SIAFI 2006 PROJECT

Safety and Interoperability –
Signals Passed at Danger (SPADs)

Project Team:
Margriet Cuypers, Senior Safety Advisor, NS, Netherlands
Erik Halland, Manager, Rolling Stock Technology, JBV, Norway
Sandro Botticelli, Project Manager, SBB, Switzerland
Toru Miyauchi, Manager International Affairs, Railway Technical Research Institute, Japan
Louise Webb, Project Manager, RSSB, Great Britain
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1 Background, specification and methodology

1.1 Background

It is a requirement as a delegate on the 2006 SIAFI course, to choose a project to be completed as a team. Several projects were put forward and those named above opted to investigate Signals Passed at Danger (SPADs). The original remit for this project was deemed to be too wide and too general to give proper attention in a six month time frame.

Instead, the Project Team identified the following aspects as being important to their respective companies:

- Why are SPADs important – Safety point of view
- What is a SPAD
- How many SPADs do we have and how many accidents are caused by SPADs (benchmark 5 countries)
- Why measure SPADS - point of view of the Railway Undertaking (RU) & Infrastructure Manager (IM)
- What do SPADs say about safety (point of view of the RU & IM)
- Cost of SPADS
- Conclusion: Proposal for a new definition/new way of looking at SPADs

SPADs are an unfortunate occurrence on railway systems throughout the world, and have the potential to cause significant injury and death. Many studies have been carried out to ascertain common causes and to identify safety systems that can help to mitigate the risks involved.

The project remit was to consider the complex and potentially dangerous occurrence of SPADs in a European context. Attention was to be given to the current situation in the country of each Project Team Member, and also to the variety of definitions and categorisation models that exist. Collating this data, common themes were to be identified and some recommendations made. These recommendations should be applicable across Europe and seek to reduce the number of SPADs, and/or reduce the consequences of them.

1.2 Methodology

It was agreed at SIAFI 2006, April session, that each Project Team Member would obtain a variety of information from their own organisations in order to compare the current situation. The range of information included:

- SPAD statistics
- How SPADs are dealt with
- Definition of SPADs
- Categorisation of SPADs
- Information on the cost of SPADs (where possible)
- Causes of SPADs
- Measures that can be taken to prevent SPADs or to reduce the severity of their consequences
- Any other relevant information

This information was shared with the team via email in the first instance. A meeting was then held in Oslo in which a more detailed analysis of the data was carried out. Unfortunately one Project Team Member was unavailable to attend this meeting, but had provided some useful
information for review. A second meeting was held in Utrecht with all team members to complete the report and presentation.

It soon became clear that even the Project Team’s more limited project scope was too wide to achieve within the timeframe. Nevertheless we have added some extra information in our appendices. Some of the data, particularly that relating to the cost of SPADs was proving very difficult to obtain. It also took almost a whole day to agree on a definition of a SPAD that we felt would be acceptable and useful to all European countries.

It was therefore agreed, that the scope should be limited further, with passing reference made to those items which we were unable to expand on within the limits of the project remit. The Project Team felt that an examination of definitions, causes of SPADs and SPAD mitigation measures in a European context should be the main emphasis. For the costs it’s given an example of how this can be approached, ref. chapter 3.4.

2 Executive Summary

Each country has a similar definition of a SPAD with only minor differences, whereas the categorisations are rather different. Therefore a direct comparison of the number of SPADs and their categorisation is difficult between countries. In this report we propose an international definition of a SPAD which will permit comparison between countries: “A train movement beyond a fixed point (signal) where the train has no authorisation to pass, excluding shunting movements.” This includes:

1. Train/driver has an authorisation to pass but the signal changed to unauthorised at a time/position where the train has no possibility of stopping. This can occur because:
   - Of a technical failure of the signal
   - The signaller changes the signal to red too late for the driver to stop
2. The train/driver has never had the authorisation to pass the signal, and does so in error.

This proposed definition is not adequate on its own. The group also proposed that consideration is given to a new method of categorising SPADs. On a European level we would opt for the categorisation “by risk and possible consequences” because it focuses purely on the level of safety. This will need a common risk ranking tool which has not yet been developed.

On a European level we should focus more on the human factors side of SPADs and the exchange of best practice between countries (e.g. a European SPAD working group). Cooperation between IM and RU should be promoted.

