

Human Centred Rail Freight Preparation for Decarbonisation and Climate Resilience

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SUMMARY

Rail freight is undergoing systemic change in response to climate shift and need for decarbonisation. Many changes are implemented for engineering expediency. A holistic systems model is proposed to express the interrelated nature of change on people in the freight yard, to design safe and effective transitions.

KEYWORDS

Railways, freight, logistics, climate, decarbonisation

Challenge, background and gap

Climate, decarbonisation and rail freight are inextricably linked. On one hand, rail freight offers a mode to transport goods with significantly lower emissions than road and air freight. Moreover, technical and operational changes, such as longer trains and alternative power sources (Knibbe et al, 2022) hold promise to make rail freight even more carbon efficient. On the other hand, climate change is bringing volatility to rail freight and the need for new operational practices. Extremes of heat and cold, high winds, and flooding all impact rail operational performance (Ludvigsen & Klæboe, 2014) thus, freight operations and technology also need to adapt to be resilient to these climate events.

Our understanding of measures we can take to decarbonise rail network operations and increase their climatic resilience is growing. This is typically focussed on the driving of trains, or the condition of assets out on main rail network, or operational strategies. However, for rail freight, another key and often overlooked area is the rail freight yard. This is where trains are marshalled and prepared, checked for network readiness, dispatched, and received at their destination. It is also the location where most wagon maintenance takes place.

The rail freight yard is a context that is still shaped by human work; it combines the physical tasks of train preparation with cognitive tasks of planning and checking, and organisational tasks of cooperating with customers and third parties, all of which occurs across different layers of management. Successful train preparation is thus dependent on good work design, both to ensure safety within the yard itself and, critically, because issues with train preparation are exported out on to the network to manifest as delays, but also more potentially serious incidents, such as derailments. Despite the importance of the work, the yard is an area that has received scant research focus from the ergonomics and human factors community. The research that does exist highlights the fluidity of yard work, and the variability of work based on factors such as location and yard characteristics, and its physical and cognitive demands (Reinach and Viale, 2006).

When it comes to the confluence of climate / decarbonisation and the freight yard, the issues of human activity become acute. Innovation needs to be developed with a view to how trains will be managed and prepared, and the human work associated with that—not just for engineering or

operational expedience. A simple example is that longer trains produce lower carbon emissions per tonnage compared to shorter ones (Network Rail, 2025). Yet, do they demand new approaches to yard management, altered task structures, or place new pressures on ground staff?

What is required is new thinking in the form of a holistic conceptual model which explicitly links climate and decarbonisation change and impact, with a systemic view of human factors relevant to the freight yard. This is the first step to anticipating change and making sure adaptations (and work designs) occur in a way that is more attuned to the needs and realities of yard work. In the rest of this paper, we summarise our conceptualisations based on literature review, our own empirical work in the freight yards of UK (Golightly et al., 2025) and Australia (Naweed et al., 2018) and discussion with freight experts.

Conceptual framework

The conceptual framework comprises four key elements.

Climate mitigations – These are measures taken to minimise the impact of extreme and shifting weather patterns. This covers: flooding and rainfall, particularly convective rain with shorter extreme and less predictable bursts; high winds; snow and low temperatures; and high temperatures. Each of these comes with specific impacts and mitigations; for example, trains may need to run with lower wagon weights, or on different routes, to avoid damaging bridges that are no longer able to withstand higher loads due to climate impact over time.

Decarbonisation innovations – Concurrent with climate mitigation, decarbonisation measures target both trains and operations. This includes making mainline trains and shunters more carbon-neutral through electrification, hybrid systems, and hydrogen power, as well as improving operational efficiency by lengthening trains and enhancing the appeal of rail freight to reduce emissions per ton of goods compared with road or air transport.

Train preparation system – This represents the process of receiving, stabling, loading, preparing and checking trains before they head out on the network. The system must operate safely and effectively for those in the yard, while ensuring the integrity of trains once deployed. Conceptually, it is essential to account for both direct changes within the yard environment (e.g., warmer conditions during preparation) and external changes that must be reflected in yard practices (e.g., adapting preparation methods to address how heat affects train performance on the network).

Human impact – The model illuminates how factors such as climate, mitigation efforts, and decarbonisation innovations impact people involved in train preparation. Increased yard movements to accommodate longer, lower carbon trains, working in heat or during convective rainfall, or shifting the ways train are prepared to maximise stability in high winds, all exemplify points of friction with change rippling through to yard work, and largely unmanaged expectations that human work and processes will simply ‘adapt’. We link these changes as having risk in three key areas: (1) immediate safety to yard workers; (2) the safety and effectiveness of train preparation for departures, and (3) long-term psychosocial impact on yard staff.

Relevance and application

In the full model (as described in the presentation) we both visualise the model and illustrate the value of the model by pulling through specific use cases of innovation and mitigation, tying them to specific risks in the three areas of human impact. By doing so, we move towards a systemic approach for linking climate to human performance, and thus, build foundations for change that have more alignment to the needs of yard workers, ensuring a safe, successful and attractive rail freight service for the future.

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