Getting at the Underlying Systemic Causes of SPADS: A New Approach

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Introduction

Now, more than at any other time in the history of the railways, there is an urgent need for the industry to learn lessons from near misses and incidents. In this first of two articles, we examine the extent to which the current procedures for gathering data on accidents such as SPADs provide support for the identification of underlying causes. An alternative approach is outlined, which we believe has the potential to allow a much more comprehensive and structured assessment of underlying causes to be made during SPAD investigations. This process is based on the research findings on the causes of SPADs, combined with the practical knowledge possessed by experienced personnel such as drivers and Driver Standards Managers.

Approaches to Accident Analysis in the Rail Industry

The overall approach to accident analysis in the rail sector is similar to that in many high-risk industries. It is characterised by the following features:

- The main focus of the investigation is on the individual, and it is assumed that human error is mainly due to *individual human failings or inadequacies*.
- Limited information is collected on the ***context*** of the incident, i.e. the conditions that prevailed at the time of the incident that could have contributed to its occurrence.
- It is assumed that a single root cause exists for every incident.
- Every incident is assumed to be unique, so there is no incentive to identify systemic, recurrent causes.

Focus on the individual

The primary focus in SPAD investigations tends to be on the individual who was the last link in the chain of events leading to the accident. In the case of non-technical SPADs, this is the driver of the train. Because it is usually assumed that the accident is 'caused' by the driver, there is a strong bias in the incident reporting form on questions relating to driver characteristics. These tend to focus on issues such as his or her physical or mental state, e.g. possible alcohol and substance abuse, or fatigue, or on issues relating to levels of experience and competency. This view assumes that human error is primarily controllable by the individual, in that people can choose to behave safely or otherwise. This one of the reasons why information on the underlying causes of incidents is often not collected in a systematic manner. If the investigator and the investigation process assume at the outset that the SPAD analysis process is primarily intended to categorise an incident into broad groups such as misread, disregard or misjudge, then there is little incentive to try to understand the underlying causes.

Context

The types and frequency of human errors depends on the context in which a task is performed. Context refers to the specific conditions that existed when an accident or near miss occurred. Without collecting this information in a systematic and structured manner, it is not possible to identify the recurring causes that may be present in many incidents. This is essential to develop preventative strategies that address the underlying causes of incidents, rather than wasting resources in trying to apply solutions based on a few high profile incidents. Because there is an almost unlimited range of information that *could* be collected when an incident has occurred, a model of human error is needed to select the most important factors.

Why not why?

The focus on the individual means that the information gathered about who was involved is fairly comprehensive and will include their experience, duty rosters prior to the incident, last refresher training etc. In addition, where and when the SPAD occurred is described in detail. However, gaining an understanding of 'why?' is hindered by the current SPAD classification scheme. The classification is not linked to any underlying model of the accident process. The major classification groups for non-technical SPADs are as follows:

- Misjudgement
- Misread
- Disregard
- Miscommunications.

There are a number of drawbacks to this scheme. Two SPAD incidents can arise from quite different underlying causes yet may be classified in the same category. For example, a SPAD incident assigned to the 'Disregard' category could have occurred due to a failure to *see* a signal or a failure to *respond* to a signal. These are two distinctly different types of failure, influenced by different factors, yet at this level of analysis no differentiation between the two is made. This surface level classification hampers any attempts to identify systemic trends. There is also a mixture of error types and error causes in this classification. For example, 'Miscommunication' is often the outcome of a number of fundamentally different error types, e.g. message not heard, or message misunderstood - each of which is influenced by different factors (e.g. attention focussed elsewhere, communication system failures in the first case, or lack of training in the second).

Assumption of a Single Root Cause

Generally the investigation of a SPAD stops when a primary cause of an incident has been identified from the sub-categories specified in the SPAD reporting form. This implies that the incident only arose though a single cause. However, it is well known in accident research that accidents do not arise from a single cause but from a combination of conditions. Many of these conditions will have occurred in previous incidents, but without a systematic framework for gathering information consistently during each incident investigation, the frequent recurrence of the same systemic causes may not be recorded.

