MANAGEMENT OF DISTRACTION RISK FROM MOBILE PHONES IN THE UK RAIL INDUSTRY

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ABSTRACT

The objective of this work was to assess whether the risk of train driver distraction from mobile phones is adequately controlled within the GB rail industry and to make a recommendation for its management going forward. In support, a review of incidents was undertaken to establish the current level of risk attributable to mobile phone distraction. Published literature was reviewed to estimate the extent to which train driving performance would be affected by mobile phone use. Workshops with operational experts were conducted to validate the findings and to explore operational constraints relevant to rail industry-wide mobile phone policy.

KEYWORDS

Distraction, Mobile telephones, Train driving, Safety, Policy, Communication

BACKGROUND

The GB rail network and the role of RSSB

The GB rail network is privatised and is used for both passenger and freight services. These services are operated by a large number of different companies under different contractual arrangements.

The fragmented nature of the GB rail industry gives rise to a requirement for the role of RSSB. This is to assist with consensus building in situations where different organisations need make a collective decision in order to initiate a change and achieve a benefit. RSSB are authors and custodians of the industry-wide rules and standards and manage the process of change in response to emerging needs and a regular review timetable. RSSB also provide specialist technical input to inform debate and development of industry-wide strategy and sponsor research projects on behalf of the Department for Transport.

Each individual train and freight operating company is responsible for managing their own drivers and other employees and for controlling their own risks within a

framework of rules, standards and other regulatory requirements. This includes managing the risk of accidents caused by inattention or distraction.

The Chatsworth train accident

The risk of distraction from mobile phone use was highlighted in September 2008 following a fatal train accident which occurred in California USA. This accident is thought to be the result of the train passing a red signal (known as a Signal Passed at Danger or SPAD). Shortly prior to this the driver had exchanged a series of text messages on his mobile phone. The signal which was passed was protecting a single track section of the line. As a consequence, there was a head on collision between two trains. Twenty five people died as a result of their injuries and numerous people were injured [1].

In response to this tragedy, the Federal Railroad Administration (FRA) concluded that cellular phones and other electronic devices were being used in violation of railroad rules to an extent that 'constitutes an emergency situation'. The FRA issued an emergency order to restrict the improper use of cellular telephones and other distracting electronic and electrical devices by on-duty railroad operating staff [2]. This requires all electronic devices to be switched off while on a moving train except in circumstances when radio failure occurs.

Current management of mobile phone risk

The circumstances of this recent accident in the USA prompted the question of whether mobile phone risk is currently adequately controlled in GB. RSSB were commissioned to explore this issue and make recommendations regarding the management of mobile phone risk across the industry.

Currently in GB, mobile phone distraction risk is controlled through Rule Book requirements and individual company policies. At the time of this work (October 2008 – July 2009), operating company policies regarding mobile phone use ranged from a complete ban on mobile phones in the train driving cab to less stringent policies that allowed mobile phones to be used while driving under certain circumstances. Operating companies also use a range of other measures to support their policies, such as, safety briefings and monitoring of mobile phone bills.

The Rule Book requirements relevant to train driver distraction by mobile phones are summarised in Table 1.

Table 1 – Current Rule Book requirements relevant to mobile phone distraction

Module	Requirements	Applies to	Relevance
G1 – General safety responsibilities [3]	'You must not use mobile communications equipment if it may cause distraction or compromise safety.' 'When on duty you must use a mobile telephone, your own or one issued to you, only as shown in your employer's instructions.'	All	The rules rely on company policies and the quality of individuals' judgements to determine when communications equipment is used.
G1 – General safety responsibilities	Only particular authorised people are permitted to travel in the cab with the driver and they do so under the instruction that they must not distract the driver.	All	Passengers in the cab also have the potential to distract the driver.
G1 – General safety responsibilities	Using televisions, videos, radios, personal stereos or other similar equipment is not permitted unless authorised by a manager	All	Mobile phones now have many additional functions which could potentially be used while driving a train.
TW1 - Preparation and movement of trains: General [4]	'You must not use the radio when the train is moving if you might become distracted and put the train in danger.' '…you must not make those announcements [public address system] when the train is moving if you may become distracted and put the safe operation of the train in danger.'	Driver	This requirement acknowledges that use of cab radio equipment and public announcement equipment while driving can cause distraction and threaten safety. However, their use is not actually prohibited; the driver is free to make a judgement about whether they would be distracted. Currently, there are no specific requirements related to the restriction of the use of mobile phones in this module.
S4 - Trains or shunting movements detained, or vehicles left, on running lines [5]	A driver is permitted to contact the signaller when standing at a signal by mobile telephone if the Cab Secure Radio (CSR) or Signal Post Telephone (SPT) are not available. In these requirements, the mobile telephone is equal in order of preference to the National Radio Network (NRN).	Driver and signaller	Mobile phones are acknowledged as a potentially useful communication tool and the rules officially permit them to be used for communication between the signaller and driver when the train is stationary and the more preferable systems of CSR and SPT are not available. NRN has several limitations and this is why it is equal in preference to mobile phones.