To stress the importance of reducing the number of SPADs, we have made a proposal on how to approach the calculation of the costs of a SPAD. It is possible to make a rough conclusion that the total SPAD costs are 3-4 times as high as the direct costs (e.g. repair costs of rolling stock) related to accidents. More research could be done to make this number more accurate. This should be an additional motivational factor for greater effort to reduce the number and potential consequences of SPADs.

The definition and categorisation put forward in this report could be shared and serve as a starting point for further discussion in Europe.
3 Situation Today

3.1 Two approaches for five different Safety Systems:

To understand how the different countries deal with SPADs, it is important to understand how they deal with safety as a system. We can recognize two different approaches, as schematized in the graphic:

![Two different safety models](image)

**Figure 1** Two different safety models

In the **first model** the safety system adopts a reactive model: the railway introduces measures only once the accident or incident has happened. In this model it is not the causes of the incident which are stressed but the incident itself. Japan and Switzerland adopt such a model.

The **second model** is more proactive, which means that preventative measures are taken before the incident or the accident happens. This model is used by Netherlands, Great Britain and Norway.

Another important point to understand is that SPADs are not always a “cause” of an accident or incident. The effects of a SPAD can be dangerous but the SPAD itself is not.

As we will see in the next paragraphs, the safety systems of some railways stress the effects caused by SPADs. For example Japan or Switzerland concentrate their safety efforts on the effects of the SPAD. If an accident is caused by a SPAD, only in this case they will treat the cause of the SPAD. But they do not have an organisation which actively tries to avoid SPADs.

On the contrary other countries like Great Britain, Netherlands or Norway give more attention to the cause of the accident and are also consequently organised. In GB it is possible to find magazines and websites about SPADs, which have always been on a major concern to the industry.
3.2 Current definition

Each country has a similar definition of a SPAD with only minor differences.

<table>
<thead>
<tr>
<th>Country</th>
<th>Definition of SPAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>UIC current</td>
<td>Any occasion where a train passes a signal at danger and runs beyond the danger point</td>
</tr>
<tr>
<td>UIC SSMG</td>
<td>When &quot;any part of a rail vehicle proceeds beyond the limit of its authorised movement&quot;</td>
</tr>
<tr>
<td>Great Britain</td>
<td>When any part of a train has passes a stop signal at danger without authority or where an in-cab signalled movement authority has been exceeded without authority.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>SPAD is called the non-compliance of the order of a STOP-showing signal. Not valid as SPAD is when the train was stopped by the driver or the automatic train protection in front of the signal. As well not valid as SPAD is the return of the signal to red immediately before the passing of the train when a stop in front of the signal was physically impossible (e.g. technical SPAD). Only SPAD of trains are counted, not of shunting movements.</td>
</tr>
<tr>
<td>Norway</td>
<td>When a train physically passes the red signal (one centimetre is enough), we have a SPAD. The same goes also for the signal &quot;Shunting prohibited&quot;.</td>
</tr>
<tr>
<td>Switzerland</td>
<td>The unlawful passing of a Stop signal</td>
</tr>
<tr>
<td>Japan</td>
<td>Train passes stop signal (red signal)</td>
</tr>
</tbody>
</table>

Table 1  Current definitions in 5 countries

3.3 Current categories

On the contrary to the previous paragraph there are big differences between the categorisation of SPADs.

<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
</tr>
</thead>
</table>
| Great Britain | **Category A** – A stop signal is passed at danger without authority, where the stop aspect was displayed correctly and in sufficient time for a train to be stopped safely at the signal.  
**Category B** – When a cab or in-cab signalling system previously showed a proceed aspect, but then reverted to a stop aspect and the train passes this signal.  
**Category C** – When a stop signal is passed at danger without authority, or where an in-cab signalled movement authority has been exceeded without authority, because the indication was not displayed in sufficient time for the train to be stopped safely at the signal. This would happen as a result of an emergency or through automatic operation of signalling equipment. |
**Category D** - When vehicles without any traction unit attached, or a train which is unattended, runs away past a signal which is at danger, or without an in-cab movement authority.

| Netherlands | - Technical (E.g. Signal failure)  
- Non-technical (E.g. Driver error) |
|-------------|----------------------------------|
| Norway      | Technical causes  
- Signal turns to red  
- No signal shown  
- Vegetation / obscured visibility  
Driver Fault  
- Inattentive driver  
- Slippery rails  
- Driver miscalculates braking distance  
Traffic Operation Management  
- Signaller turns signal to red |
| Switzerland | - Infrastructure  
- Communication  
- Technical  
- People error:  
  ▪ signal not seen  
  ▪ signal seen, but too late  
  ▪ signal confusion  
  ▪ miscalculation braking distance or “force”  
  ▪ departure with Stop signal  
- Not known |
| Japan       | - Human error  
- Technical error |

**Table 2  Current categories in 5 countries**

### 3.4 Costs and statistics

For statistics and the calculation of costs of SPADs, please refer to Appendix 1.

