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Are you fit to continue? Approaching rail systems thinking at the cusp of safety and the apex of performance

Anjum Naweed [a,b,*], Sophia Rainbird [a,b], Craig Dance [c]

[a] Central Queensland University, Appleton Institute for Behavioural Science, Australia
[b] Cooperative Research Centre for Rail Innovation, Australia
[c] Rail Corporation New South Wales, Australia

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ABSTRACT

The incidence of driving a train through a stop signal continues to have implications for safety on railways. Industry rulebooks advise how to manage these events, but there has been very little investigation of causality from the systems-view. The increasing trend for maximising rail capacities could be exacerbating the issue and warrants investigation from this perspective to determine the factors impinging on safety decisions in train driving. A participative research approach incorporating cab rides, focus groups, and a generative scenario simulation exercise was used to investigate how train movements and safety risk was managed, and the implications of this on the rail organisation. Twenty-eight train drivers participated from eight passenger rail organisations across Australia and New Zealand. Inductive thematic analysis of the data revealed factors associated with (1) changes to signal meaning, (2) the nature of the driver-signal relationship, and (3) the confounding practice of asking a driver if they were "fit to continue" driving after going through a stop signal. The findings reflected a strong pattern of a normalisation of deviance. The results are discussed in terms of the mechanisms underlying the observed phenomenon and a model outlining prospective solutions for future research is presented to contribute to the development of novel ideas for further thinking and research.

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1. Introduction

Railways are designed to guide trains over pre-set routes and train movements are managed to optimise network performance. Signals show the train its *movement authorities* (i.e. where the train is permitted to be) on the track but it is left to the train driver[1] to determine how they respond and stop based on safe-working requirements (Branton, 1979). In practice, driving a train can be a bit like driving a semi-trailer on ice with a blindfold on (Naweed, 2013b). This is because of how it feels to drive steel wheels over steel tracks, and because railways curve a lot, it is not always possible to see where you are going. Rail corridors are filled with vegetation and other visual obstructions, and the markers that constitute movement authority (e.g. signals, speed boards, temporary speed restriction boards) are often hidden from view. All of this creates the need to have very reliable knowledge of the routes and a good awareness of the evolving situation (Luther et al., 2007).

Given the sighting constraints and requirement for stopping accuracy, railway signalling is designed to preview what the next signal is likely to show. This provides the driver with time to correct their speed and to brake appropriately. Fig. 1 illustrates three examples of how signals in railways are designed. The signals vary in colour and configuration but all three use the same principles for driving safely over railways – that of a *multiple aspect* design that provides early indication of the cautionary and stop (i.e. danger) signals in a strict sequence. This gives the driver the time they need to reduce the speed of the train and stop appropriately. However, as the distances between caution and stop signals may go on for some time, there is also a requirement for the driver to stay alert.

Given the safety imperative for trains to remain within their areas of authority, driving past a signal at danger is understandably one of the biggest failure modes. In rail organisations this is referred to as a "SPAD," an abbreviation for "signal passed at danger."[2] Research is pointing to a common finding that these events do

* Corresponding author at: Central Queensland University, Appleton Institute for Behavioural Sciences, 44 Greenhill Rd, Wayville, SA 5034, Australia. Tel.: +61 8 8378 4520.

E-mail address: anjum.naweed@cqu.edu.au (A. Naweed).

[1] The term *train driver* varies from country to country and changes from organisation to organisation. Those who operate trains can also be called Locomotive Engineers, Railroad Engineers, Train Operators, Engine Drivers, or Loco Pilots.

[2] The term "SPAD" is also used to describe situations where the train has exceeded its track authority or limits so it is possible to have a "SPAD" with no signal.