Module	Requirements	Applies to	Relevance
M1 - Train stopped by train accident, fire or accidental division [6]	'You must tell the signaller about the accident in the quickest way possible, by using: • the cab radio emergency call procedure • any available telephone, or • any radio system.'	Driver and guard	Mobile phones may offer the quickest way to communicate with the signaller. There is no order of preference here as speed is the priority. This rule does not specifically state whether it is permissible to contact the signaller while the train is moving.
M2 – Train stopped by train failure [7]	'If your train is stopped by failure, you must immediately tell the signaller about the circumstances by using… any available telephone.'	Driver	Again, this acknowledges that mobile phones may offer the best method to contact the signaller. The use of the word 'stopped' implies that the train should be stationary at this point but this is not explicitly stated.

Overall, the rules aim to minimise the risk of distraction from communications and electronic devices in general but offer flexibility to reflect operational needs and the responsibility of individual companies to manage their own risk.

In addition to rules aimed at minimising distraction from mobile phones and other communications equipment there are several requirements that are aimed at reducing the risk of miscommunication when using any medium of communication. One example is Section 11 of Rule Book Module G1 which mandates methods of clear communication such as the use of the phonetic alphabet and particular common phrases. Miscommunication was not the subject of this work so is not considered further in this paper.

The effect of mobile phones on train accident risk

The Rule Book requirements and company mobile phone policies are based on the assumption that the use of a mobile phone while driving a train will result in impaired driving performance. However, while the effect of mobile phone use on car driver performance has been thoroughly researched and is well documented, there is no equivalent research base in a train driver context. The literature search conducted as part of this work was unable to identify any published work where the effect of mobile phone use on train driving has been measured.

One piece of work that was available was an unpublished review conducted for RSSB to assess the feasibility of several different rules change options [8]. The motivation for this was the limitations of some existing communications systems and the potential for mobile phones to improve communication resilience. Inability to contact the signaller can contribute to risk and delay. Mobile phones have the potential to complement existing communications systems as another possible communication option. One option assessed was to allow the use of mobile telephones for operational communications by the driver when the train is in motion. The work concluded that this would increase risk by 0.12 Fatalities and Weighted

Injuries[1] (FWI) per year due to increased risk of SPADs and other driver errors and this was not recommended to be taken forward.

There are several fundamental differences between train driving and car driving which could mean that it is not valid to assume that train driving would be adversely affected by mobile phone use. However, there are also similarities in the underlying skills required that appear to make it likely that performance would be affected in similar ways. One aim of this work was to consider the car driving literature in detail in relation to the train driving task and reach a conclusion regarding the likely effects of mobile phone use on car driving. This research also sought to examine GB statistics to establish to what extent mobile phone distraction has already contributed to incidents. Finally, the work aimed to identify the operational constraints that dictate the extent to which mobile phone distraction risk could be further controlled.

METHODS

Incident and risk analyses

RSSB's SPAD and SMIS (Safety Management Information System) databases were reviewed to identify incidents that were wholly or partly attributed to distraction from use of a mobile phone.

Two different time periods from the same data source were examined. In order qualitatively understand the nature of mobile phone distractions leading to SPADs, all recorded SPADs were examined. This encompassed the period June 1998 to July 2009, although data are only considered complete post 2001. This approach maximised the number of examples for consideration.

To provide a data set for comparison to other types of distraction and estimation of the level of risk, the three-year period from July 2006 to July 2009 was examined. This was selected because it best reflected the current culture for mobile phone use and in-cab use policy whilst maintaining a reasonable number of data points.

