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Throwing good money after SPAD? Exploring the cost of signal passed at danger (SPAD) incidents to Australasian rail organisations

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ABSTRACT

This study sought direct estimates of incidence, preventative costs, and reactive costs associated with the occurrence of low risk ('typical') Signal Passed at Danger (SPAD) events in Australasian rail. In a cross-sectional multiple-case design, a descriptive questionnaire was sent to eight operators, and completed by managerial personnel with responsibility for SPAD-risk mitigation. Items addressed SPAD frequency, operator delays, and a range of preventative and reactive costs associated with low-severity ('low-risk') SPADs. Delay costs varied between cases, with each having different organisational size and network density. Preventative costs were mostly comprised of internal SPAD prevention team maintenance, participation in a collaborative SPAD Group, and resultant network modifications. Reactive costs were largely comprised of driver-related factors and in two cases, of higher low-risk investigation and regulatory costs. The ratio of preventative to reactive costs (*P:R*) varied widely, approaching equilibrium for two cases only—both participated in internal and external SPAD preventative team consultation. One freight organisation noted a large *P:R* imbalance due to very low preventative costs. Low-risk SPADs represent a host of substantial annual costs for each Australasian passenger- and freight-rail organisation. As this study gives preliminary estimates, these likely underestimate the full costs, as multiple other factors are yet to be accounted for. This study justifies the need for detailed analysis of SPAD-associated costs to contrast data from multiple rail organisations, and a clearer picture of how organisational expenses are allocated within SPAD prevention and reaction.

1. Introduction

Rail services are a constant aspect of daily life; with the public often being the sole shareholder in rail infrastructure and operations, people hold a reasonable expectation of safe and predictable transit. For the most part, this expectation is met. In Australia, achieving on-time running and service provision targets (Bureau of Infrastructure Transport and Regional Economics [BITRE], 2016), along with railway-related injury data supporting low public risk (Office of the National Rail Safety Regulator [ONRSR], 2016), and consistent service provision, all contribute to positive perceptions and increasing patronage of rail transit services (L.E.K. Consulting & Tourism and Transport Forum [TTF], 2017). Rail commuting, for example, is a growing alternative to road commuting (Australian Road Research Board [ARRB], 2016), and considered a safer (Savage, 2013) more logistically efficient, environmentally friendly, and lower cost alternative (Transport for NSW, 2017). Rail organisations, however, are acutely aware that beneath their complex system lies an array of human, mechanical, and organisational factors. This perspective was introduced as early as the 1930s by Heinrich (1931) who established a scientific basis through which to identify causal factors of accidents within industrial settings. In the railway content then, these factors integrate into risk-relevant aspects of train driving, most notably signalling systems (Zoer et al., 2014). Train drivers maintain such an intimate relationship with signalling information that signals become respected as, and indeed equated with, physical boundaries (Naweed et al., 2015); this relationship directly informs train control dynamics, visual strategies (Naweed and Balakrishnan, 2014), and ultimately, the physical safety of the drivers and public. As a result, disruption can have consequences ranging from the very minor to the catastrophic, the most common being the 'signal passed at danger' (SPAD) (Naweed, 2013).

SPAD events arise when a train encroaches beyond a stop (or danger) signal or block limits into a section of unauthorised track, effectively exceeding safe working authority (Naweed et al., 2015;

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Rainbird and Naweed, 2016); for this reason, they represent the most common disruption to safety boundaries in safe working/signalling systems within the rail industry. Often, this type of event is prioritised as a precursor to catastrophic potential outcomes such as derailment or collision, though it can also occur when movement authority is simply ambiguous or uncertain. This was the case, for example, in Wootton Bassett, Wiltshire in the UK, where two passenger train services almost collided (Rail Accident Investigation Branch: Department for Transport, 2016). In Australia, two Victorian trains did collide as a result of one proceeding beyond a stop signal aspect under conditions of uncertainty, injuring the driver, conductor, and a number of passengers (Australian Transport Safety Bureau, 2014). Moreover, despite overall rail safety improving throughout the last two decades—for example within Europe and the USA (Evans, 2013)—in large organisations, SPADs still occur at a relatively high and fairly consistent yearly frequency (Rail Safety and Standards Board, 2016). The probability of their occurrence is commonly estimated using stop (or danger) signal aspect approach rate data (Zhao et al., 2016).

Although Australian data for SPADs is not entirely publicly accessible, the unavoidable costs associated with them remain significant, and necessary investments to prevent and mitigate SPAD risk both add to this and require careful management for optimal allocation of preventative resources, relative to reactive expenditure.

Low outcome-severity or low-risk SPADs causing no accident or physical damage are—compared to high-outcome severity SPADs (Independent Transport Safety Regulator, 2011)—a relatively frequent occurrence in large rail networks. These represent a uniquely valuable source of information about prevention, experience, and management of SPAD events: the distribution of associated preventative and reactive costs. Commonly, these are separated into direct (i.e. incident caused) and indirect costs (i.e. time and resource impacts) (LaBelle, 2000). Yet recent examination of these costs has shifted focus from differences in direct/indirect, insured/uninsured, and controlled/uncontrolled aspects to the relationship between railway performance shaping factors (Kyriakidis et al., 2012) and SPAD costs (Simanjuntak, 2015).