To stress the importance of reducing the number of SPADs, we made a proposal on how to approach the calculation of the costs of a SPAD. It is possible to make a rough conclusion that the total SPAD costs are 3-4 times as high as the direct costs (e.g. repair costs of rolling stock) related to accidents.

### 3.5 Conclusions

- We must be very attentive when we compare the definition or the categorization of SPAD between different railways because their importance is for each organisation not always the same.
- By comparing the number of SPAD the same carefulness is required. The numbers depend on the used definition and categorization.
- It is impossible to say which country is safest in regard to the number of SPADs because there is not a homogenous definition of what is a SPAD and what is not.
4 Proposal of a new definition of a SPAD and a new categorisation

4.1 New definition of a SPAD – Proposal

As referred to in chapter 3 there are a lot of different national definitions of a SPAD. In this chapter we will make a proposal for a common definition.

For the railways to be safe, there should be as few accidents as possible. Any SPAD can lead to an accident. So if we want to prevent accidents, we should start with preventing SPADs. The number of SPADs is therefore an indication of the accidents that could have happened. If you want to know how safe your railway system is, the measurement of SPADs is a good indicator.

Since the ERA is constructing definitions for Common Safety Indicators (CSI), a common definition of a SPAD will be among these CSI. These CSI will be the guidelines to agree on a common level of safety (which can be measured) for the railway sector in Europe, the ultimate goal being to improve or sustain railway safety in every European country.

Taking into account that every railway situation (technical and procedural) differs by country, constructing a common definition of a SPAD isn’t as easy as it seems. Therefore to make sure every country uses the definition of a SPAD in the same way, we describe the situation which we will call a SPAD.

Our proposed definition:

“A train movement beyond a fixed point (signal) where the train has no authorisation to pass, excluding shunting movements.” This includes:

1. Train/driver had an authorisation to pass but the signal changed to unauthorised at a time/position where the train has no possibility of stopping. This can occur because:
   - Of a technical failure of the signal
   - The signaller turns the signal to red too late for the driver to stop
2. The train/driver has never had the authorisation to pass the signal, and does so in error.

The number of SPADS should be measured per million train kilometers per country (so as to diminish the differences between large railway countries and smaller ones). Raw data gives an inaccurate view.

4.2 Categorisation of SPADs - Proposal

Only measuring the number of SPADs, doesn’t give us enough information about the relative safety of a railway system. If we want to understand better the differences between different European countries/companies, a categorisation of the number of SPADs is important.

By comparing the different categorisations used by the countries involved in this paper, we were able to provide some possible options for categorisation:
4.2.1 Possibility 1 – Categorisation by cause
If we categorise each SPAD following the cause, it enables the railway companies on the one hand to take accurate measures to reduce the number of SPADs (If you know what caused them, you know in which direction you have to take measures). On the other hand by categorising by cause, the responsibility and the eventual costs for a SPAD can be linked to the responsible party (Railway undertaking, Infrastructure manager or both). Linking the responsibility of a cause to one of the parties involved however, may cause finger-pointing and will stand in the way of co-operation between RU and IM to improve safety. In this stage of European development of interoperability and a common understanding of railway safety, cooperation is of the utmost importance. We would therefore not advise to use this categorisation on a European level. On a corporate level this information is of course important to have to improve railway safety. We feel that on a European level you should agree on the results each country should achieve regarding railway safety, not enforce how to achieve this.

4.2.2 Possibility 2 – Categorisation by effect or consequence
If we only look at SPADS when a collision, fatality, injury or derailment occurred after the SPAD, we don’t take into account all the other SPADs that could have also caused an accident. This is a reactive way of looking at SPADs instead of a proactive way, which the Safety Directive requires. Nevertheless it is important for a company to look at the effects of SPADs and at lessons learned to generate recommendations. To be able to define the level of railway safety on a European level, this isn’t a categorisation we would advise.

