

**Summary:**

## **Helping train drivers pass signals safely: Lessons from ten case studies**

**Train drivers depend on surrounding systems of supporting organisational and technical factors to help them pass signals safely. We identify gaps in these systems by analysing ten hazardous signal approach incidents using a method for the selection and classification of error antecedents. Systematic aggregation of antecedent chains shows that hazardous approach situations are characterised by unusual conditions (excessive task demands or poorly salient signals) which increase the chance that drivers will employ inappropriate routine expectations about signal aspects. In a separate survey we find that 83% of the drivers themselves rate the ‘danger of developing assumptions based on routine’ as worthy of investigation. We recommend that the organisation finds ways to challenge the establishment of cognitive schemas by drivers exposed repeatedly to unchanging signal aspects. Technical and other organisational recommendations are also given. Further development of the analytical method used is discussed.**

In-depth analysis of ten railway incidents is carried out to identify limitations in the way surrounding systems of organizational and technical factors support train drivers on their approach to signals. A secondary aim of the project is to further assess and develop CREAM (Cognitive Reliability and Error Analysis Method) for in-depth railway incident analysis.

To identify suitable signal incidents for case analysis, 115 train drivers were surveyed on three occasions over an 18-month period about their involvement in signal approach incidents. The average survey response rate was 26 per cent.

The share of drivers reporting that they had passed a main signal at danger in the past year was very low. However, in the same period over one in four drivers reported that they had missed an approach signal with the result that the train’s computer system (ATC) had had to intervene with automatic braking to prevent the train passing a main signal at danger. Over a two-month period, over one in four drivers reported triggering a “permission to drive” indicator button when waiting at a station, even though the station exit signal did not show green. Also over a two-month period, one in three drivers reported receiving the all-clear signal from a conductor at a station when the exit signal did not show green.

Thus, although signal-passed-at-danger (SPAD) incidents themselves are rare, a substantial share of drivers report involvement in potentially hazardous “pre-SPAD” incidents.

To learn more about influential factors in the build up to these incidents, twelve drivers were questioned in-depth about a single main signal approach incident in which they had been involved. The questions were based on a framework designed to provide data for incident analysis by CREAM.

Two out of the twelve interviews were incomplete, and the analyses were therefore based on ten cases. A systematic aggregated analysis of the case study findings suggests that three event chains are commonly implicated in the run up to a missed observation by a driver, which in turn results in the hazardous approach of a main signal. These chains are as follows:

1. The driver appears to have an inadequate plan or faulty schema for signal approach, which often fails to include the possibility of deviant events such as a non-routine signal aspect. Absent or forgotten knowledge about occurrence of deviances is often implied as an antecedent to a faulty schema.
2. Inattention by the driver is also a common antecedent of a missed observation. Inattention, which may be more accurately described as inappropriate attention, is linked to an expectation about a stretch of track formed after experiencing it repeatedly in an unchanging state.
3. A lack of signal salience (information failure) in the driver's environment 'forces' the driver to employ a faulty schema about signal aspects, and increases the chance of a missed observation.

Systematic aggregation did not capture all implications highlighted by several of the individual CREAM analyses. In particular, informal analysis of six incidents also showed that:

4. Extraneous demands increase the likelihood that the driver will rely on a schema they have formed about routine signal aspects on a stretch of track.

**In summary, the dangerous signal approaches examined here are characterised by the following elements:**

- **Unusual deviance from the situation norm**
- **Several demands placed on driver**
- **Driver employs a schema based on the situation norm**

Because of the problem of schema development, we claim that routine exposure to systems in an unchanging state is a pervasive and dormant potential hazard for drivers. This finding is echoed by the drivers themselves in their responses to a survey about important safety issues by which they were affected. The dangers of routine assumptions was the most highly rated issue, with 83 per cent of drivers saying that it was worthy of investigation. Other issues rated as important by most drivers were fatigue / shiftwork (rated by 75 per cent of drivers) and signage and visibility (rated by 52 per cent of drivers). Although few drivers saw driver-to-driver communication as an issue, almost one in three thought that communication between drivers and conductors is an issue, while a slightly greater share believed driver-manager communications are worth investigating.

Recommendations for the prevention of hazardous signal incidents involving drivers are summarized as follows:

- Find ways to challenge the formation of inappropriate or unsafe schemas by drivers exposed routinely to unchanging signal aspects.
- Design a signal environment that better accounts for human factors, making deviant signal aspects easier for drivers to perceive.
- Design through driver consultation better systems to brief drivers about deviant situations they can expect as they journey on the day's route.
- Promote open communication among drivers of strategies used to deal with the dangers of routine *e.g.* group discussions
- Use refresher training to prime driver's minds about the possibility of deviances and dangers of routine assumptions, and to challenge any inappropriate schemas.
- Consider whether the way ATC is used by drivers is optimal in terms of safety. (We do not consider improvement of the ATC system itself.)
- Investigate factors influencing conductor involvement in incidents occurring on station exit.

Our findings support claims that CREAM is a useful method for the analysis of signal incidents on the railway. We find that the systematic aggregation of ten analyses leads to new information about commonly occurring antecedent events.

Finally, ideas are outlined on how the CREAM method can be evolved. In particular we recommend that CREAM be evolved to better account for feelings and mood in driving.