Monitoring train driver alertness in GB railway: Insights from live industry trial

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SUMMARY

Fatigue was identified as a contributing factor in the fatal 2016 Sandilands tram accident, highlighting the serious consequences of loss of driver alertness. In addition, a study into Signals Passed at Danger (SPADs) revealed that driver alertness and attention were factors in 49% of events. The Rail Safety and Standards Board (RSSB) therefore instigated a study to trial a driver alertness monitoring device on the GB railway. The aim of the project is to evaluate the effectiveness and feasibility of the technology, as well as its ability to help identify underlying causes and contributing factors associated with loss of alertness in train drivers. The trial involves three train companies and is structured into four stages: a silent monitoring period, an alarm calibration period, an operating procedures calibration period, and a live running period. The paper provides details on the methodology and initial findings.

KEYWORDS

Fatigue, alertness, driver monitoring technology, train driving

Introduction

Loss of driver alertness can have serious safety consequences. This was evident in the Sandilands tram accident in 2016, where it was identified as a contributory factor, resulting in seven fatalities and multiple injuries. Moreover, in 2018, a study revealed that driver alertness and attention were factors in 49% of SPADs, with an additional 4% involving drivers being asleep or incapacitated (Gibson et al., 2018).

Evidence suggests that driver alertness monitoring technology can help reduce this risk, particularly systems that use a driver-facing camera to track facial features and provide real-time feedback when loss of alertness is detected (Lenne & Fitzharris, 2016; Leach & Basacik, 2021; Huysamen et al., 2024). For example, the implementation of such technology at Croydon Trams led to a 75% reduction in fatigue events. Similar results from implementing driver alertness monitoring technology have also been reported in road transport (buses, trucks, motor vehicles) and the mining sector (Leach & Basacik, 2021).

Consequently, the Office of Rail and Road (GB rail regulator) challenged the rail industry to explore how this technology could be implemented and the potential safety benefits, a position further supported by the Rail Accident Investigation Branch (RAIB).

To address this, the RSSB instigated a live industry trial to evaluate the effectiveness, feasibility, and potential safety benefits of implementing driver alertness monitoring technology in GB rail.

Method

This section describes the approach used to design, prepare, and deliver the live industry driver alertness monitoring trial on GB mainline.

Project objectives

The research objectives are to:

- Evaluate the practical deployment and acceptability of driver alertness monitoring technology in GB mainline operations
- Assess the technology's ability to detect microsleeps and mitigate their occurrence
- Examine whether operational interventions further reduce fatigue-related events
- Develop an understanding of the underlying causes of loss of alertness in train drivers

Trial preparation

The live trial was preceded by preparatory work to ensure the design supported the research objectives and could be delivered safely, ethically, and within a fair culture context. These activities, described in detail in Huysamen et al. (2024), provided the foundation for the live trial, which is being implemented progressively across participating companies.

Driver alertness monitoring technology

The technology, selected through a structured selection process, uses a driver-facing camera to detect behaviours indicative of a microsleep, defined as eye closure lasting at least 2 seconds. Monitoring is active when the train is travelling above 10 km/h. When a microsleep is detected and alerts are active, the system provides real-time feedback to the driver (e.g., audible and haptic alerts) and to the organisation. All events are reviewed by the supplier, with highly trained personnel determining whether each event represents a true positive or a false positive.

Trial design and stages

The live trial is being conducted within the context of a fair culture, with three train companies representing GB mainline rail. The trial is divided into four stages (Table 1), with each stage designed to address the research objectives and iteratively refine procedures and the trial plan based on findings from the previous stage. Success criteria were defined for each stage, with progression to the next stage contingent on meeting these criteria.

Table 1: Overview of the four stages of the driver alertness monitoring trial.

Trial stages		**Stage description**
1	Silent monitoring	The device monitors microsleeps and other key system metrics with alerts deactivated. Data from this stage will be used to calibrate system sensitivity and collect baseline data.
2	Alarm calibration	Alerts are activated for both the driver and the organisation. Data collected during this stage are used to calibrate alert settings and refine operating procedures.
3	Operating procedures calibration	Operating procedures and driver support interventions are implemented in line with the fair culture policy. Data from this stage are used to evaluate and refine these operational measures.
4	Live running	Alerts, procedures, and interventions are fully implemented. Data collected during this stage are used to address the trial objectives.