The information on the cause of the incident was contained within the narrative sections of the record. Therefore, a search was performed for the words 'mobile', 'text', 'phone', 'concent' (for concentration, concentrate etc.), 'distract' and 'attention'.

Each narrative was then read to determine whether the incident was contributed to by distraction from a mobile phone or other source and to classify the offending distraction. Formal investigation reports for the incidents identified in the SMIS database were reviewed where available for further relevant details.

Driver distraction or inattention was identified to be a contributory factor of a SPAD if the narrative or full incident report included one or both of the following:

- Acknowledgement by the driver that they were distracted or inattentive

[1] Fatalities and Weighted Injuries (FWI) is a measure of safety loss accounting for fatalities and injuries, with 10 major injuries, 200 minor RIDDOR reportable injuries or 1000 minor non-RIDDOR reportable injuries being considered equivalent to a fatality.

- Distraction or inattentiveness was identified as a an immediate or underlying cause

Distraction by mobile phone was considered a factor if the narrative or incident report included one or more of the following:

- The mobile phone was in use/active at the time of the incident.
- The use of a mobile phone was identified as an immediate or underlying cause of the incident.
- The phone was acknowledged as attracting attention, such as ringing or following using a phone, the train driver's thoughts were focussed on the call content rather than driving actions.

Incidents were excluded if they involved calls being made over the NRN or CSR and if the error was due to a miscommunication, rather than a distraction.

Analysis of published literature in relation to train driving tasks

A literature search was conducted to identify research on the effect of using a mobile phone on various aspects of driving performance. The scope of the search included car driving, commercial vehicle driving and train driving. The majority of the papers concerned results of research in a car driving context and no papers were found concerning train driving.

The research findings from the literature were summarised and categorised based on the driving performance measures where adverse effects were found such as reaction time, lateral control and hazard detection.

Task analyses of train driving which were produced as part of a previous project were examined to identify the key elements of the train driver task [9]. This was compared to each of the driving performance decrements found in the literature review to qualitatively predict the effect of mobile phone use on train driving.

Workshop with operational experts

A workshop of representatives from passenger and freight operating companies was conducted to validate the conclusions of the literature review and to explore the operational and organisational constraints that dictate the contents of companies' mobile phone policies.

The workshops were attended by representatives from passenger, freight and engineering companies who employ train drivers. Their roles in the companies ranged from driver to senior manager responsible for safety. A representative from ASLEF, the train drivers' union, (Associated Society or Locomotive Steam Enginemen and Firemen) also attended.

The results of the literature survey were presented to workshop attendants. A range of operational scenarios was then considered in terms of the likely effect that

distraction would have on driver performance and the circumstances in which mobile phone use would and wouldn't be considered acceptable.

The input of the operational experts was key to deciding what would be recommended as a suitable approach for the future management of mobile phone risk.

FINDINGS AND DISCUSSION

Risk analysis

A review of incidents in RSSB's SPAD database during the three-year period 1 July 2006 to 1 July 2009 shows that there were 1021 SPADs on Network Rail Managed Infrastructure[2], of which 12 involved the driver being distracted by a mobile phone. Approximately one third of the SPADs in this period were associated with some form of distraction or inattention (346/1021).

The average risk from all causes of SPADs is estimated to be 0.74 FWI per year [10]. The current risk of mobile phone distraction is therefore estimated to be 0.0087 FWI per year; that is around 1% of SPAD risk and 0.006% of network risk. Much of the risk from SPADs is mitigated by the Train Protection Warning System (TPWS) and/or Automatic Train Protection. These systems are widely installed on the passenger network and are designed to automatically stop the train before it reaches a conflict point in the event of a signal being passed at danger.

Extending the data period further from June 1998 to July 2009, 37 SPADs were identified that involved driver mobile phone distraction. These can be categorised as follows:

[2] Network Rail Managed Infrastructure includes the main national railway but excludes activities on other railways (such as London Underground) or within privately owned depots and sidings.

