

# The Strategy for the Train Protection and Warning System (TPWS) – Issue 2 (Draft)

February 2015

Document presented by the Train Protection Strategy Group on behalf of the Vehicle/Train Control & Communications System Interface Committee.

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# Executive Summary

## The strategy

For the Train Protection and Warning System (TPWS) to remain an effective train protection system for use on the mainline railway network for the next 25 to 35 years, the strategy will be for the railway industry to cooperate to:

1. Ensure TPWS continues to comply with the requirements of the 1999 Railway Safety Regulations and the relevant exemptions<sup>1</sup>.
2. Ensure TPWS continues to be reliable and continues to meet or exceed the minimum availability requirements specified in Railway Group Standard GE/RT8075.
3. Review the application of TPWS to infrastructure and trains on an ongoing basis to ensure that the risk mitigated by TPWS, in conjunction with other risk mitigation measures, remains as low as reasonably practicable.

This document is an update of Issue 1 of the TPWS Strategy (RSSB, 2009) that has been used over the period 2009 to 2014. The strategy is overseen by the Train Protection Strategy Group (TPSG). This issue of the strategy covers the industry activities through to the end of Control Period 5 (March 2019). The strategy will be updated again for Control Period 6.

## Summary of actions to be taken to achieve the strategy

1. Ensure TPWS continues to comply with the requirements of the 1999 Railway Safety Regulations and the relevant exemptions.
  - The industry will ensure that for both new signalling layouts and modifications to existing layouts, TPWS will continue to comply with the requirements of the 1999 Railway Safety Regulations and the relevant exemptions
  - For the foreseeable future the industry does not anticipate challenging the regulations or seeking any further exemptions from them.
  - Review and comment as appropriate on the changes to legislation effecting TPWS
2. Ensure TPWS continues to be reliable and continues to meet or exceed the minimum availability requirements specified in Railway Group Standard GE/RT8075 based on the new method for monitoring reliability and availability (RSSB, 2015)

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<sup>1</sup>The ORR expects these regulations to be recalled and replaced in 2015 (ORR, 2015).

- Infrastructure equipment:
    - Network Rail<sup>2</sup> will continuously review the TPWS infrastructure equipment reliability data and failure modes considering both wrongside and rightside failures.
    - Network Rail will consider the feasibility of using its fleet of track measurement trains to detect damaged, displaced and missing TPWS track equipment on main routes.
    - Network Rail and the equipment manufacturers will manage component obsolescence and take steps to mitigate its consequences before it impacts on equipment reliability and availability.
  - On-train equipment:
    - Train operators and the V/TC&C SIC Technical Subgroup will continuously review TPWS on-train equipment reliability data and failure modes considering both wrongside and rightside failures.
    - Train operators and equipment manufacturers, facilitated by the V/TC&C SIC, will manage component obsolescence and take steps to mitigate its consequences before it impacts on equipment reliability and availability.
    - TPWS control units provided for new trains and where upgraded on existing trains will contain in-service testing functionality to alert the driver of a fault in the TPWS system while the train is in service.
  - TPWS event and component failure reporting:
    - The industry will cooperate to improve reporting and monitoring of TPWS component failures, including the development and implementation of a Defect Recording and Corrective Action system (DRACAS).
3. Review the application of TPWS to infrastructure and trains on an ongoing basis to ensure that the risk mitigated by TPWS, in conjunction with other risk mitigation measures, remains as low as reasonably practicable.
- 3.1 Infrastructure
- Regulated TPWS fitment:
    - Network Rail will continue with the application of the Signal Overrun Risk Assessment Tool (SORAT), taking account of the recommendations from the TPWS design criteria assessment, to main aspect signals protecting junctions to provide assurance that the risk is SFAIRP.
    - No further change is currently foreseen to the configuration of TPWS fitments on the approach to buffer stops.