Data analysis

A range of quantitative and qualitative data is being collected and analysed throughout the trial to identify key insights and trends. Data sources include monitoring device data, shift data, demographic and employment data, operational intervention data, fatigue reports, and safety event data. Additional insights will be collected through interviews and surveys, as well as lessons learnt. All data will be reviewed and statistically analysed to identify trends and relationships. Several factors and relationships will be assessed, including microsleep frequency and distribution, shift-related factors and time-of-day effects, route location, monitoring device reliability, the effectiveness of alarms, operational controls and driver support interventions, and impacts on safety events.

Findings

Stage 1 of the trial (silent monitoring with alarms deactivated) is currently underway at one company, with the remaining companies scheduled to begin in 2026. The findings in this paper relate solely to this first company, which entered the trial in July 2025. The trial group at this company comprises 220 drivers, with approximately 16 devices in use on an average day. As of 1 January 2026, cumulative active monitoring time, defined as the total duration during which the monitoring device observes drivers for microsleeps, is estimated to be between 5,193 and 7,789 hours.

Some analyses presented in this paper are restricted to drivers' first microsleep event per shift. Analyses incorporating total microsleep frequency are ongoing and will be reported separately.

Microsleep analysis

Initial analysis of this company's data shows a substantial number of microsleeps among drivers, highlighting the potential safety risk associated with loss of alertness. Between 1 July 2025 and 17 December 2025, 2,686 microsleeps were recorded across 103 drivers. Drivers frequently experienced multiple microsleeps within a single shift. The highest recorded instance was 106 events within a 30-minute period, during which cumulative eye closure corresponded to approximately 8 km of travel. Figure 1 displays the distribution of microsleeps across drivers.

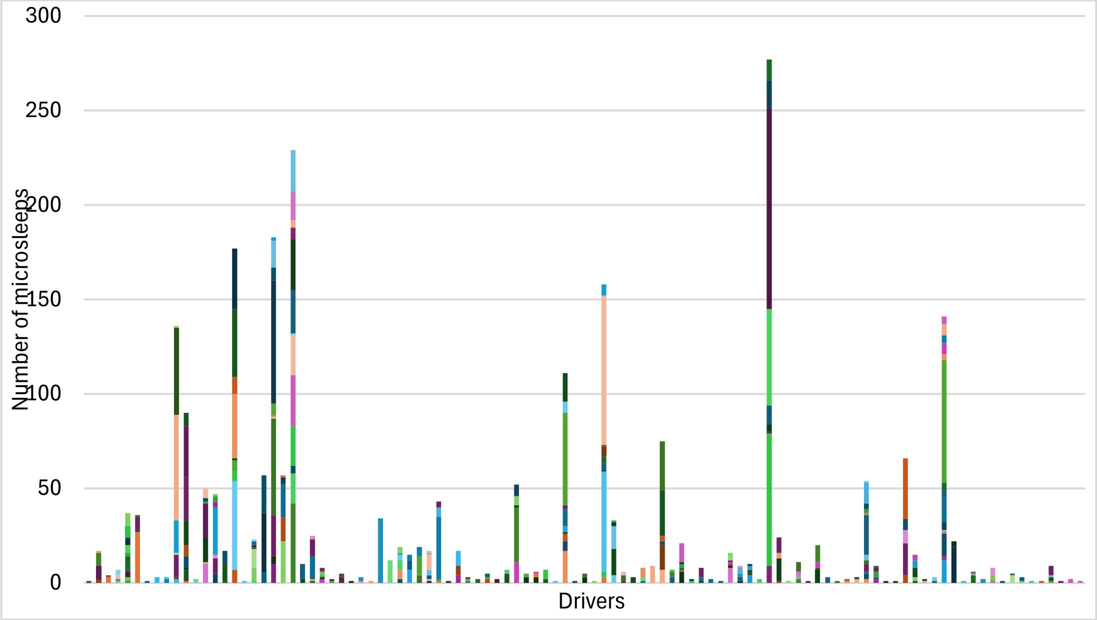

Figure 1: Total microsleeps recorded per driver between 1 July 2025 and 17 December 2025. Each bar represents an individual driver, and colours correspond to different shifts.

