Human performance in the rail freight yard

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SUMMARY

Human performance in the rail freight yard has been identified as source of risk to rail freight operations. It is, however, an area that has received little research attention. Observations and expert elicitation explored work in the freight yard, leading to an understanding of freight yard activities, the impact of freight yard design and environment, and external pressures. Together, these factors make the freight yard a complex and challenging environment, where fluid, cognitive planning optimises physically demanding, cooperative processes. The implications for future management of rail freight operations are discussed.

KEYWORDS

Rail human factors; freight; logistics; planning

Introduction

Rail freight is a key function of the economy. Freight moves 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 good vehicles from the roads (Rail Delivery Group, 2021). Therefore, the continued success and growth of rail freight is a cornerstone of transport decarbonisation, nationally and globally (e.g. UNESCAP, 2021).

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

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 driven by an increase in derailments. Further, over this period, 288 trains were stopped on the network due to issues with vehicles, importing safety risks and delays to the network. The National Freight Safety Group (NFSG) has been set up to address rail freight risks. 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. The RSSB and Newcastle University are 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.

In a structured analysis of rail freight incidents on the network (Golightly et al., 2022), a number of human performance issues were identified that caused or contributed to events linked to the condition of the freight vehicle on the network, or in the freight yard. Typical events involved runaways in or outside of the yard, handbrakes left on wagons or airbrakes left on locomotives which then damage the wagon and rails if the train departs onto the network, or wagons entering the network in an unfit state (e.g. poorly loaded leading to derailment, damaged parts hanging out of gauge leading to collision). Slips, lapses and omissions in train preparation were the major human performance issues identified in yard tasks. The analysis also explored potential causal or contributory factors that led to these events. Usability of equipment, yard conditions (lighting, walking routes), wagon maintenance condition, time pressure and the organisation of work were identified as underpinning factors behind these human performance issues.

These initial findings warranted further exploration both to further understand the causal mechanisms, and to identify solutions. 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 (Ryan et al., 2021). Human factors knowledge of tasks, competences, immediate and wider work environment, and pressures due to cultural / commercial / policy constraints is not widely available. Zhang et al (2019) carried out a structured analysis of US freight train accidents, and identified the preeminent types of accident were derailment and collision, with a range of human performance factors as primary causes. However, these human factors causes are attributed as a direct cause of the accident as it occurred (primarily attributed to the driving role) and the analysis did not look back into causes or human performance failures that may occur in the yard potentially leading to issues out on the network. Lawton (1998) studied violations in shunting work in freight yards. While the focus was somewhat different from Golightly et al (2022) (e.g. the work was pre-privatisation and therefore the organisation of work was different; Golightly et al (2022) found few violations in their dataset), many of the factors influencing work (e.g. time pressure, work arounds to complete tasks quickly) were similar. While Bowler and Basicik (2015) study rail operations at a port, their outputs are methodological, though they do state the difficulty in understanding work purely from procedures and the importance of observations and interviews to understand risk. Vaghi et al (2018) do not present human factors findings *per se*, but do highlight the importance of understanding human factors as an influencing factor in the deployment of new technology for rail freight. Hricova (2016) gives an example of this, highlighting the benefits of RFID tags on wagons to reduce error in wagon identification.

Given the significant knowledge gap in how work is performed in the freight yard, the following study aimed to develop knowledge of freight yard practices, in order to evolve our understanding of how human factors in freight yard work may contribute to freight train incidents on the network. Specific objectives included (1) capture freight yard tasks and activities; capture the environmental and design aspects of the freight yard (2) identify specific human performance risks (3) identify future steps to address human performance risks. Critically, and following on from the understanding of people as contributors to safety, as much as potential points of failure (Ryan et al., 2022) we also sought to understand the factors that might facilitate work, and how people adapted their work to fit conditions and constraints.

Method

The method involved a two-stage approach, building on the groundwork and understanding of the freight yard context in Golightly et al (2022). The first stage involved site visits with both observations, and structured and unstructured interviews with operational and management staff. This involved visits to five different freight yards and constituted over 35 hours of observations. During the course of these observations, informal interviews took place with over 30 members of staff on site, across multiple grades and functions. Observations included supervisory areas in freight yards for operational planning, extensive walk-arounds of the yard involving observations of freight preparation activities, observations of maintenance work, train cab access and opportunities to try out train preparation tasks. This included one observation during the night shift (a time of high workload in that particular yard) to observe conditions at that time of day. Observations also included visits to office areas for freight commercial planning, as this gave important insight into the inputs that shaped work in the freight environment.