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<sup>2</sup> And other infrastructure managers where applicable  
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- Unregulated TPWS fitment:
  - For all types of signal fitment for which TPWS fitment was not required by the 1999 Railway Safety Regulations there is an ongoing review of the number of SPADs, the risk ranking scores derived from SPADs that occur and the outcomes of accident/incident investigations to identify potentially higher risk signals. Where appropriate Network Rail subject these signals to a defined signal risk assessment and cost-benefit analysis methodology to determine if it is reasonably practicable to fit or modify TPWS at the signal or apply or modify other control measures. If such analyses demonstrate that TPWS fitment is reasonably practicable for a particular signal, Network Rail will also ensure that the implications for similar signals are considered.
  - It is not anticipated that any general classes of plain line signals will be fitted with TPWS (although individual signals may be fitted where justified – see above). It is also possible that modular signalling may include a TSS at certain locations.
  - It is not anticipated that any general classes of signals protecting level crossings will be fitted with TPWS (although individual signals may be fitted where justified – see above).
  - RSSB research and development project T1007 will produce a methodology for analysing SPAD risk at signals protecting level crossings taking due account of TPWS as appropriate.

### 3.2 On-train

To address reset and continue:

- New trains:
  - The driver-machine interface (DMI) on all new trains that are required to operate on TPWS fitted lines, will incorporate the new TPWS ‘3 indicator light’ functionality that will be specified in Railway Group Standard GE/RT8075.
- Existing trains:
  - RSSB and the train operating companies will assess whether the TPWS DMI on existing trains should be modified to incorporate improved functionality as described in GE/RT8075.
  - Where trains are upgraded to include ERTMS consideration should be given to incorporating the TPWS ‘3 indicator light’ functionality that is specified in the Railway Group Standard GE/RT8075 .
- Driver training and briefing:
  - The train operating companies will continuously review their driver training and briefing arrangements to minimise the likelihood of reset and continue events.

- TPWS to ERTMS transitions
  - Need to work with the ERTMS team to develop a suitable transitions approach. RSSB research project T1091 will be looking into transitions between conventional aspect signalling and ERTMS operation with a view to understanding more about the impact of transitions between signalling systems on driver performance/risk.

3.3 All risk assessments and cost benefit analyses relating to TPWS will be carried out using the principles outlined in 'Taking Safe Decisions'<sup>3</sup>.

4. This strategy will be monitored by the Vehicle/Train Control & Communications System Interface Committee (V/TC&C SIC) and an update on progress will be provided to the RSSB Board annually.

DRAFT

# 1 Introduction

TPWS was implemented in the UK as an interim measure to reduce the consequences of Signals Passed at Danger (SPADs), pending implementation of full protection through systems that monitor driver performance continuously. In the Uff-Cullen report<sup>4</sup> it was envisaged that this higher level of protection would be delivered by the roll out of ERTMS within ten years.

In 2004, following a series of reset and continue events in the early years of TPWS operation, the industry undertook a review of TPWS. RSSB, on behalf of the industry, issued a position paper on TPWS. The paper presented a proposed strategy for (a) minimising the possibility of reset and continue events in the future and (b) optimising the risk reduction achievable by considering a series of actions relating to TPWS fitment at PSRs and buffer stops, TPWS+, fitment at plain line signals, the design of the in-cab TPWS to driver interface to minimise reset and continue and system reliability and reporting.

Since that time progress on these issues has been made under the guidance of a number of industry working groups and Network Rail actions. At the same time, development of the implementation plan for the European Rail Traffic Management System (ERTMS) with its Automatic Train Protection (ATP) functionality, has progressed and it is now clear that TPWS will be a core railway system for several decades to come. According to the Department for Transport<sup>5</sup>, on some routes ERTMS will never be fitted and therefore TPWS is likely to remain the primary train protection system for these routes for the foreseeable future.

At the operational risk conference held in July 2008 the ORR gave a presentation on 'Managing and Reducing Operational Safety Risk'. In this presentation a concern was highlighted that there is no clear strategy for the long term future of TPWS.

In response to these issues the RSSB Board directed the Vehicle/Train Control & Communications System Interface Committee (V/TC&C SIC) to establish a working group to develop the long term strategy for TPWS. In 2014, the group expanded its remit to consider train protection systems other than TPWS. The name of the group changed from the TPWS Strategy Group to the Train Protection Strategy Group (TPSG) and the detailed remit of the group is provided in Appendix 1.