A New Approach

It is essential that the data to be collected in an investigation be driven by a model of SPAD causation. Working with Railtrack and a number of Train Operating Companies, Human Reliability Associates have developed such a model in order to inform SPAD investigations through analysis of systemic causes. This has become known as the **'Model for Assessing and Reducing SPADs'** or MARS. The MARS model consists of three categories of information processing. These represent the stages through which a driver must progress when responding to a signal:

- Detection: acquisition of information - detecting the presence of a signal and identifying the signal aspect.
- Decision: interpreting the meaning of the aspect and developing an intention to act (i.e. formulate a braking strategy-normally this will be performed without conscious thought).
- Response: executing the chosen course of action e.g. physically applying the brake.

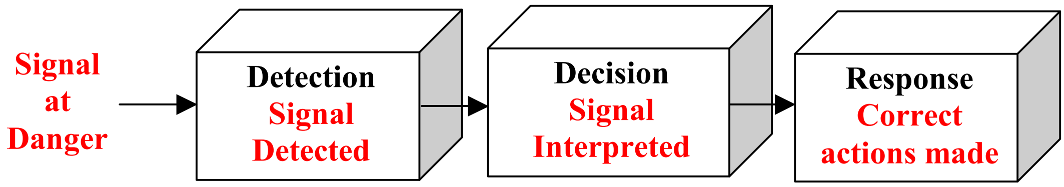

Figure 1: Stages of Information-Processing in MARS

Figure 1 illustrates these three stages of information processing. Failure to successfully progress through any one of these stages will result in a SPAD incident. These stages provide a top-level classification scheme for SPADs. This approach enables incidents to be classified according to the types of failure the driver has made. These stages are linked, in that an incorrect diagnosis at the intention formation stage could lead to an incorrect braking strategy, even though this could be executed correctly. For example, if a driver were unaware of leaf fall, he might decide to brake in way that was inappropriate for the situation, which could lead to a SPAD.

Performance Influencing Factors

The context in which human behaviour occurs determines, to a large extent, the likelihood that an error will occur. The factors that form the context in a situation are known as Performance Influencing Factors, or PIFs. When all of these factors are optimal, then performance will also be optimal. In this approach, it is recognised that human performance may be influenced by factors that are not under the direct control of the individual. The factors influencing the likelihood of SPADs in the MARS model include:

- *External* factors such as signal clarity and positioning.

- *Physiological* factors such as the driver's level of alertness and reaction speed.
- *Cognitive* factors such as attention focus (the extent to which the driver's attention is directed correctly to detect a signal), communication and multi-tasking (the extent to which the driver has to process multiple sources of information, for example at complex junctions).

Identifying the factors that directly affect the likelihood of SPADs is clearly very useful in analysing incidents. However, it is frequently very difficult to directly assess the contribution of these factors. For example, a factor such as 'Degree of signal clarity' will obviously affect the likelihood of signal detection. However, in order to assess whether signal clarity was good or bad in a particular incident, we might want to ask questions about factors that directly influence it, such as track curvature, and the degree of confusability between the signal and its background. The *Influence Diagram* provides a method for guiding the SPAD analyst in assessing these influencing factors, thus making the analysis process more structured and consistent.

Influence Diagrams

An Influence Diagram (an example of which is shown in figure 2) represents the relationships between causes (both direct and indirect) for a particular class of accidents, e.g. SPADs. Influence Diagrams are developed by combining scientific research on accident causation with insights from the experience of 'domain experts', e.g. drivers. These diagrams place a degree of structure on the complex interactions of factors that combine to cause an incident. The direct influences on behaviour such as signal visibility and alertness are combined in the same framework with indirect factors, such as organisational culture and management policies.