Microsleeps most commonly occurred in close succession, indicating periods of high fatigue. The duration of these periods varied; for example, one driver experienced microsleeps over a 9-minute period and another over 42 minutes. In some cases, gaps of an hour or more were observed between events, with the longest interval being 5 hours and 33 minutes. This indicates that microsleeps do not only occur in close succession during periods of high fatigue but may also arise later in the shift. Based on findings from other industry trials and supplier data, the real-time alerts to be implemented in Stage 2 are expected to mitigate subsequent microsleeps, particularly those occurring shortly after an initial event.

Among drivers who experienced microsleeps, more than 60% had microsleeps on more than one shift, indicating repeated occurrences across shifts (Table 2). A small number of drivers showed particularly high frequencies; for example, five drivers experienced microsleeps on 10 or more shifts, with the highest being 14 shifts. These drivers may benefit from targeted medical screening and support interventions.

Table 2: Number of drivers experiencing microsleeps by shift count.

Number of shifts	Number of drivers	Percentage
1	34	33.01%
2	18	17.48%
3	14	13.59%
4	9	8.74%
5	8	7.77%
6	2	1.94%
7	7	6.80%
8	3	2.91%
9	3	2.91%
10	2	1.94%
11	1	0.97%
12	0	0.00%
13	1	0.97%
14	1	0.97%

A microsleep was defined as eye closure of two or more seconds. While the average microsleep duration was 3.29 seconds, indicating most events were brief, a few unusually long microsleeps were observed. Fourteen events exceeded 10 seconds, with the longest lasting 15.2 seconds and corresponding to 410 metres of travel with eyes closed. With the introduction of real-time driver alerts in Stage 2, microsleeps exceeding two seconds are expected to be substantially reduced, helping to mitigate the associated safety risks.

Time of day effects

Analysis of the data showed shifts typically ran from 04:00 to 02:00. Therefore, the analysis and figures in this section depict the 24-hour day relative to working hours, rather than the conventional 00:00–24:00 clock.

As seen in Figure 2, drivers most frequently experienced their first microsleep in the early morning, with a clear peak between 06:00 and 09:00. A smaller secondary peak was observed in late afternoon, specifically between 17:00 and 18:00. These patterns are consistent with known circadian rhythm variations in alertness, including reduced alertness in the early mornings and a secondary dip in the late afternoon.