The TPSG considers train protection systems other than TPWS. This document however is just concerned with the long term strategy for TPWS developed by the group following the principles outlined in 'Taking Safe Decisions'<sup>6</sup>. It is an update of Issue 1 of the TPWS Strategy (RSSB, 2009) that has been used over the period

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<sup>4</sup> Joint inquiry into train protection systems. Uff – Cullen. 2001

<sup>5</sup> ERTMS National implementation plan. Department for Transport. September 2007

<sup>6</sup> Taking Safe Decisions RSSB 2014

2009 to 2014. This issue of the strategy covers the industry activities through to the end of Control Period 5 (March 2019). The strategy will be updated again for Control Period 6.

## **1.1 Progress made by TPWS Strategy Group since 2009**

In summary the objectives of the TPWS Strategy Group were to:

- a) Review TPWS, taking full account of the current proposals for the implementation of ERTMS. Including assessment of:
  - Current TPWS performance (operational and safety)
  - Equipment Design / Engineering
  - Equipment Operation / Isolation
  - Equipment Maintenance / testing
  - Configuration Control
  - Equipment Migration
  - Operational/performance opportunities
- b) Develop the long strategy for the future of TPWS, investigating the risks, mitigation options and opportunities available.

In setting these objectives RSSB Board requested the group to specifically consider:

- Does TPWS in its current form comply with the regulations that caused it to be implemented and is there anything that should be done to ensure continuing compliance in the future?
- On the basis of the ERTMS implementation plan, is TPWS fit for purpose in the long term and likely to remain fit for purpose, given that it may be in operation for some decades to come (beyond its initial life expectancy)?
- Is the industry currently SFAIRP in the areas of risk controlled by TPWS and is it likely to remain so in the future, notwithstanding technical evolution?
- The funding arrangements or proposed funding arrangements for any steps that are recommended should be identified.

The following outlines a summary of the key progress made against these objectives since the inception of the group.

- A detailed risk assessment and cost-benefit analysis to assess the benefits/dis-benefits to be gained from changing the design basis of TPWS to better reflect the emergency braking rate for the trains operating on a particular route has been undertaken. The analysis considered the strategy for both new/modified signalling scheme design as well as routes currently



operating trains with less than 12%g emergency braking. The assessment concluded that no change should be made to the use of 12%g as the design criterion for TPWS and for that Network Rail should continue to apply the design principle that calculates the number of loops necessary to protect 12%g trains, and then optimise the design on a site by site basis to maximise the protection provided by that number of loops, so that it provides better protection for lower braking rate trains that will continue to use the routes into the future (see section 4.1 for more detail).

- The Signal Overrun Risk Assessment Tool is now live and being used part of the Network Rail routine signal risk assessment process. The algorithms for determining the TPWS effectiveness developed as part of the TPWS design basis assessment have been incorporated into the SORAT methodology.
- Network Rail have conducted a half-life assessment of the performance of the track equipment and identify the requirements to ensure that it remains capable of maintaining as a minimum the current level of performance to at least 2050.
- Improvements made to the Safety Management Information System (SMIS) in October 2010 enabled better reporting of TPWS related events during train operations.
- A report assessing the reliability and availability of TPWS has been published. This study concluded that the overall availability of the TPWS system is currently around 99.98% and introduced a new method for monitoring availability.
- Development and update of the train operator specific reset and continue analysis
- Rules were updated
- Guidance on the use of TPWS was published by the Ops standards team
- Work on the ERTMS DMI design was completed

## 2 TPWS Background

In 1994 following the decision by BR (initiated by the Department for Transport and with the agreement of the HMRI) not to retrospectively fit Automatic Train Protection (ATP) across the railway network, the former Railtrack (now Network Rail) set up a project to examine alternative ways of preventing and reducing SPADs, including a more cost-effective method of providing train protection. An output of this work stream was the development of TPWS which was initially trialled in 1997/98. Fitment of TPWS was subsequently accelerated post the Ladbroke Grove Rail accident under regulatory requirements, with the fitment programme being completed during 2003. It was originally envisaged that some 20% of signals would be fitted with a focus on high risk junctions and points of conflict presenting the greatest risk, but as the work progressed there was pressure to increase the number of fitments with around 13,000 signals eventually being fitted (some 42% of the signal network), plus fitment to permanent speed restrictions and buffer stops.