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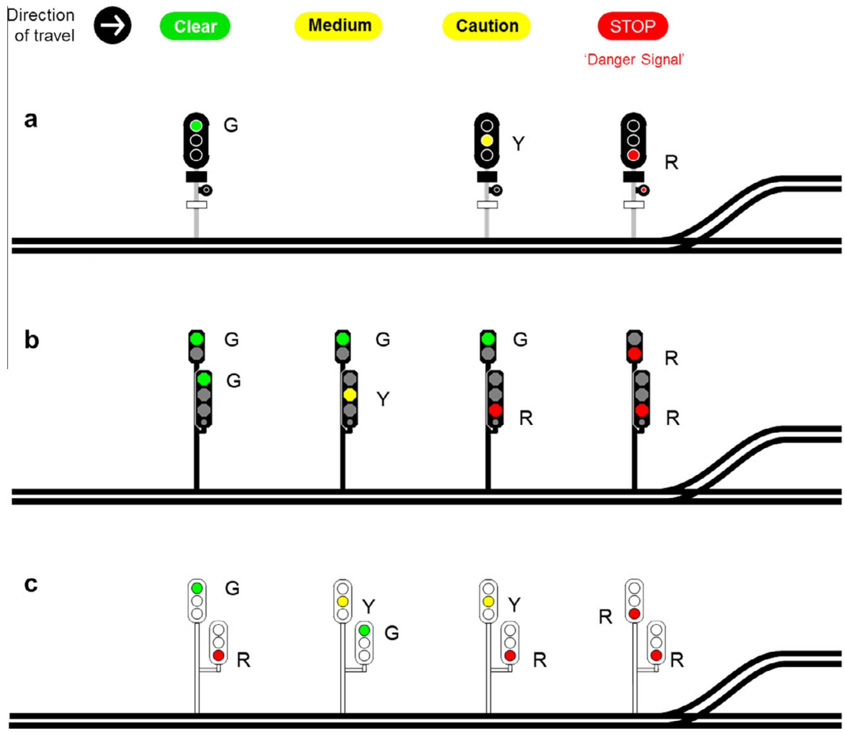

Fig. 1. Examples of multi-aspect signalling design. Tracks (a) and (b) illustrate three- and four-aspect signalling conventions on railways in Australia (Sydney, NSW) respectively. Track (c) illustrates four-aspect signalling in New Zealand (Wellington).

not occur equally at all signals but often, are associated with certain conditions. Some signals are identified as *multi-SPAD signals* or *SPAD hotspots*,[3] which recognises a location or signal that is associated with numerous events, but also reflects chronic issues with the task and/or use of the signal in this location. However, these issues could be associated with a number of different things, such as varying levels of train exposure, problems with signal visibility, higher densities of signals in that location, and so on. For this reason, it can be very difficult to triangulate the cause of signal passed at danger events, and a systems-oriented view of the problem can provide a useful lens with which to examine it through.

Whilst the majority of signal passed at danger events do not result in accidents, they do present significant collision risk, thus rail operators have dedicated "SPAD management" teams as part of the systems they use to manage safety. These teams support network recovery when there is an incident, collect event data, investigate causation, and deal with the train drivers after an incident. In most parts of the world, reporting signal passed at danger events is a statutory obligation and part of the licensing agreement for rail operators (Ministry of Transport, 2005). This creates a need to minimise these events in order to meet safety targets, but given that most rail operators are also businesses that profits from punctuality, there is an imperative to minimise network disruption and avoid receiving penalties and fines for late running.

1.1. Complexity in maximising rail network capacities: a systems view

In recent years, complexity theory has emerged to advocate a view of systems where complexity is becoming the defining characteristic (Dekker, 2011; Dekker et al., 2011; Goh et al., 2010). This theory describes how failure may emerge opportunistically from the systems put in place to prevent them, but also explores notions of deviancy and deviant behaviour as something that becomes normalised. The normalisation-of-deviance theory was first developed out of research and investigation into the tragic Challenger disaster in 1986 (Vaughan, 1997). In the social context, the theory describes the effect of people within organisations growing accustomed to a deviant behaviour, so much so that they do not consider it as deviant, even though they far exceed the own rules or codes for elementary safety (Vaughan, 1997). Models and frameworks of risk management in dynamic society such as the Practices Migration model add to these ideas (Amalberti, 2001; Amalberti et al., 2006; Rasmussen, 1997). They suggest that a system can be easily stressed by a rapid pace of technological change, through increasingly aggressive and competitive environments, and from changing regulatory practices and public pressures. All of these elements feature pervasively in the rail domain. It is therefore quite easy to see how these combined productive pressures result in a rapid migration to areas at increasing risk through the standardisation of violations. In this regard, the signal passed at danger can be viewed as a "wicked problem," meaning that the failure mode is linked with cultural challenges and changing requirements that are often contradictory, incomplete and difficult to recognise (Rittel and Webber, 1973). In this way, SPADs can be likened as a symptom of other problems.

The normalisation-of-deviance and complexity theories have since been used to explain how compliance may give rise to hazards through deviant behaviours, and how these may erode to a level that effectively reduces the level of risk reduction afforded by the system. Considering how signal passed at danger events are managed from the systems view may provide new information to the people involved with the issue, and explain how complexity may arise between the immediate and/or remote components of the failure mode. The intersection of different approaches and perspectives used to manage these events may have a tendency to blur the issue, and in some respects, the failure may essentially remain unmanaged. As an overarching theoretical framework, complexity and systems thinking may be used to provide insight into safety decision making.

[3] These terms are used in Australia and NZ to describe signals and areas associated with a high SPAD rate. They may be referred to differently other parts of the world.

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