Contemporaneous notes were taken, with a debrief between the authors after each visit. The observations lead to summary materials including a site complexity risk mapping, task models, and presentation. These materials were then used in a validation workshop with 13 members of the rail freight community. This workshop lasted a full day and involved structured activities to (1) validate task models (2) confirm key human factors challenges (3) explore strategic solutions. Comments were collated in breakout groups through the use of ‘workbooks’ where participants were guided through questions or to complete tables relevant to the discussion of freight yard activity. Notes arising from each theme were analysed and summary conclusions were drawn.

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Results

Work in the Yard

Typical yard tasks include receiving and stabling trains, moving wagons and locos, composing new train sets, preparing wagons for the network (e.g. preparing couplings, checking handbrakes), inspecting wagons, and negotiating with either the mainline rail network, or the yard of a receiving customer (e.g. a port) to dispatch a departing train. Key roles were the drivers (either mainline drivers or shunters), supervisors (who planned day to day operations), groundstaff (who prepared trains and wagons, amongst a range of other tasks), and maintenance staff. The configuration of roles changed due to local practice, needs and resourcing. One yard involved remote supervision; in another the supervisor conducted groundstaff work. Yards visited noted different peaks of work depending on the type of freight handled (e.g. night shifts at a yard linked to a steel works; approaching weekends when preparing infrastructure engineering trains).

In terms of the yard itself, we found an environment that was complex, physically and organisationally. Capacity was often limited as 1) specific tracks (or roads) in the yard had designated purposes (e.g. for refuelling) preventing flexible use 2) wagons were stored for maintenance 3) certain trains being prepared or stabled needing to be split to fit within yard constraints. Therefore, yards that seemed large were often very restricted in capacity. Track length is also an issue as this required longer trains to be split for stabling overnight, and then rejoined when being prepared for departure.

The number of movements coming into and out of the yard could be high, with trains arriving every few minutes. These might be trains specifically for processing in that yard, but also when locomotives were needing to find somewhere to stable during mechanical failures, or during rest breaks for drivers. Furthermore, the movement of trains *within* yards was often high, to construct train consists, move wagons for maintenance and so on. This increased the physical risk associated with moves as well as the number of times handbrakes needed to be applied or released – a key problem when trains with handbrakes missed went out on the network. In addition, while some yards had separate inflow and outflow access for trains, others were terminating yards, so terminating locomotives needed to be taken off the front of trains, and run round to form a new service. Yards had different topography and gradients which necessitated different configurations of handbrakes on sets of wagons. In general, each yard had local idiosyncrasies that shaped (and typically increased) the number and complexity of train moves required. Little or no data was available on the number of moves within a yard.

These moves required not only complex communications between the groundstaff and shunting drivers. Workshop participants noted the reliance on communications and the potential for overfamiliarity leading to deviation from appropriate communication. Furthermore, shunting moves that required trains to leave the confines of the yard and to enter mainline network (albeit sometimes for a matter of a few hundred metres before reversing back into the yard on a different line) required communications with the Network Rail signaller, which was also time constrained by requiring a sufficient gap in other services on the network to accommodate the move.

Staffing varied across yards – some being staffed 24/7 while others were staffed on an occasional basis or operated by staff driving to the yard on an as needed basis. Even when yards were staffed, the supervision (the planning and sequencing of work) may be remote, and this sometimes meant supervisors did not always have a good understanding of local constraints on the ground.

The arrangement of assets and wagons in the yard was also complex. Wagons come in many different types and train sets would often require specific combinations, thus increasing the number of shunt moves as a number of wagons would need to be pulled out from within a larger set of wagons. This complex compilation of wagons also applied to wagons being located and moved to maintenance areas, either for repair or regular inspection.

In terms of the physical environment, walking conditions, lighting, the exposed nature of the yard (with many activities taking place in the open air) all added to the challenges of the work. Several yards are immediately next to live running mainlines. Yards were often broken into two or more separate areas which required walking and sometimes travel by van. This was also additional time to be factored into tasks.

Also, the tasks in the yard were often physically demanding. For example, handbrakes required a high degree of torque, particularly if clogged with debris from travel, or stiff after a period of non-use. Handbrakes could be quite low down on the wagon (e.g. around 0.6) metres and require significant stoop for taller members of staff. Other physically demanding tasks involved removal of stanchions, required to hold loads in place, weighing 7 or 8kg but with several on a wagon (and up to 40 wagons) this could be a significant task. Other tasks included loosening and tightening of couplings between trains, involving both a physical force to perform the work, and a stoop to get under buffers. All of these tasks took time and increased the physical demands of work in the yard.