A more detailed description of TPWS, its configuration and the way it is operated is given in Appendix 2.

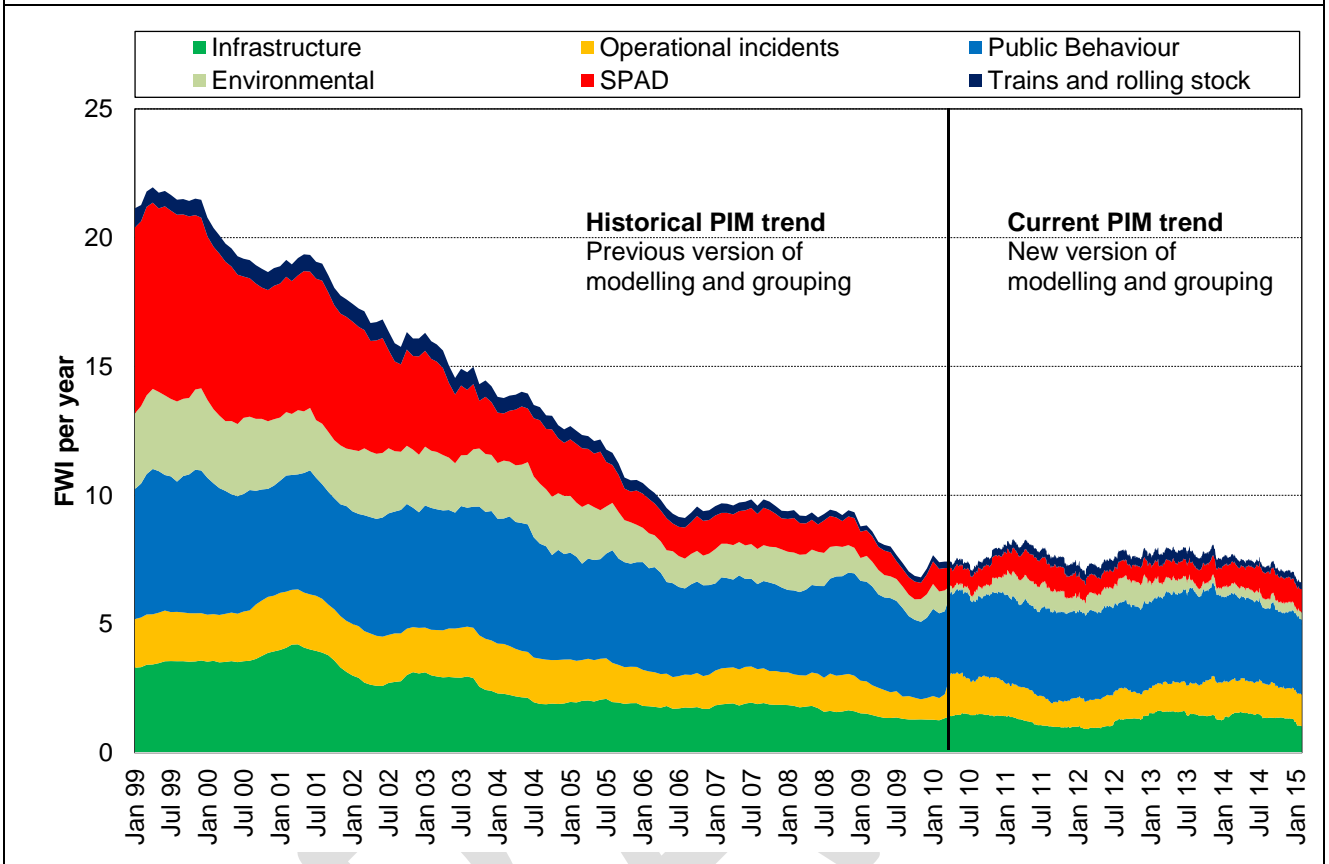
### 2.1 Overall risk from Signals Passed at Danger