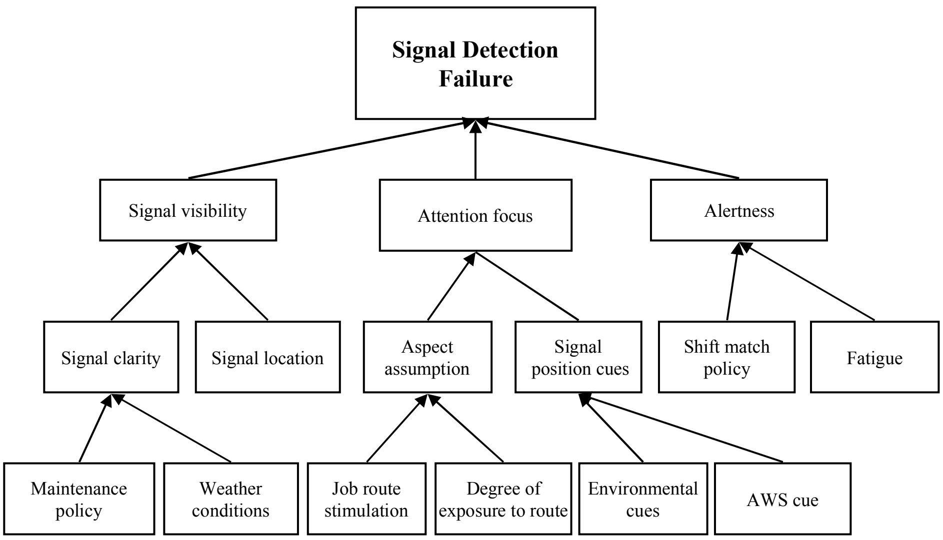

Figure 2: Example of an Influence Diagram

In the Influence Diagram shown in figure 2, signal visibility, attention focus and alertness all influence the correct *detection* of a signal. Each of these three factors is in turn influenced by other indirect factors further down the Influence Diagram. Moving down the chain of influences in the diagram leads us to factors that are further away from the incident in space and time. For example, signal visibility is influenced by signal clarity, which in turn is influenced by the maintenance policy of clearing away visual obstruction. We can see that the Influence Diagram allows the chain of causes to be traced back from the direct, surface causes to the indirect or policy level decisions that may be the ultimate 'root causes'. Influence Diagrams have been developed for each of the three stages in the MARS model – signal Detection, Decision-making and Response.

Summary

The use of the MARS model and the associated Influence Diagrams brings together research findings and the expert knowledge of drivers and other experienced individuals to provide a coherent structure for analysing SPADs.

A major benefit is that the method allows information on underlying causes from a number of incidents to be aggregated over time, so that in the long term, the most important causes can be identified. Such an analysis of trends has the potential to provide a rational basis for allocating resources to address those causes that are the most important contributors to risk.

In Part 2 of this article we provide further information on how this is achieved, and also illustrate how the model is actually used to structure a SPAD investigation. We shall also show how the approach is able to pinpoint the most cost effective areas in which to apply preventative measures. In addition, we shall show how the method can be used predictively to assess the expected number of SPADs at an 'at risk' site, before and after the application of improvement measures.

Rail Professional
September 2000

Using the MARS Model for getting at the Causes of SPADs

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Introduction

In last month's article, a new approach for incident investigation was outlined. This used of a model of SPADs known as **'Model for Assessing and Reducing SPADs'** or MARS. MARS consists of three stages through which a driver must progress when responding to a signal: i.e. Detection, Decision and Response. Failure to successfully progress through any one of these stages will result in a SPAD incident. Various factors can affect a driver's performance at these stages. These can range from external factors such as 'signal clarity' to driver related factors such as 'attention focus'. The way in which these factors combine to impact upon the likelihood of SPADs can be represented as an Influence Diagram

An Influence Diagram links the causal factors in a hierarchical manner to represent their effects on the likelihood of failure in one or more of the stages in the MARS Influence Diagram. The links from the factors directly influencing the likelihood of failure (e.g. signal visibility, attention focus and alertness- see figure 2 in last month's article) at the top of the diagram, to more indirect factors at the bottom, represent typical chains or pathways of accident causation that recur in many SPADs. This hierarchical organisation makes the Influence Diagram ideal for providing a consistent and systematic questioning structure for SPAD incident investigators. The benefits of using Influence Diagram in SPAD incident investigation are as follows:

- Influence Diagrams allow *multiple* causes to be considered as contributors to an incident.
- They provide a pre-defined structure for guiding incident investigators down specified chains or pathways of causality to find *fixable* 'root causes'.
- The use of this structure ensures that a consistent approach to investigation is adopted, thus allowing frequently recurring ('systemic') causes to be identified and addressed

The following case study illustrates the advantages of the approach.