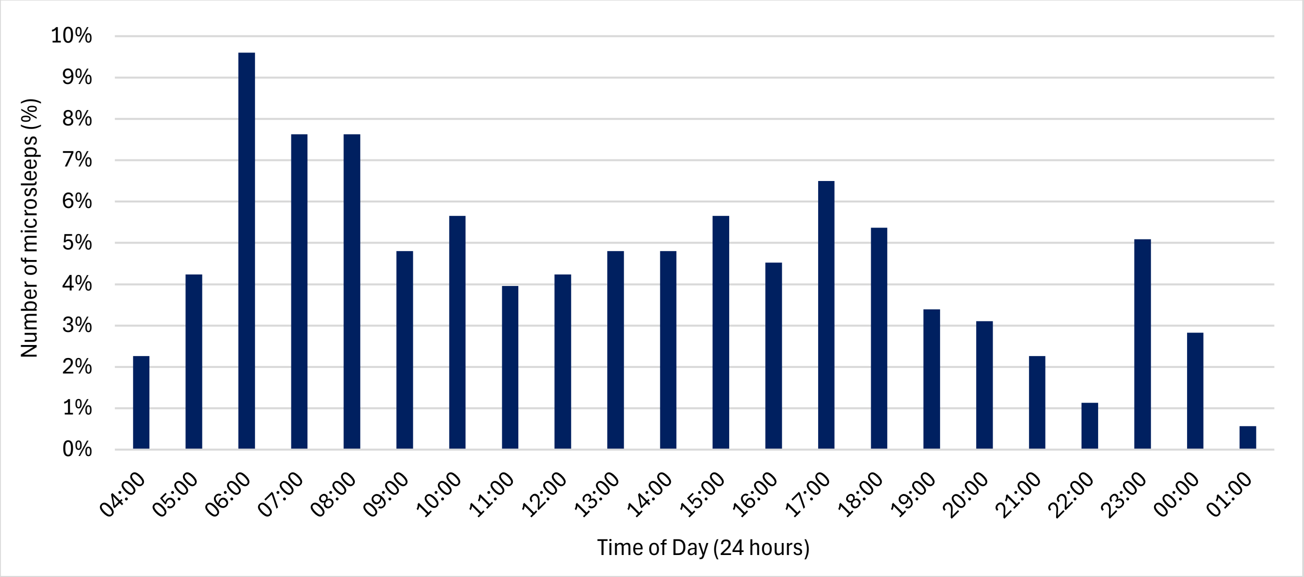

Figure 2: Distribution of first microsleep events by time of day.

Shift duration

Analysis of the timing of the first microsleep per driver per shift showed that events most commonly occurred earlier rather than later in the shift. As seen in Figure 3, 30% of drivers experienced their first microsleep within 2 hours of starting their shift, and 50% within the first 4 hours. The majority of shifts (67.5%) lasted between 7 and 10 hours, with a mean duration of 7 hours 37 minutes (range: 2 hours 37 minutes to 10 hours).

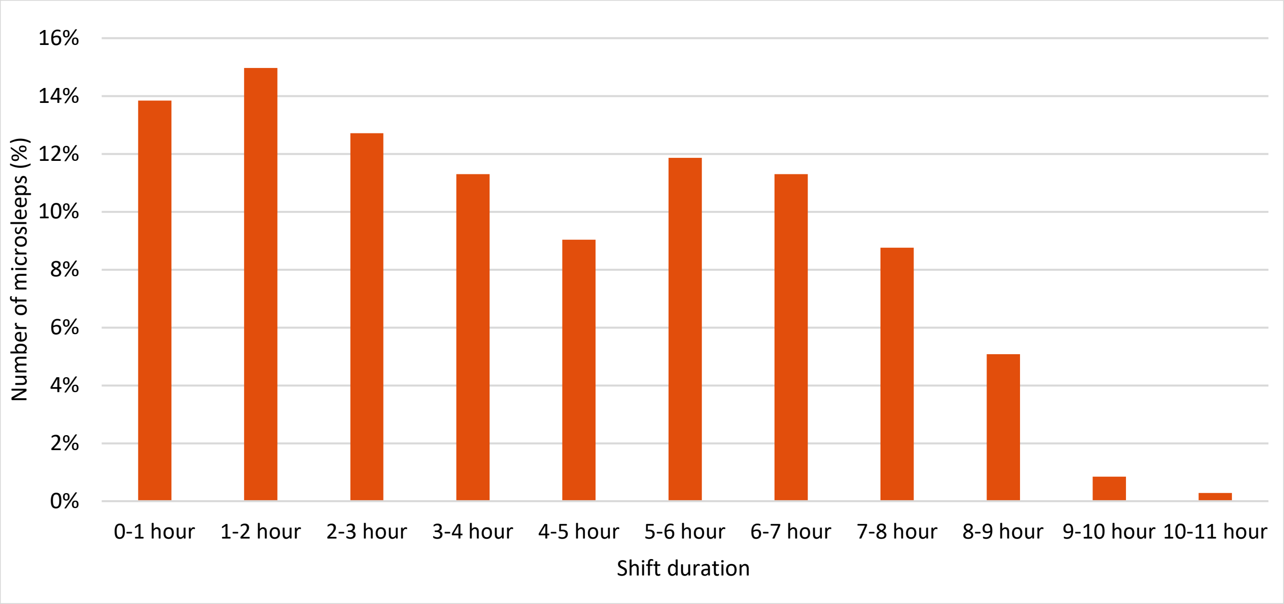

Figure 3: Distribution of first microsleep events by shift duration.

Shift start time was also explored. Microsleeps were most frequent in early morning shifts, particularly those starting before 07:00, which accounted for about half of all shifts with at least one microsleep. Shift start time also appeared to influence when the first microsleep occurred: for shifts starting before 07:00, 62% of first microsleeps occurred within the first 4 hours; in contrast, for shifts starting between 07:00 and 10:00, 64% of first microsleeps occurred after 5 hours on duty.