Train accident risk is monitored by the industry on an ongoing basis using the Precursor Indicator Model<sup>7</sup> (PIM). The PIM, using outputs from the Safety Risk Model, estimates the relative levels of risk resulting from infrastructure failures, operational incidents, public behaviour, environmental factors, Signals Passed at Danger (SPADs) and failures on trains and rolling stock. The results from the Precursor Indicator Model are shown in Chart 1.

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<sup>7</sup> The risk contributions in the PIM are calculated by quantifying frequency of selected precursor events within the six risk categories times the average consequences of the accidents that the precursor events can cause.

**Chart 1. Trends in train accident risk**



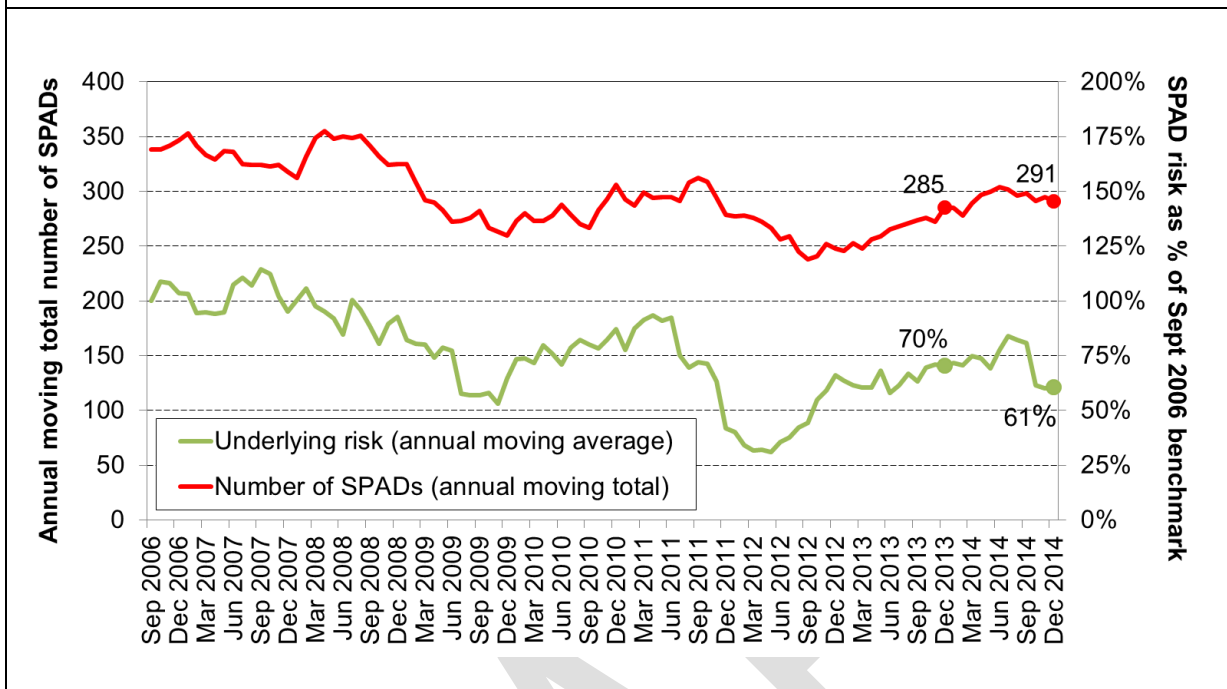
Recent improvement to the data sources and modelling used to produce the PIM have led to a discontinuity in the PIM at April 2010. The trend in the total PIM is unaffected, however trends in PIM sub groups cannot be compared across the discontinuity.

Between January 1999 and January 2006, as a proportion of overall train accident risk, the risk contribution from SPADs reduced markedly. A resurgence in the risk contribution from SPADs has not been observed.

