Tool for Estimating Rail Freight Yard Complexity and impact on human performance

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SUMMARY

Previous research has identified that the complexity of freight yards – layout, capacity, access and local physical context – is one factor that impacts the safe performance of freight yard tasks. We present the rationale, method and contents of a tool that makes explicit the definition of site complexity, and elements that comprise site complexity. Applications of the tool include site risk assessment, impact assessment of operational change, and potential to underpin a design standard.

KEYWORDS

Human performance, rail, freight yard, safety, contextual factors

Context and knowledge gap

Previous work in Great Britain's rail freight operations has identified freight yard 'site complexity' as a contributing factor towards performance and safety both in the yard and out on the network (Reinach and Viale, 2007; Golightly et al., 2023). Site complexity broadly encompasses factors such as infrastructure limitations within the yard, or complexity of operations, that make the stabling, build and preparation, and departure (including post-departure checks) more difficult for ground-staff. The implication is that complexity increases the physical and cognitive difficulty of ground-staff tasks, or increases the number of tasks required, thus increasing risk of omissions, incomplete tasks, violations or misapplication of rules. For example, a freight yard with multiple gradients may require a more complex application and removal of wagon handbrakes to secure the trainload, thus leading to the incorrect handbrake application (RAIB, 2020). One issue with the notion of site complexity is that there is no single definition. Furthermore, while qualitative work and incident analyses have generally pointed to the factors that make site operations more complex, there has been no systematic, cross-site analysis of the factors that contribute to site complexity. Finally, should such a classification be feasible, it is necessary to understand the applications of the classification as a tool, and how it fits within a broader socio-technical perspective.

Aim, objectives and methodology

The aim of the work (currently ongoing) presented in this paper was to develop a site complexity tool. This was inspired by tools such as Operational Demand and Evaluation Checklist (ODEC) (Pickup et al., 2007) or SWEAT (Shanahan et al, 2012), where demand characteristics of a domain are elicited, and rated for different (e.g. high or low) demand conditions. To achieve this for the freight yard domain, specific objectives were to (1) make a concrete definition of site complexity (2) identify and validate the set of demand characteristics (3) identify applications. In terms of method, incident reports and a summary of site interviews, plus a site observation, were used to generate an initial draft definition and set of ten factors. This version was then elaborated through four subsequent sites visits each covering discussion with multiple staff, leading to an updated list

of 24 factors. This list was reviewed by the project team, identifying a further six factors, plus wider understanding of tool scope and application.

Table 1**:** Factors and Clusters

CLUSTER	FACTORS
Access	Roll-by check access; Running line nearby; Public access and right of way; Train / road access restrictions; Groundstaff access restrictions; Proximity / access for end user; walking routes
Infrastructure	Spare yard capacity; Number of operational roads; Rail access to roads; Road length; Gradients; OHL / 3rd rail; Site speed limits; Point switching
Operations	Need for Network Rail clearance for yard moves; Number of moves within yard per day; Predictability / quality of plans; Prep for transition to / from yard (e.g. couplings); Variability of loads (e.g. stanchions); Number of customers; Maintenance on site; Fuelling on site
Organisation	Staffing; Supervision; Number of FOC users; Number of non-FOC users
Traffic	Load weight; Train splitting; Mix of traffic; Dangerous goods; Number of moves in/out of yard per day

Table 2**:** Example row from tool

ID	Cluster	Factor	Description	Low impact	Medium	High
1	Access	Roll-by check access	Access to vantage point for roll-by check	Good access/ visibility at all times	Some / occasional restrictions	Always limited access for roll-by check

Outputs

The definition of site complexity became "The physical characteristics of a yard, operational features of a yard, and external operational conditions in the immediate vicinity of the yard that increase the numbers of moves required in a yard, or number of activities required to stable / prepare a train." The final tool comprised 31 elements with ID, cluster, factor, description, and low-medium-high demand definitions. Table 1 shows the 31 categories of site complexity factors, clustered around six themes. Table 2 gives an example of a line from the site complexity tool.

Reflections, planned next steps, and future applications

The definition and factors list represent a more concrete understanding of site complexity than has previously been available. While some of the factors would have been anticipated from the literature (Rienach and Viale, 2007) (e.g. complexity associated with reversing or 'propelling' moves, particularly in yards that do not have through access), the act of eliciting the factors has identified other unexpected factors such as the proximity that the public have to certain sites, or the impact of human access to and from the yard. We believe the 31 factors are highly representative, but further work is still required to confirm their validity. At the moment, the tool is skewed towards larger yards, and application to smaller yards needs further validation. Other steps to validate the tool include cross checking again Common Safe Systems of Work documentation for yards. This includes the high-medium-low risk ratings for each factor which are currently heuristic.

The tool is deliberately narrow and specific in focus, contributing to a specific work stream within a wider programme of work to improve freight operational safety (RSSB, 2024). The tool is envisaged as a 'ready reckoner' to assess site complexity, for example before performing observational work, and therefore the risk ratings may only need to be simple. However, there is the potential to use the tool as a more formal assessment standard – for example to rate sites as 'high' or 'low' risk in a similar manner to COMAH site ratings. Currently, there is no design standard for freight yards, and the tool could inform such a standard. The 31 factors are currently treated as

independent, but there are interdependencies (e.g. between length of train, length of road, and train splitting). HF/E considerations such as welfare, lighting and environmental conditions have been considered out of scope for this tool, as they do not increase the number or complexity of tasks directly, and while the tool is not intended to be a full socio-technical analysis of the factors that affect work in the freight yard, a future step would be to look at the identified factors through a theoretical framework that would be highlight interdependencies between these factors and performance, and ultimately map the factors to operational incidents and risk, thereby giving a prioritisation of the most important factors for determining safe, high performance sites.

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