The shift duration analysis provides additional insight into trends observed in first microsleep frequency across different times of day. Early-start shifts (before 07:00) were the most prone to microsleeps, with events typically occurring within the first four hours, which may help explain the high frequency of first microsleep events between 06:00 and 09:00, as shown in Figure 2. In contrast, for shifts starting between 07:00 and 10:00, more than 60% of drivers experienced their first microsleep after 5 hours on duty, which may be related to the smaller peak observed later in the day, between 15:00 and 19:00 (Figure 2).

Roster analysis

A trend was identified in the roster analysis, where the actual work patterns of drivers who experienced a microsleep often did not match their assigned roster. In the 14 days leading up to a microsleep, 71% of drivers had actual schedules that differed from their assigned roster. Many of these drivers (68%) worked on one or more scheduled rest days. This highlights how additional workdays and deviations from roster schedules can contribute to fatigue risk. Another influencing factor may be the return to work after a rest day or leave (e.g., annual leave, sick leave). Nearly one-third of shifts with microsleep events occurred on the first day back, and 52.8% occurred within the first 2 days, suggesting potential adjustment issues or residual sleep debt (Figure 4).

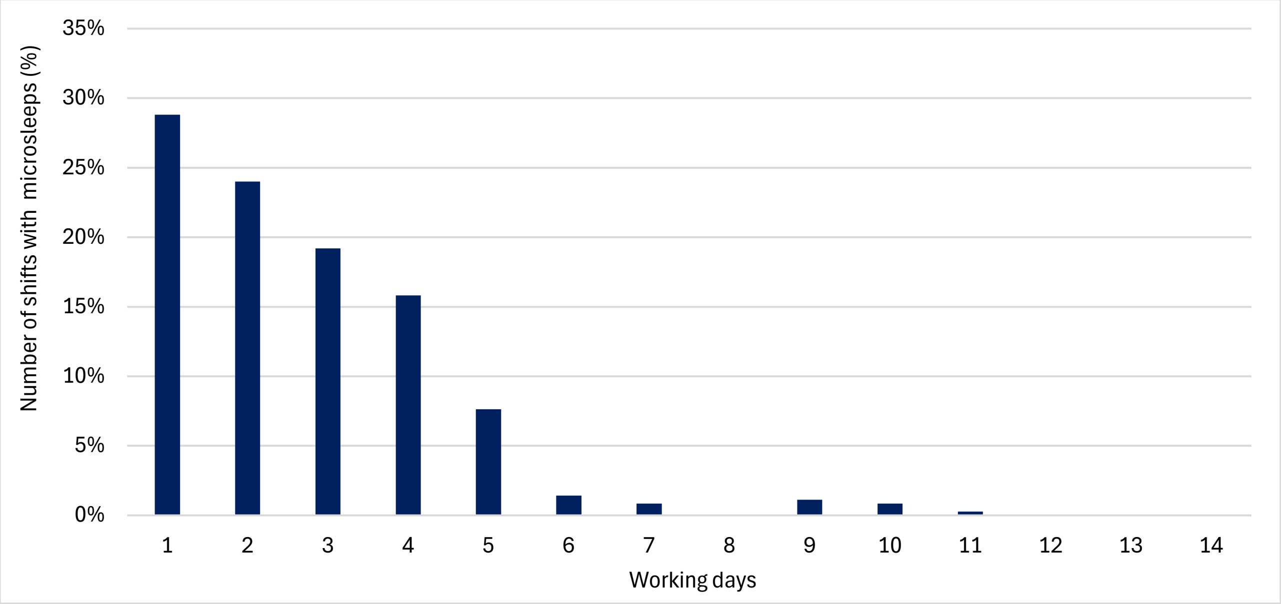

Figure 4: Distribution of shifts with microsleep events by days worked after a rest day or leave (e.g., annual leave, sick leave).