Figure 1 Key tasks identified in observations and workshop

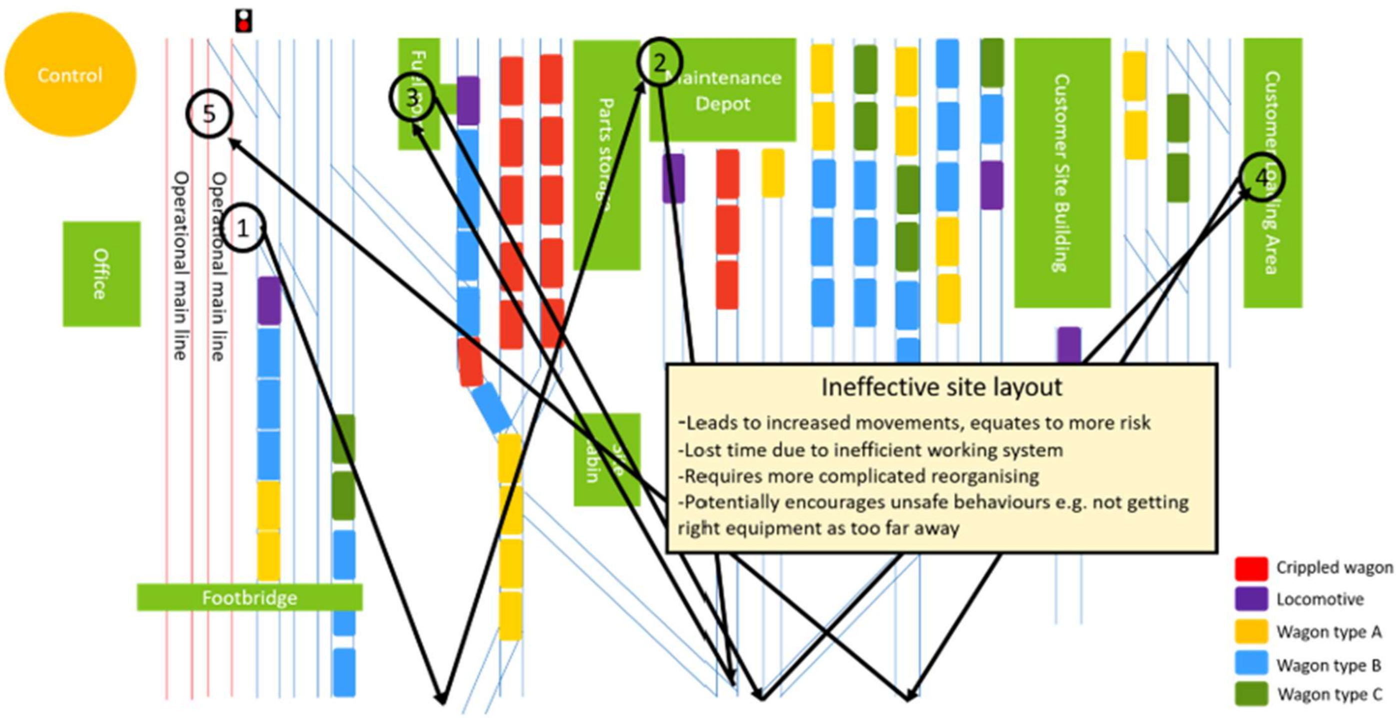

Figure 2 - Schematic of task flows in a generic freight yard

Task Models

Figure 1 shows the high level task model and task flows for work. A key finding from observations and discussion was to consider the relevance of office and planning work feeding into the yard. This involved planning the commercial arrangements, planning of paths and rosters. This proved to be a crucial factor in setting up the task loads in the yard.

These tasks were also subject to their own ergonomics issues, and planning and rostering was still a somewhat manual task that could be prone to errors in data entry, and requiring multiple rounds of checking. Also, there was comment in the workshop that planning and commercial processes often did not take into account the capacity of the yard and practical constraints.