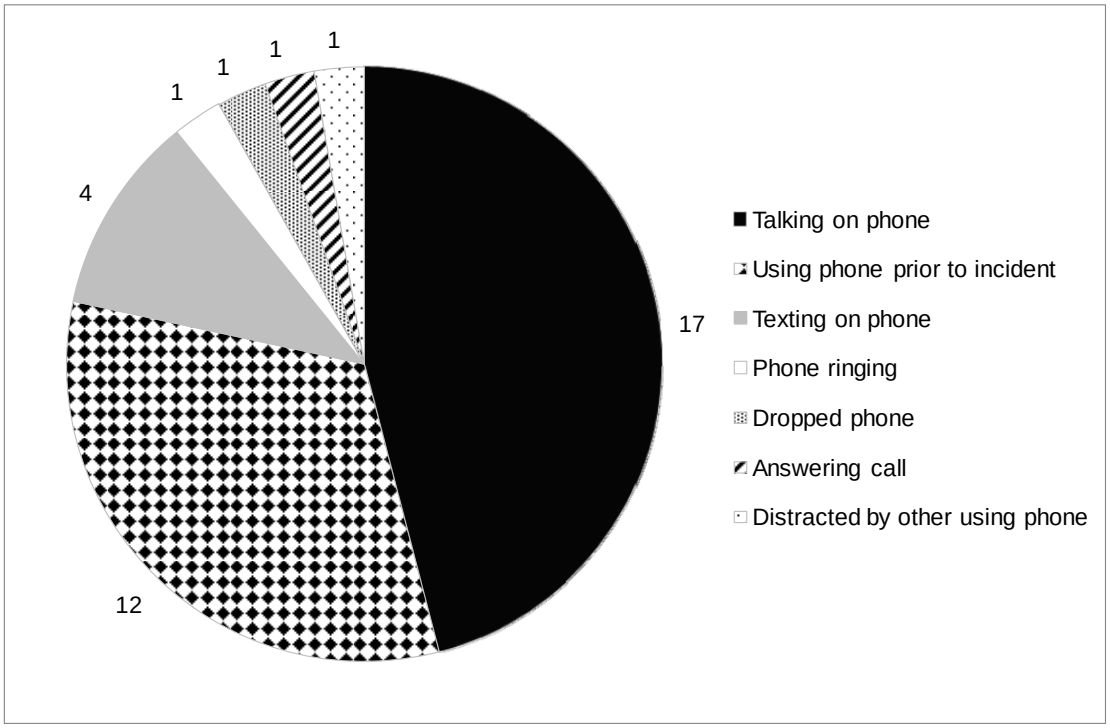

Figure 1 – Classification of the causes of SPADs contributed to by mobile phone distraction June 1998 to July 2009

Talking, texting, answering calls, and the phone ringing are all factors which could be mitigated by not using a mobile phone when driving. These factors were present in 23 out of the 37 SPADs (62%) identified. Eliminating these SPADs could potentially have a maximum benefit of reducing the risk from SPADs by around 0.0054 FWI per year. Other factors, such as using a phone prior to an incident, would be more difficult to mitigate, as the phone call or text that initiates the distraction may occur when the train is stationary.

It was also possible in some cases to classify the nature of the phone use to be personal (e.g. phonecall from spouse asking to bring groceries home) or operational (e.g. a phonecall from a roster clerk to confirm shift availability). In some cases such as where the phone was dropped or just ringing, the nature of the call is not relevant (noted in Figure 2 as N/A) and in other cases it was not possible to determine the nature of the call from the narratives or formal investigation reports.