Application of MARS to a SPAD Case Study

Prior to the SPAD, the driver of a High Speed Train was approaching a recently re-signalled platform. There was heavy rain, but he was fresh and alert at this stage of his shift. Due to the number of obstructions at the location, the signal was only visible for 5 seconds on approach. However, the regular drivers on the route had not complained about this feature of the signal. The branches of the trees near the signal head had grown and now partially covered the signal head so that it was obscured until a train was close. The driver had been on the footplate for 3 years, primarily in urban areas and had signed for this particular route six months previously. The details of the signal changes in the area had only been available in an infrequently used common room at his Depot. The driver said that he had not seen the signal at danger.

Questions from Influence Diagram

The first job of the incident investigator using MARS is to determine the stage in the normal routine of approaching signals at danger where the driver failed to perform correctly. This involves the use of a simple flow chart shown in Figure1.

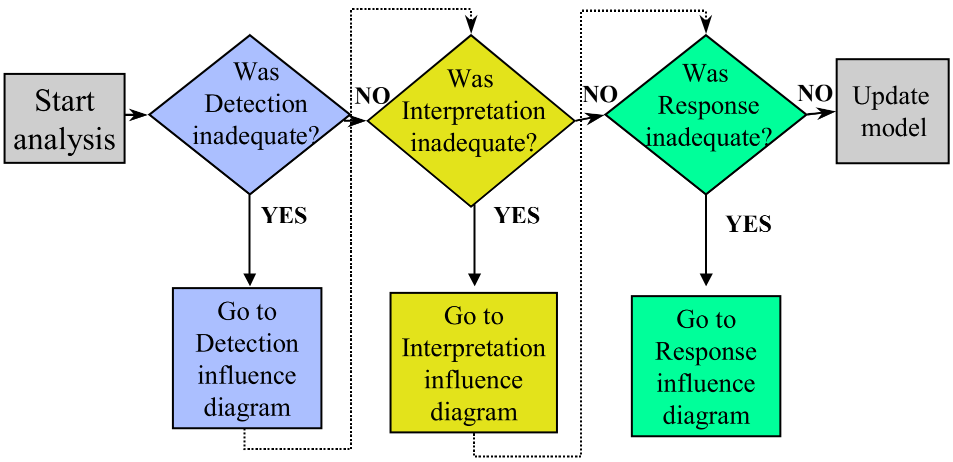

Figure 1: Flow chart to determine the stages that failed

In this case study, the incident investigator would go to the Signal Detection Influence Diagram, as the driver stated that he did not see (detect) the signal. Using the structure of the Signal Detection Influence Diagram, a set of questions can be generated. An example of these questions can be seen in Figure 2.

Alertness Questions	
7. Was fatigue level an issue?	Y/N
7.1 What was the quality of sleep like?	
7.2 What was the time of shift?	
7.3 What was the medical condition of the driver?	
7.4 *Any other* fatigue factors?	
8. *Any other* alertness factors?	

Figure 2: Example of question list generated from Influence Diagram

These questions are based on the factors contained within and the structure of the Influence Diagram. Moving down the chain of influences from top to bottom, the direct, surface causes can be traced back to the indirect or 'root causes'. If the direct level factor 'alertness' is implicated, then questions about potential causes of this problem, e.g. 'shift match policy' and 'level of fatigue' are asked. If 'level of fatigue' is found to be a contributory factor, then questioning will carry on down this causal pathway (see Figure 2 Questions 7.1 – 7.4). It should be noted that the questioning structure is not completely rigid and there are many opportunities for new factors, specific to the situation under consideration, to be incorporated. This feature of the MARS investigation process means that new factors that affect SPAD likelihood, but which were not present in the original model, can be incorporated as more incidents are analysed. This means that incident investigation can provide information about frequently recurring causes implicated in a number of incidents, rather than focussing on each incident as a unique event, as is currently the case.

