loading Don't know (2) related to yard conditions (layout and underfoot)
Risk management (20)	Ineffective risk assessment (10) Management not fixing safety problem (5) Management not finding out about a safety problem (4) Don't know (1)	Various reasons for ineffective risk assessment with no single pattern. Risk assessment topics included train movements in yard, potential for residual load in wagons, risk falling between two organisations. Management not fixing safety problems included not addressing vegetation at yards, and known brake problems on locos. Management not finding out about safety problems typically concerned reporting of safety issues.
Process and procedures (20)	No process or not comprehensive (14) Incorrect or incomplete (3) Process change issues (1), difficult to understand (1), don't know (1)	Lack of processes primarily comprised wagon composition and testing before leaving the yard, with a minority of reports relating to issues with maintenance process. Relates to safe system of work and wagon roll tests

Table 2 Incident factors and description (part 1 of 2)

Workload and resourcing (17)	Resourcing issues (10) Tasks put a strain on people (7)	Resourcing issues typically arose because insufficient staff, often from other companies were not available. This sometimes occurred due to short-term changes of plans. Several of these cases noted where train preparation or drivers had to travel to the site from elsewhere, which was both physically fatiguing and increased time pressure. It was noted in several instances that COVID-19 working arrangements had made the task more difficult, either because there were fewer resources, or because it required less effective ways of working (e.g. more difficult to share a cab).
Teamworking and leadership (8)	Poorly structured teams (5) Poor ineffective relationships (2); don't know (1)	Teamworking and leadership issues mostly related to lack of organisation between agencies – for example, a lack of coordination between loading/unloading of bulk, and the Freight Operating Company
Competence management (8)	Training or briefing (7)	Issues mostly related to training in specific processes (5) with other general issues with lack of competence and supervision (3)
Other issues	Written information on the day (6) Verbal communication (5) Persons environment (3) Fatigue (3)	This mostly included details missing (4) concerning short-term changes to plans Assorted issues relating comms within teams and between organisations(e.g. staff not communicating the state of handbrakes) This included two issues of yard lighting, and one of noise from releasing brakes This included issues of physical fatigue due to length of time walking, rostering issues, and time taken to get to site

Table 2 Incident factors and description (part 2 of 2)

DISCUSSION

Summarising the Human Performance Factors analysis, there were high numbers of slip and lapse and decision errors. In practice, it was often hard to differentiate between these two categories in that it was often unclear from the reporting whether something was an omission or a conscious decision. Furthermore, the 'don't know' category, with 10 occurrences, comprised those examples where it was not possible from the report to identify whether something had been omitted or had been a conscious decision. Put together (slip/lapse, decision error, don't knows) almost all recorded human performance failures fell into this broad category of things that were missed, or not executed properly on the day. On the other hand, there were no explicit recordings of intentional rule breaking– there was no evidence of a wilful culture of not following rules or having to consciously adapt rules to fit with work constraints.

The majority of issues occurred at a train preparation phase. While initially the intention was to specify sub-tasks where the Human Performance Factors occurred, this could not be determined in many of the investigations as it was unclear whether a failure was a failure of action (e.g. to release a handbrake) or a failure of inspection (e.g. to notice the handbrake was still applied).

Summarising the Incident Factor analysis, there are a high number of maintenance-related issues – both as a direct cause, but also as an exacerbating factor of incidents. This is reflected in the high number of "Infrastructure, vehicles, equipment, clothing" factors, many of which were attributable to faulty equipment. Complexity of working arrangements at sites is a significant factor. This was in part due to issues of yard / site complexity spanning multiple factors (design, environment, even training when it came to site briefings). It is also closely linked to operational practice (e.g. how trains need to be split and then rejoined during yard operations). There are problems with the usability of equipment to understand whether brakes (handbrakes, or air brakes – particularly in non-leading locos) are working; this also includes usability of wagons to support inspection and testing to check whether brakes have been released. Finally, resourcing and workload is an issue. Primarily this is an issue of resourcing of people (e.g. lack of availability and having to cover multiple roles) rather than a traditional 'human factors' subjective workload issue.

There was also a lack of analysis of 'upstream' issues. For example, there were cases where faulty wagons had been included in train consists, but it was unclear why the decision had been made to allow these wagons out on the network in the first place. These reporting issues suggest a revised and strengthened approach to the analysis and consistent reporting of adverse events in rail freight is needed.

Limitations

The quality of reporting varied and, subjectively, the quality compared well with reports used in a similar analysis of passenger operation Safety of the Line incidents (Madigan et al., 2017). While the consideration of human factors was often good, it was not consistent. Most investigations did not use an explicit incident classification. Reports often included information that strongly suggested human performance factors, but did not explicitly reference them.

CONCLUSION

In summary, this study indicates a clear link between human performance issues and freight preparation, while identifying a range of systemic factors that underpin human performance failure. Going forward from this point, a number of further actions are recommended.

1. Look at maintenance human factors in other domains, particularly aviation to understand how human performance issues occur and are managed. Also include

human performance analysis of operational decision making (e.g. why to send faulty wagons out on the network).

2. Build a way of measuring and model site complexity – that captures both the physical / infrastructure complexity as well as the operational complexity (eg the need to split trains, the number of moves per day etc.). Understand typical movement patterns in a yard and how that might generate more opportunities for risk.
3. Understand operational planning – analyse how freight yard operations are planned, the constraints that might make these plans challenging to implement or time-pressured, and understand the tasks and roles involved in executing plans.
4. Improve consistency of data collection on incidents, including human performance/system factor information.
5. Take a Safety-II perspective - try to understand, both qualitatively and quantitively, where human functions have mitigated risks before they have developed into incidents.
6. Understand the potential of technological solutions to the problems – increased use of monitoring of wagons within yards, roll-out of remote condition monitoring solutions and predictive maintenance.

Actions 1, 2 and 3 are now being implemented by the National Freight Safety Group.

ACKNOWLEDGEMENTS

The research was funded by the National Freight Safety Group and Rail Safety and Standards Board. Support for paper preparation was provided by Newcastle University QR Policy Support Fund.

Keywords: freight, human factors, train preparation, wagon

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