Driver monitoring technology reliability

Since the start of the trial at this company, the driver monitoring device has generated 1,860 false positive events. These are identified through a review process, in which highly trained individuals examine each microsleep video recording to determine whether it represents a true microsleep or a false positive. Of the 1,860 false positives, 1,074 were classified as ‘criteria not met’, 657 as ‘drowsiness’, and 129 as ‘yawning’. The distribution of these events can be seen in Figure 5.

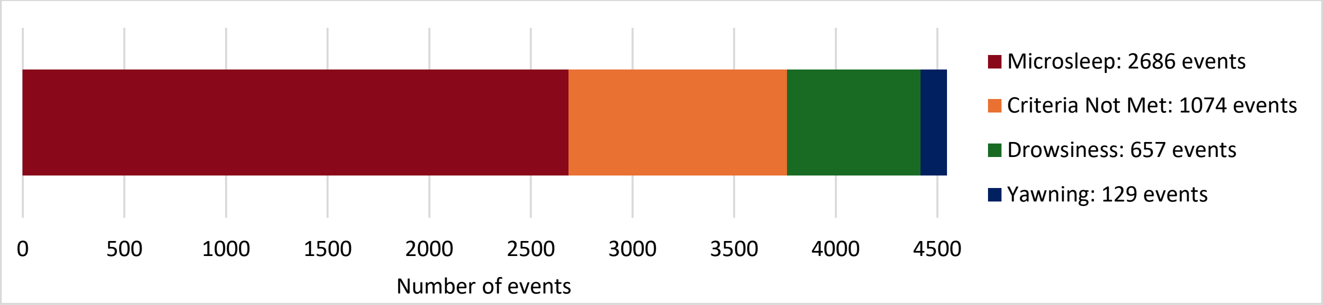

Figure 5: The classification of events detected by the driver monitoring device.

The overall false positive rate, which steadily declined during Stage 1 in line with its objective, is 41%. As yawning and drowsiness are recognised as early indicators of fatigue, a second false positive rate, called unmet criteria, was calculated; it considers only events classified as ‘criteria not met’ as false positives. At 24%, this rate provides a clearer assessment of system performance in cases where no fatigue-related behaviours were observed.

The causation of “criteria not met” events was investigated to better understand why they occurred. This analysis revealed that some events were associated with behaviours such as looking down, stretching, interacting with the face or other parts of the body (e.g., rubbing eyes or shoulders), signing, talking, chewing, eating, and drinking. In these cases, drivers had their eyes closed for at least 2 seconds while performing these tasks, or adopted a posture that made their eyes appear closed long enough to trigger the system, for example, leaning back to avoid sun glare or to scratch their neck. Some of these behaviours may reflect drivers managing fatigue, and in certain instances, an alert may be beneficial. For example, one driver had their eyes fully closed for 10 seconds while stretching, and another had their eyes closed for 10 seconds while signing, covering a distance of 356 m.

Conclusions

To date, the trial data highlight the prevalence of loss of alertness among train drivers within one company. A substantial number of microsleeps were recorded across many drivers, indicating a potential fatigue-related safety risk. Inclusion of data from the remaining two companies will provide a more comprehensive understanding of microsleep prevalence across GB mainline rail.

At an individual level, the data identified drivers with high levels of fatigue across multiple shifts, suggesting a need for targeted support or medical screening. At a system level, observed trends related to factors such as time of day, shift start time and duration, and roster deviations can inform operational decisions to minimise fatigue risk. Future analysis will further support these decisions by examining overall microsleep frequency, rather than focusing solely on the first event, to better understand patterns and potential mitigation strategies.

Based on operational experience, the introduction of real-time alerts in Stage 2 is expected to significantly reduce the frequency and duration of microsleeps. Future analysis will assess the impact of these alerts on microsleep trends, including time of day, shift characteristics, roster patterns, false positive events and driver behaviour. Stage 3 will introduce operating procedures and driver support strategies to further mitigate microsleep events and provide deeper insight into the underlying causes of fatigue at both individual and system levels.

As the trial expands to additional train companies, comparisons across organisations will provide valuable insights into common patterns and differences in driver alertness and monitoring device performance. Overall, the findings from this study will offer new, actionable data for the GB rail industry, supporting the development of evidence-based fatigue risk management strategies to enhance safety.

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