Identification of Root Causes

The answers from these questions can then be mapped on to the Influence Diagram structure to help build up a graphical image of the causes of the incident. The text in the speech bubbles in Figure 3 illustrates the type of evidence that is elicited as part of the process. The factors that were not cited as causes in this incident have been omitted from the diagram.

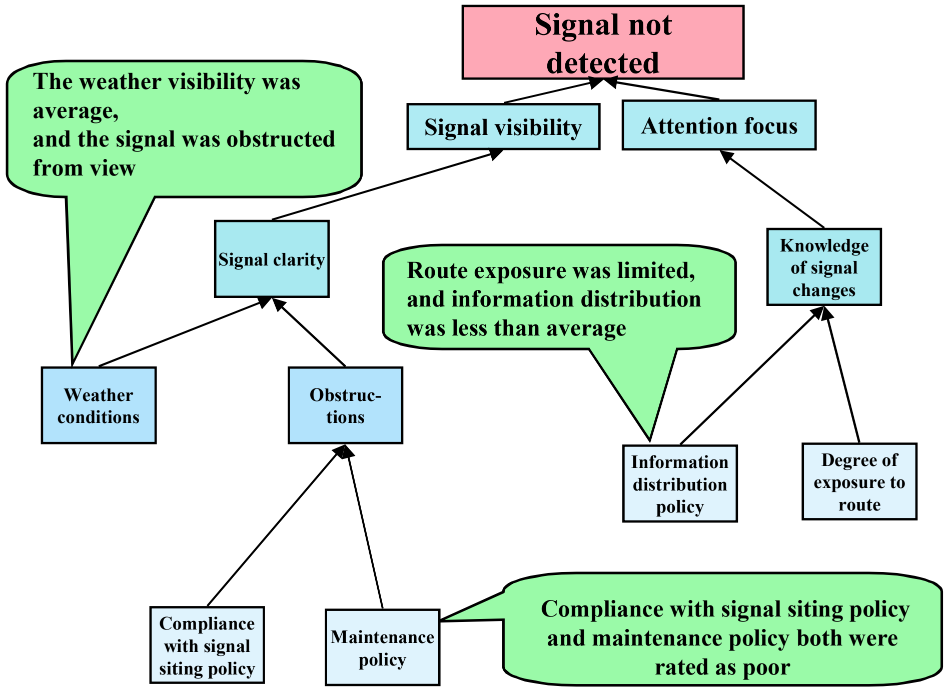

Figure 3: Graphical display of causal pathways for this incident

Using this process, insights into the combination of causes that led to the SPAD can be generated. The driver was not fully aware of the exact new location of the signal. The available information had not been passed to him directly and the lack of exposure to the route since the changes contributed to his lack of knowledge about the new signal location. Even if the driver had had his attention correctly directed at the line side at this location, the inadequate visibility of the signal would have reduced the likelihood of detection. The weather, positioning of the signal outside the normal 7-second rule constraints and the overgrown foliage all contributed to the reduced signal clarity. The combination of both the poor signal visibility and the inappropriate attention focus of the driver gave rise to the SPAD.

Summary

MARS specifies a structured process for investigators to use during SPAD investigations. As would be expected in any model of SPAD causation, these include questions on infrastructure as well as factors relating to the driver. The structure of the investigation process provided by the MARS Influence Diagram ensures that the investigator considers the possibility of multiple causes at the outset. Although the process considers causal factors relating to the driver, it does not make any initial assumptions that inadequate driver performance is the most likely cause of the SPAD. A pilot application of the approach to an incident investigation inquiry has indicated that this give rise to a much more open attitude, which facilitates the identification of the multiple causes usually involved in an incident. The existence of a clear causal model behind the data collection system in MARS supports a systematic approach to root cause analysis. Incident analysts already ask some of the questions specified by MARS during the SPAD investigation process. However, these interviews are often unstructured with no guarantee of consistency of questioning between interviews or interviewers.

Using a common MARS model of accident causation as a initial basis for all SPAD incident analyses, means that a high level of consistency can be achieved. This in turn allows underlying systemic patterns and trends in the factors giving rise to SPADs to be observed and therefore tackled effectively in the long term.