4.2.3 Possibility 3 – Categorisation by risk and possible consequence
If we want to know more about the relative safety of a railway system by measuring SPADs, a categorisation of what could have happened after a SPAD can clarify the potential severity of the SPAD. If after a SPAD the train passes the signal by a few centimeters and stays far away from the danger point, the possible consequence/risk of the SPAD is low. If you have a lot of SPADS with potentially high risk overruns, the railway system is less safe. The advantage of this categorisation is that you take into account the potential seriousness of each individual SPAD which will give a more accurate notion of the relative safety.

4.3 Conclusion and proposal of the group
We would advise to use the definition of a SPAD proposed in 4.1 in conjunction with a categorization system. The number of SPADS alone will not give enough information about the level of safety. All three categorisations mentioned above have their strengths and weaknesses. On a European level we would opt for the third system (categorisation by risk and possible consequences) because it focuses purely on the level of safety. Since most of the railway systems in the different countries differ from one another, comparing statistics generated from different railway situations doesn’t make sense. Only if we look on an abstract level at the risks and possible consequences of a SPAD, the statistics will be meaningful. It is then necessary to use a common ranking system within Europe, and the development and implementation should be conducted by an ERA working group.
Also the other common safety indicators (CSI) the ERA is developing, focus on the possible risk. The causes and consequences of SPADS are already looking into what can be done to improve the level of safety. We feel that the way to improve the level of safety should be a concern for the individual organisations. On a European level the focus should be to measure the level of safety (the result) and not focus on the way to achieve this.

5 Measures to reduce SPADs

5.1 Measures to reduce SPADs by cooperation between RU and IM

In this project we have worked side by side as railway companies (Japan, Switzerland, UK, and the Netherlands) and infrastructure manager (Norway). Each party is making improvements or taking measures to reduce the number of SPADS. It became clear to us that by cooperation between RU and IM different measures can be taking to further reduce the number of SPADS. We have identified the following joint measures:

1. Communication between signaller and train driver is important in driving a train safely. In this field there could be some improvements made. These could include:
   ➔ Common use of phonetic alphabet
   ➔ Clarification of language used by cross-border traffic
   ➔ More exact measurement of the competence of a foreign language
   ➔ During degraded modes communication is very important. Extra education for both the signaller and train driver could be very useful (e.g. by the use of simulation).

2. Signal sighting committees of RU’s and IM could improve the local situation of the placing of signals.
   ➔ Both parties should share their best practice
   ➔ Both parties should share their mutual competencies in analysing signalling situations

3. Form a national SPAD working group consisting of IM and RU’s to reduce SPADs
   ➔ Both parties can share their best practice
   ➔ With both point of views present, new and innovative measures can be developed
   ➔ (Such a national working group already operates in the Netherlands. It consists apart from R.U. and I.M, of the Inspectorate and Ministry)

4. On the educational side, introduce SPAD as part of safety culture. This can be achieved by:
   ➔ Making joint investigations after a SPAD
Developing a mutual awareness programme, where we move away from blame culture / finger-pointing. This programme could also include awareness of cost of SPADs in terms of time, money, delays etc.

Formulating common targets based on risk

5. When developing new signalling schemes, involve the RU and human factors specialists
   ▸ Involve them from the planning stage
   ▸ Cooperate in signal sighting and positioning
   ▸ Cooperate in defining braking distances

6. Joint training of drivers and signallers.
   ▸ This will give the training a more true to life experience (where they also have to work together)
   ▸ Joint simulator/simulations
   ▸ Work shadowing

Measures that can be taken by a RU or IM are listed and categorised in Appendix 3.

5.2 Measures to reduce SPADs at European Level

Since on a technical level a lot has been done to prevent SPADs, in most countries the main causes of SPADs nowadays are human errors. This doesn’t apply to Norway however, where 85% are caused by technical errors. If you look at the measures IM’s and RU’s could take together, most of them concern human factors issues. Particular measures relating to training and organisation could help to mitigate against this. On a European level the sharing of best practice across Europe in respect to recruitment and training, would be a good starting point.

On a European level this could be made more concrete by promoting studies across Europe on the human factors side. We could also learn from RU’s who already work interoperably/across borders.