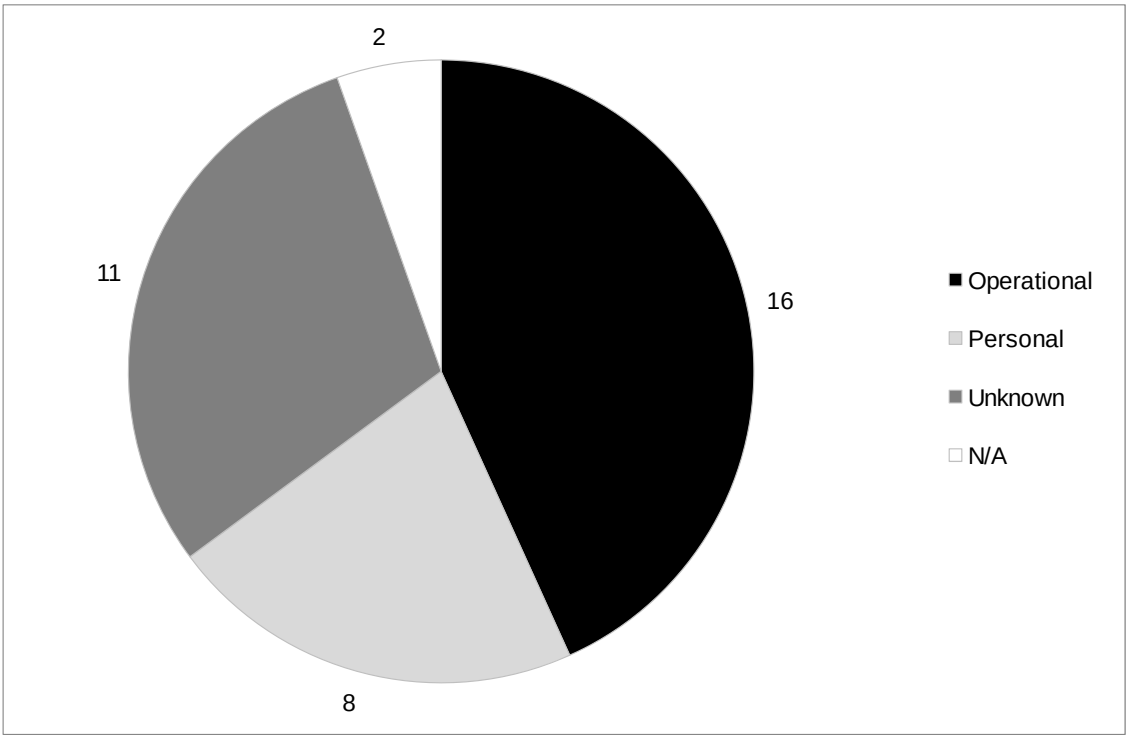

Figure 2 – Breakdown of SPADs by nature of mobile phone use June 1998 to July 2009

Other forms of in-cab communication also represent hazards as a distraction to the driver. Table 2 shows the number of SPADs found related to these distractions in the three-year period from July 2006 to July 2009.

Table 2 – Number of SPADs related to distraction from other in-cab communications July 2006 to July 2009

Distraction	Number of SPADs	Relative number of SPADs to mobile phone distraction
Other person in cab	22	1.83
Use of CSR/NRN	8	0.75
Passengers on board or boarding the train	3	0.25
Use of public announcement system	2	0.17
Use of train intercom	1	0.08

Car driving research and implications for train driving

A review of train driver task analyses identified the core elements of the train driver task while in motion. These are summarised in Table 3.

Table 3 – Core elements of the train driver task while in motion

Activity	Target
Visual detection/Vigilance	Signals/Hand signals
	Signs
	Track workers
	Level crossings
	Other hazards
Auditory detection	3Automatic Warning System (AWS) alarm[4]
	Vigilance alarm
	Train crew communication
	Passenger communication
	Instructions/information from others
	Radio communications e.g. emergency call from the signaller
Monitoring	Speed
	Location on the route
	Track conditions
	Train status
Checking	Instrumentation
Recall	Route knowledge
	Previous signal aspect
	Stopping pattern
	Rules
	Driving skills/traction characteristics
Judgment	Distances (to signals, platforms, buffer stop)
	Rate of speed change (Acceleration/deceleration)
Anticipation	Future situation (e.g. aspect of next signal, hazards being approached)
Decision making	Response to signals
	Response to speed restrictions and other route features
	Response to weather
	Response to hazards and unusual situations
	Response to alarms
	Response to communications
Control	Speed (Power/Brake)
	Stopping
	Horn
	Other controls (e.g. lights, wipers)
Communication	Signaller
	Train crew
	Passengers

[3]The AWS alarm sounds a short distance (usually 200m) before a signal or other hazard (e.g. a speed restriction). It is designed to alert the driver to the nature of signal aspect or hazard through the use of a bell or horn alarm sound.

[4]Most trains are fitted with some form of driver vigilance device. These devices require input from the driver (e.g. keeping a foot pedal depressed). If the driver response is absent for a certain period of time then an alarm will sound. The driver must respond to silence the alarm. If no response is made then the train brakes will be automatically applied.