Figure 2 gives a pictorial representation of a generic, large yard. Trains arriving from the mainline (1) may need maintenance (2) and then refuelling (3) before travelling to the loading area to pick up a set of loaded wagons (4) and then onto the network (5). Note how each move requires going out of the yard and then reversing or running the loco around to the front. Even this, however, is an oversimplification, both as observed and verified in the workshop. While the models in Figure 1, and the scenario in Figure 2, are linear, this is not how work is performed. In order to complete tasks as efficiently as possible, multiple tasks would be combined and conducted in parallel. For example, groundstaff might conduct multiple train preparation tasks, or combine together multiple wagons into a single shunt move to cut down on time and best manage the constraints of the freight yard. Also, these timelines belie how much plans are subject to change. Plans would often have to be adapted within short (less than 24 hour) timeframes. A final comment from workshop participants on the task models was that there was insufficient emphasis on the interactions with 3rd parties such as maintainers, 3rd party companies responsible for wagon loading, Network Rail, customers etc. Finally, Table 1 provides a summary of the tactical and strategic solutions to proposed by workshop participants to address human factors issues in the yard.

Discussion

When considered in combination, the freight yard reveals a complex picture of fluid cognitive planning and replanning. The physically demanding nature of the job, plus the need to work around site constraints, further influenced the planning and execution of work. In order to manage the external pressures for delivering freight (subject to short-term replanning), supervisors work with groundstaff to tie multiple tasks together, conducting them in parallel or compiling together for efficiency, to put capacity back into a stretched system. Work in the yard requires a high degree of flexibility, tacit knowledge and cooperation. Space in this paper prevents a full listing of the myriad factors that make work complex in the freight yard.

The work correlates with the limited previous findings so far. First, the understanding of work is difficult through paperwork alone (Bowler and Basicik, 2015) and the difference between work-as-imagined and work-as-done is significant. This is vital as we look towards the introduction of European Train Control System or digital coupling. While such developments may offer key benefits for the freight sector, they cannot be successfully introduced until they fully reflect the complexities of work in the freight yard, and the realities of human factors in the freight environment (Vaghi et al., 2018).

Many of the situational factors such found by Lawton (1998) relevant to the shunting task are found to more widely impact work across the freight yard. What was unexpected was the degree to which back office, planning and commercial processes set the scene and constraints under which freight

Table 1: Workshop participant solutions to human factors

Tactical- Unobtrusive monitoring of comms/actions through CCTV, audio recording, body cams etc
Tactical- Better understanding of freight system in training e.g. planners spending more time with groundstaff to see what role is like.
System- Industry take a lead on tools to make process easier e.g. automatic reading of locos and wagons, recognise where they are in the yard (geo-location)
System- Operationalising a fair culture that applies to staff and senior management. Something similar to Network Rail model and freight life saving rules suggested.
System- Better integration of non-technical skills
System- Develop SSOWs with human factors in mind.
System- Standardised training school for staff- drive a common standard throughout the industry.

yard work operates. Several groundstaff commented that customers drove the demands that need to be followed. In a manner, the freight yard provides the resilience in the wider freight system – this is the point in the network that can handle short-term changes, turn trains around quickly, and adapt to changing customer demands. This is only achievable through the commitment flexibility and adaptability of the workforce. In Woods (2015) definitions of resilience, this is robustness – an ability to soak up, changes and work fluidly, but not necessarily without cost. While the commitment, quality / safety of work and professionalism of on-site staff was evident and paramount, this kind of flexible and adaptive working will inevitably lead to trade-offs and the kind of events identified in Golightly et al (2022).

There are a number of limitations of the work. First, it is primarily wagon-based and, as noted in the workshop, a different process would be observed for the management of dangerous goods. Second, the observations focussed on large yards with on-site or nearby supervision. However, many sites are smaller and operate with remote, mobile working as it is needed. Not only does this work need to be observed, better statistical analysis is required to understand the risk associated with these sites. While they have fewer train movements they may generate disproportionate risk. Finally, the type of analysis we performed was observational and more about the working context. It would be valuable to conduct a more structured cognitive task analysis of the supervisory role in sites. Taking our lead from recent work in areas such as healthcare (e.g. Sanford et al., 2022) this would help us to identify adaptive behaviours that are occurring to balance work within constraints, thus identifying when workarounds are highlighting specific issues, and potential areas for improvement.

Conclusions

Overall, the freight yard has received little research attention, yet is a potential source of risk both to staff working there, and for trains that then head out onto the network. The observational and workshop activities presented in this paper captures the role of people in the freight yard, a unique and challenging environment, highlighting physical risks, but also highly fluid and cognitive planning to achieve success. This work contributes insight to anyone looking at human performance in freight and logistics, and will also be specific relevance to those looking at digital technologies such as ETCS and digital coupling, giving insight into the practicalities of how ‘work as done’ could impact the acceptability of deployments.

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