In the U.K. SPADWEB and a SPAD publication (Red Alert) informs and promotes the sharing of knowledge on how SPADs can be prevented. In line with these means, it could be helpful to form a European SPAD working group with access to a similar European version of SPADWEB and Red Alert. In this working group IM’s and RU’s across Europe could hold workshops to exchange experiences and ideas and also make an effort to innovate in the field of SPAD reduction by cooperation.
6 Conclusion and next steps

6.1 Conclusion

To improve comparison between safety indicators and monitor the relative safety of a railway system, we advise to use on a European level a definition with a categorisation by risk and potential consequences. Furthermore it is easier to create awareness of the importance of the reduction of SPADs when you are aware of what could have happened. We hope that it is also common ground for IM’s and RU’s to work together to improve safety.

If we look at the future, we can see that the introduction of ERTMS could mean the end of the majority of SPADs. This depends on the functionality of the already existing ATP-systems in the different countries. The human factor in driving a train will be reduced and passing a red signal or danger point unauthorised will be made technically impossible. Nevertheless there are still some situations where a SPAD could happen:

- During extreme weather (e.g. extreme slipperiness/railhead contamination) the braking curve programmed in the train might not be sufficient. This can cause the train to come to a stand after the danger point thus causing a SPAD.
- When passing from a secured to a non-secured area (and vice versa). Not all areas on the railway system will be equipped with ERTMS. Therefore when passing from a secured to a non-secured area, the train driver could ignore a signal or danger point thus causing a SPAD.

Another point of attention during the implementation of ERTMS will be the over reliance of train drivers on technology. If the technology always intervenes and a driver depends on the technology, his expectation will be that he won’t need to pay attention to signals or danger points anymore. When he crosses areas that are not yet fitted with ERTMS, this expectation and consequent behaviour could be dangerous.

Nevertheless we are sure that when measuring SPADs by possible consequence and risk, it will become clear that our railway system will have become safer because of ERTMS. Our current efforts to reduce SPADs might become superfluous. Yet the knowledge we acquire when sharing our experiences on a European level, might still be needed to face this new European situation and the challenges it will bring.

6.2 Next steps

(1) Agreement upon international definition and categorisation
(2) Definition of common ranking system
(3) Implementation
(4) Comparison and measures (loop)

Figure 2 Next steps
1. Agree upon an international definition of a SPAD + a categorization following risk and possible consequences.

2. It is then necessary to define a common ranking system. The development and implementation should be conducted by an ERA working group.

3. Implementation

4. Comparison and measures (this will then loop back to number 1 to ensure continuous evaluation).

Parallel to this, measures could be implemented on an international level to reduce the number of SPADs:

- On a European level the sharing of best practice across Europe in respect to recruitment and training.

- On a European level this could be made more concrete by promoting studies across Europe on the human factors issues. We could also learn from RU’s who already work interoperably/across borders.

- In the U.K. SPADWEB and publication (Red Alert) informs and promotes the sharing of knowledge on how SPADs can be prevented. In line with these means, it could be helpful to form a European SPAD working group with its own SPADWEB and publication. In this working group IM’s and RU’s across Europe could take place to exchange experiences and ideas and also make an effort to innovate in the field of SPAD reduction by means of cooperation.
7 Appendix 1 – Costs related to SPADs

7.1 General

There is no doubt that costs can be related to SPADS. The obvious costs are those that occur when accidents happen as a result of a SPAD. Nevertheless there will be a great number of SPADs that do not cause an accident, for each accident that does occur.

It is a well known accident theory that there is a relationship between numbers of accidents and numbers of incidents. This can be illustrated with the ‘Heinrich Pyramid’, see figure 3. The Heinrich Pyramid shows that for every fatal accident, there will be 3-5 non-fatal accidents, and 7-10 incidents, but there will be hundreds of unreported occurrences (the exact ratios vary with the nature of the endeavour).

Based on the fact that the railway in general provides a safe means of transportation and that few numbers of serious accidents take place, it is important to log and analyse incidents that could lead to an accident. The data can generate knowledge that later on can be used to increase the level of safety. Serious accidents therefore, can be prevented by reducing the numbers of low-risk incidents.

Data provided on low-risk incidents can also be used as basis to estimate the total costs related to SPADs generally, not only costs related to accidents.