The key distinctions between car driving and train driving are the lack of lateral control and greater reliance on anticipation and decision making in train driving. Trains have a much longer stopping distance, do not directly interact with other traffic and can travel much faster than cars. Therefore, train drivers need to be aware of what they will encounter some distance ahead and use the cues in the environment, such as signals, to make appropriate decisions about how to control the train to ensure they can stop in time for red signals and stations. In many cases, train drivers need to make a decision in response to a route feature that is not yet in view and they need to recall information seen or heard previously to inform this decision making.

Table 4 summarises the key findings of the literature survey and considers the likely effect of each type of performance decrement on train driving performance and safety.

Table 4 - Relationship between car driving performance decrements due to mobile phone use and the train driving task

Driving performance measure	**Examples of effects on car driving and relationship to train driving**
Perceptual visual field	Perceptual visual field is reduced by up to 10% when talking on a mobile phone [11]. This is likely to reduce a train driver's visual detection and vigilance ability. Train driver route knowledge is used to ensure that visual attention is targeted toward key features such as signals [12] so a reduction at the peripheral of the visual field would have most effect on the detection of unexpected hazards such as trespassers.
Glance behaviour	When talking on a mobile phone, car drivers keep their eyes on the road ahead for longer at the expense of other monitoring behaviours such as checking the mirrors and vehicle instruments [13], [14]. Mobile phone use may affect the extent to which train drivers are able to effectively direct their attention to key targets. Signals may be situated around a bend and the driver must search a specific part of the scene to detect the signal at the earliest opportunity. If this process is disrupted then the time available for decision making and control actions would be reduced which could contribute to a SPAD.
Hazard detection	Research has found a significant increase in failure to respond to hazards when talking on a mobile phone while driving [15]. One study investigating the effects of texting on driving performance found that participants failed to respond to twice as many targets while texting, when compared with a control drive [16]. Failure to detect hazards or features in the driving scene would be a significant problem in train driving. Decision making in response to signal aspects is the highest priority for train driving. If signals are not detected then SPADs are likely. Other hazards such as speed restrictions and track workers also demand an appropriate response.
Reaction time	Many studies have shown increased reaction time when using a mobile phone for texting or talking. A meta-analysis of research in this area showed that a 0.25s increase in reaction time has been found when mobile phone tasks are carried out while driving [17]. Due to the stopping distances of trains there are few situations in train driving where a difference in response time of this magnitude would change the outcome. However, reaction time is often considered to be a proxy measure of workload.

Driving performance measure	Examples of effects on car driving and relationship to train driving
Workload	Car drivers subjectively rate their mental workload as being higher [13],[14],[15],[18],[19] when using a mobile phone while driving. High workload is associated with a general increase in errors [20]. In train driving there is potential for errors to have a safety impact, particularly decision making and memory errors. For example, if a driver forgets the aspect of the previous signal they may not anticipate that they are approaching a red signal and fail to stop.
Lateral control	Lateral control is measured in a variety of different ways e.g. number of steering inputs, lane excursions and lane position variability [21]. Many driving simulation studies have measured the effect of mobile phone use of lateral control and found variable effect sizes [17] Lateral control is not relevant to train driving.
Following behaviour	Some research has shown that when engaged in a mobile phone conversation car drivers may increase their distance from the vehicle in front, perhaps as a compensatory mechanism. However, other studies have shown that car drivers may get closer to a car they are following [17]. In general, train drivers are not required to interact with other moving vehicles as train separation is maintained using the signalling system. However, there are some exceptions that may occur during engineering work. If there is the potential for headway to be decreased when using a mobile phone then this is relevant in that it may be especially important to avoid mobile phone use in these situations which are likely to be higher workload situations with greater potential for collisions to occur.
Speed control	Research has shown that car drivers tend to reduce speed slightly when using a mobile phone and that this effect is greater for hand held phones than for hands free phones [17]. This is thought to be a symptom of high workload and an attempt to compensate for the reduction in driving performance. The main control input made by train drivers is the control of speed. The manner of this is different from car driving and so are the decision making criteria. In good conditions, train drivers are required to maintain the defined line speed and variations in speed are minimised. In response to an unexpected hazard a train driver is likely to either stop completely or just report it rather than slow down. Maintenance of speed does not require continuous manual input, rather the power controller is usually set to a particular point for a period of time and only moved when a speed change is required. Train drivers make use of systems such as the Automatic Speed Limiter (ASL) to prevent overspeeding. Overspeeding is considered to be a serious violation. The hypothesis from this is that, if the effect of mobile phone use on train driving were measured, small reductions in speed when using a mobile phone while train driving would not be observed. Generally, impaired speed control would have a negative impact in terms of increased risk of derailment or SPAD if overspeeding, or delays if travelling too slowly. Some of the risk of overspeeding is mitigated by TPWS overspeed sensors which are installed at some locations and will activate the train brakes if it is travelling too fast.