Early work pioneered by Heinrich (1931) and then by Bird and Germain (1966, as cited in Swuste et al., 2016) have shown the considerable impact that costs connected with accidents can have in comparison to the costs of accidents themselves. This work has also highlighted the importance of harnessing these data for informing prevention. The costs of SPADs to Australasian rail operators are minimally documented and opaquely presented within annual operator financial and rail safety reports, and much like the topic of "fatigue", are often treated as an internal and even taboo topic of discussion (Naweed et al., 2015; Filtness and Naweed, 2017). Although the frequency of SPADs has broadly declined from levels seen ten years ago (Australian Transport Safety Bureau, 2012) to approximately 95–110 officially reported SPADs per year across South Australia and New South Wales (Office of the National Rail Safety Regulator, 2015), it needs to decrease further, as it still poses a public safety risk when viewed through an organisational 'zero harm' lens. Despite decreased SPAD frequency after introduction of automatic train protection, such as in the UK (Walker and Strathie, 2015), there remain many opportunities to capture data about the occurrence of these low-risk SPADs, that may inform their prevention. Technological interventions represent only one preventative component characterising SPAD events, as administrative, policy, training, and performance management factors also shape SPAD frequency and costs. Consequently, obtaining a clear picture of the above issues at a national level is exceedingly difficult, and is compounded by the fragmented Australasian rail data management and reporting practices (e.g. data access, normalisation, transformation).

A recent UK review has suggested examining SPAD incidents to create organisational profiles for the underlying causes of SPADs alongside more extensive and detailed investigations to inform prevention strategies (Gibson, 2016). Key considerations were for a better understanding of SPAD risk and driver error including driving distances, network complexity, signal density, approach rates, and visibility (Nikandros and Tombs, 2007). Similarly, the costs associated with SPAD occurrence and prevention also offers insight into these events. Low preventative costs are putatively associated with high failure costs. From an industry perspective, increased preventative efforts and costs may be seen to be associated with a reduction in safety failures and, consequently, in the magnitude of necessary reactive costs—perpetuating the view that ideally, these costs will reach equilibrium (Behm et al., 2004). However, SPAD prevention is an ongoing process with those who work to mitigate SPADs trying to ensure that they do not happen. Is it therefore conceivable that an organisation with initially high reactive costs may reach equilibrium through proactive efforts at a later point, but then find that they depart from equilibrium when proactive costs begin exceeding those that are reactive. Ideally therefore, reaching equilibrium may become the ostensible focus for organisations who are reactive and many times away from equilibrium, while for others, wholly proactive expenditure may become the aspirational goal. Addressing SPADs is ongoing process, and while seeking to prevent catastrophic outcomes such as the Waterfall collision, the majority of SPAD events are low-risk, but still have associated reactive costs worth minimising.

Although the causes of SPADs have been investigated (e.g., Baysari et al., 2009; Filtness and Naweed, 2017), little is known about estimated distribution of *preventative* and *reactive* costs of low-risk SPADs to the rail industry as, to the authors' knowledge, these have not yet been descriptively analysed or reported in the broader Australasian or even global context. This forms the purpose of the present multi-case organisational study. Importantly, given the variable nature of SPAD occurrence across the rail industry, the primary aim of the present study was to describe the individual distribution of costs at different rail organisations, as generalisability is a complex and not necessarily sought after goal within industry research.

1.1. Research question

Case studies are reported here with the main objective of exploring cost estimates associated with SPADs from rail organisations, with the two core research questions being: (1) *"How are financial costs associated with low-risk SPAD events distributed within Australasian rail organisations?"* and (2) *"How are SPAD-related costs represented in different Australasian rail organisations?"* Both questions were purely descriptive and intended to offer a broad examination of financial resources allocation within the Australasian rail context. To achieve this, we considered the nature and magnitude of such costs from the perspective of management personnel working in SPAD prevention at Australasian rail authorities.

2. Method

2.1. Study design and case selection

A cross-sectional multiple-case design was used, with rail organisations selected on the basis of four characteristics: (1) organisations were Australasia-based, (2) had a large number of employees, (3) monitored SPAD occurrence, prevention, and reaction, and (4) could provide indicative or estimated costs associated with SPAD occurrence on their networks.

The organisation was defined as the unit of analysis, and data collection was facilitated via principal contacts at eight rail authorities. These were drawn from an International Australian and New Zealand SPAD Group (herein referred to as the SPAD Group) that focused on continuous improvement and SPAD prevention on which the lead author and contacts were all members.

Although multiple-case studies are highly informative as a research methodology, they do not claim generalisability, rather they offer insightful comparisons between cases and contexts (Yin, 2003). As such,