Numbers of SPADs at different risk levels

SPADs are well known incidents that have a special focus within the railway sector. It is typically assumed that all SPADS are reported and evaluated in the same way and that comparison can be found in national statistics. The numbers of unreported occurrences can be neglected.

There is a known relationship between the numbers of incidents at each risk level. SPADs can as an example be classified within the following risk levels:
**Accident** - SPAD resulting in accident with loss of human lives, human injuries and material damage.

**High risk** – High potential for collision

**Middle risk** – Low potential for collision, but serious incident possible.

**Low risk** – Negligible possibility for collision.

Investigation of SPADs in Norway in the period 2001-2005 shows a mathematical relationship between SPADS at different risk levels. There are circa 5 incidents of low risk for each incident of middle risk and circa 3.5 incidents of middle risk for each incident of high risk.

In this period there have been no SPADs resulting in accidents so there are no numbers available for the numbers of high risk incidents per accident. The average number of high risk incidents is 1.5 per year and assuming an accident every 10 years, gives 15 high risk incidents per accident.

These numbers are only used to give an illustration of how the costs could be approached.

This gives the following distribution as shown in figure 4.

![Figure 4 Relationship between numbers of SPADS at different risk levels.](image)

7.2 **Costs related to SPADs**

The direct costs related to accidents are in most cases known but will of course depend on the severity of the accident. Standardised numbers related to human fatalities are used in risk calculations. There will also be costs related to repair or replacement of rolling stock. Indirect costs are more difficult to estimate related to investigations, lawyers and potential loss of customer business and reputation etc.
Costs related to SPAD incidents not resulting in accidents are more difficult to estimate but they do exist. As a minimum, these could include:

- Investigations (interviews, reporting, following-up)
- Stopping of traffic with possible delays
- Driver taken off duty and replaced with another driver
- Signallers taken off duty or the need for extra signallers because of interruption in traffic.

If the cause is clear the cost might be low. If the cause is disputed the inquiries will last longer and would require more investigation and ultimately the potential for more mitigating measures. A discussion about cause can occur both for the low risk SPADs and the high risk SPADs, but for making rough estimates average values can be used. Even if the measures are much the same it is assumed that the costs increase with the risk level.

When estimating costs technical SPADS will also be of interest. They will not only give costs for the infrastructure manager, train delays and possibly cancellations will often be the consequence.

Based on figures from the UK, N (Norway) and NL, rough average costs have been estimated for each risk level. It has to be underlined that the values are estimates only and used to provide rough outline costings. Further investigation would have to be done to provide more accurate figures, and to identify if they are the same for the whole of Europe.

<table>
<thead>
<tr>
<th>Incident type</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident caused by SPAD</td>
<td>5.000.000 €</td>
</tr>
<tr>
<td>High risk SPAD</td>
<td>500.000 €</td>
</tr>
<tr>
<td>Middle risk SPAD</td>
<td>100.000 €</td>
</tr>
<tr>
<td>Low risk SPAD</td>
<td>10.000 €</td>
</tr>
</tbody>
</table>

Table 3 Possible damage costs of SPADs

Average low risk costs are based on UK values of £10k for undisputed SPADs rounded to €10k. Average middle risk costs are based on UK values of £80k for disputed SPADs rounded to €100k. For high risk costs an assumption has been made of €500k. For accident costs figures have been combined from UK Ladbroke Grove £3145k + £8700k inquiry costs, NL annual repair costs of €12000k, Norwegian Aasta accident (collision two trains, 19 fatalities, 8–10 million €) and made an conservative average assumption of €5000k.

Based on this the following calculations can be done:

<table>
<thead>
<tr>
<th>Incident type</th>
<th>Damage pro Incident</th>
<th>Frequency</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident</td>
<td>5’000’000 €</td>
<td>1</td>
<td>5’000’000 €</td>
</tr>
<tr>
<td>Very serious SPAD</td>
<td>500’000 €</td>
<td>15</td>
<td>7’500’000 €</td>
</tr>
<tr>
<td>Serious SPAD</td>
<td>100’000 €</td>
<td>50</td>
<td>5’000’000 €</td>
</tr>
<tr>
<td>Low serious SPAD</td>
<td>10’000 €</td>
<td>250</td>
<td>2’500’000 €</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td></td>
<td></td>
<td><strong>20’000’000 €</strong></td>
</tr>
</tbody>
</table>

Table 4 Possible damage of SPADs
7.3 Conclusion
Out of this it is possible to make a rough conclusion that the total SPAD costs are 3-4 times as high as the direct costs related to accidents. This should be an additional motivational factor for greater effort to reduce the number and potential consequences of SPADS. More research could be done to make this number more accurate.