The conclusion from the literature review was that the use of a mobile phone would have a negative impact on train driver performance. The most significant effects would be an increased rate of failures to detect signals, other important railway features and unexpected hazards. Train drivers would also be likely to suffer reduced situation awareness. They would be less likely to anticipate emerging situations requiring a response and generally more likely to make errors such as forgetting a previous signal indication or failing to slow down in response to a cautionary signal indication. The most likely outcome of such impairments would be

a SPAD. Other possible outcomes include failure to stop at a station as required or derailment due to overspeeding.

Operational workshops and implications for policy

Workshop participants agreed that mobile phones would impact on train driver performance in the ways outlined above. All agreed that in any operational scenario where the train was in motion it should not be considered acceptable for the driver to use a mobile phone.

Several operational considerations conspire to make the complete prohibition of mobile phones impractical in the rail context. The limitations of the current communications systems dictate that in certain circumstances mobile phones are actually the most effective communication method to use as part of the safe system of work. This and the potential to use mobile phones to report emergencies means that they can reduce as well as increase risk. Drivers often need to be contacted at short notice to initiate changes that are necessary to keep the railway running, for example, to manage service disruption. This is particularly the case for freight drivers who are required to work flexibly to fit around timetabled passenger services. For these reasons, train drivers are commonly issued with company mobile phones.

Another issue highlighted was that when drivers from different companies come into contact with each other they see different behaviours with respect to mobile phones are permitted. This degrades the power of the policies to control behaviour. These issues undoubtedly contribute to a culture where, although mobile phone use while driving is generally prohibited under company policies, it is implicitly sanctioned by the working practices on the front line. This is in the context of a national culture where mobile phones are ubiquitous and offer an increasing range of functions.

The final outcome of the workshop was agreement that greater consistency of policies would be beneficial and that this should be achieved through the production of a new standard on the use of mobile telephonic equipment in train cabs. The content of the standard should clearly proscribe the use of mobile phones by a train driver while driving but should allow flexibility to ensure that the benefits of mobile phones can still be exploited.

Considerations for future work

Workshop participants identified detection of mobile phone use as a significant barrier for enforcement and incident investigation. As mobile phone use is a violation under most company policies it is probable that the incident statistics are subject to underreporting. It is particularly difficult to draw conclusions from comparison with other types of distraction, such as other people in the cab, because differences could be due to rates of detection and reporting.

It is unfortunate that the effect of mobile phone use on train driver performance has not been scientifically measured. It would be of interest to validate the conclusions of this work empirically. However, the most important outcome of this work was to

agree with the rail industry on an appropriate industry-wide approach to control this risk and this has been achieved.

Finally, train drivers are not the only group of railway employees subject to risk from mobile phone distraction. People working on the track can also be distracted by mobile phones. In this context mobile phones are even more important for smooth operation but these workers benefit from fewer systems of protection than train drivers and passengers.

CONCLUSION

The results of this work suggest that an industry-wide policy discouraging the use of mobile phones during train driving would be beneficial because it would increase consistency between company policies and re-emphasise the importance of controlling this risk. Mobile phone distraction was found to be a more frequent contributor to SPADs than most other in-cab communication activities, with only being distracted by another person in the cab occurring more often. Limiting the use of mobile phones to when the train is stationary could reduce the number of SPADs involving mobile phone distraction by up to 62%, a saving of around 0.0054 FWI/yr.

The evidence shows that while mobile phone use while driving should be strongly discouraged across the industry, there is a need to allow flexibility for contact between companies and train drivers when they are stationary and to have mobile phones available as a back-up communication method for use as part of a well designed safe system of work. The introduction of a voluntary standard on this issue was therefore recommended and is currently in development. Although this standard will be voluntary, any company choosing not to adhere to it will be required to demonstrate the suitability of their alternative arrangements as part of their safety management system.

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