8 Appendix 2 – Statistics about SPADs

8.1 Development of the number of SPADs in the last five years

<table>
<thead>
<tr>
<th>Country</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>172</td>
<td>171</td>
<td>193</td>
<td>188</td>
<td>158</td>
</tr>
<tr>
<td>CH (only SBB)</td>
<td>45</td>
<td>59</td>
<td>69</td>
<td>53</td>
<td>57</td>
</tr>
<tr>
<td>GB</td>
<td>483</td>
<td>383</td>
<td>392</td>
<td>357</td>
<td>338</td>
</tr>
<tr>
<td>Japan</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>45</td>
<td>61</td>
<td>52</td>
<td>56</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 5 Development of the number of SPAD in the last five years (do not use for comparison!)

Please note: This is raw data only and can only be used with caution.

Remark: Except for Switzerland these SPADS are caused by human error.

8.2 Proportion of SPAD to the Train km and P km

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of SPAD</th>
<th>Pkm (in millions)</th>
<th>Proportion to Pkm</th>
<th>Trainkm (millions)</th>
<th>Proportion to Trainkm</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>158</td>
<td>14'730</td>
<td>0.010726</td>
<td>110.0</td>
<td>1.436364</td>
<td>Only passenger trains are included in train km without shunting signals and without the SPADS caused by signaler</td>
</tr>
<tr>
<td>CH (only SBB)</td>
<td>57</td>
<td>13'830</td>
<td>0.004121</td>
<td>125.5</td>
<td>0.454183</td>
<td></td>
</tr>
<tr>
<td>GB</td>
<td>338</td>
<td>43'000</td>
<td>0.007860</td>
<td>472.8</td>
<td>0.714875</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>3</td>
<td>385000</td>
<td>0.0000078</td>
<td>1'215.0</td>
<td>0.002469</td>
<td>2003 data (only passenger km’s)</td>
</tr>
<tr>
<td>Norway</td>
<td>54</td>
<td>2'715</td>
<td>0.0198895</td>
<td>33.0</td>
<td>1.635917</td>
<td>Shunting signals included.</td>
</tr>
</tbody>
</table>

Table 6 Proportion of number of SPADs in 2005 to Pkm and Tkm (do not use for comparison!)

9 Appendix 3 – Possible measures to avoid SPAD’s

<table>
<thead>
<tr>
<th>Who</th>
<th>Measure</th>
<th>Type of measure</th>
</tr>
</thead>
</table>

SPAD – New European definition, categorization and measures
<table>
<thead>
<tr>
<th>RU’s</th>
<th>educational</th>
<th>technical</th>
<th>organisational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver training – initial and refresher</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Improve cab design</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigilance tests</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recruitment selection</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competence of trainers</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring and assessment</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved wheelslide protection and sanding systems, professional driving</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Lessening of distractions</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Provide enough stimulation for driver without too much distraction</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Education of importance of SPADs and investigation</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Train stop systems, TPWS, ERTMS</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Rostering</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Route knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic analysis of SPADs – to know what kind of measures are necessary – pre-cursors</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Procedures, rules, SMS</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Maintenance of rolling stock</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment fully functioning</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.M.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut back vegetation</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positioning of signals (general and further from danger point) and extra signals where long gaps or curvature of track etc</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular maintenance and renewals</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Consider LED signals</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track circuits improvement</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State of tracks themselves</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rail washers, rail contamination</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Update mitigation measures (ie renew measures to keep drivers alert)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Education of signallers, assessment, monitoring etc</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Signaller panel design – simplification of presented</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Jointly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>information, extra personnel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rostering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic analysis of SPAD and monitoring of multispad signals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved communication – safety and general</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Common use of phonetic alphabet</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Clarification of language used by cross-border traffic</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Competence of language – measurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During degraded modes – helpful</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSM-R – common system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of multi-spad signals?</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable considerations</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>risk analysis of new timetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>reduce risk by having fewer trains on same path, converging paths etc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for signallers – information overload, but this against commercial interests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal sighting committees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharing of competencies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best practice</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7  Possible measures to avoid SPADs