Chart 2 shows the annual moving total of the number of SPADs and the two year moving total of SPAD risk based on the SPAD risk ranking tool<sup>8</sup>.

<sup>8</sup> SPAD risk is estimated using the SPAD Risk Ranking Tool. The tool considers the probability of the train reaching the conflict point, given the actual overrun that occurred, and the consequences should a collision or derailment have occurred, given the type of rolling stock involved, the train speeds and the passenger loadings at the time of the SPAD.

**Chart 2. SPAD risk as of 31 December 2014**



From March 2003 to March 2008 underlying SPAD risk fell by 396%. This marked reduction can be attributed to three major initiatives from the early 2000s: an industry-wide focus on the risk from SPADs; the installation of TPWS at all main aspect signals protecting junctions and the removal of Mark 1 rolling stock. Chart 2 shows that SPAD risk is no longer falling rapidly. SPAD risk for December 2009 and December 2014 is very similar at 53% and 61% of the September 2006 benchmark respectively.

The annual moving total (AMT) for ‘all SPADs’ has been increasing since being observed at 238 at the end of September 2012, the lowest recorded SPAD AMT<sup>9</sup>. At the end of December 2014 the SPAD AMT was 291, a SPAD rate of 0.82 per million train mile. This is a decrease of 25% compared to the SPAD rate of 1.10 per million train mile ten years ago.

## 2.2 Residual risk

With reference to Charts 1 and 2 and Version 8.1 of the Safety Risk Model it can be estimated that the residual risk remaining from the collisions and derailments which TPWS has the potential to influence is 0.66 Fatalities and Weighting Injuries (FWI) per year. The breakdown of this figure is shown in Table 1. This SRM estimate assumes that the current issues relating to reset and continue have been resolved, SRMv9 will be updated to consider how to account for the risk resulting from TPWS R&C events still present. The SRM does, however, account for a residual level of risk resulting from TPWS failing to operate on demand with probability of failure of 0.02

(2%). This covers equipment failures, a nominal level of reset and continue and other driver errors, such as TPWS being incorrectly isolated when the train is in-service.

Table 1.

Type of collision or derailment event	Risk (FWI/yr)
Passenger train SPAD leading to collisions between trains	0.26
Non-Passenger train SPAD leading to collisions between trains	0.18
Passenger train derailment due to overspeeding	0.017
Non-passenger train derailment due to overspeeding	0.0035
Passenger Train SPAD at Level crossing	0.012
Non-Passenger Train SPAD at Level crossing	0.0016
Passenger train derailment due to SPAD at S&C	0.062
Non-passenger train derailment due to SPAD at S&C	0.028
Buffer stop collisions	0.10
Total risk	0.66

**Table 1. Residual risk from collisions and derailments that can be influenced by TPWS**

If we consider that this level of residual risk in the context of the current Value of Preventing a fatality of £1.8m and a similar an average value of around £1.8m per accident for material damage costs for train collisions and derailment, it can be estimated that it would be reasonably practicable<sup>9</sup> to spend around £2.4m per year to mitigate all the risk from these collision and derailment events. Assuming TPWS has a future life expectancy of 25 years at its current level of deployment, the maximum discounted<sup>10</sup> spend today that would be reasonably practicable to mitigate all this risk would be around £40m. Clearly no level of TPWS implementation could mitigate all this risk.

The original cost of TPWS 15 years ago was approximately £560m (£500m for the infrastructure fitment and £60m for the on-train fitment).

It should be noted that the above estimate takes no account of the fitment of ERTMS. As ERTMS is rolled out and sections of line are equipped with ERTMS on both infrastructure and trains, the overall safety benefit being provided by TPWS for the

<sup>9</sup> Based on the ALARP criteria specified in 'Taking Safe Decisions' RSSB 2008

<sup>10</sup> Benefits discounted at 3.5% as per Treasury Green book

network as a whole will diminish<sup>11</sup>. From the analysis carried out to determine the benefit to be gained from addressing TPWS reset and continue it has been estimated that the current ERTMS fitment programme would result in a 12% reduction in the safety benefit to be derived from TPWS over the period to 2032. After 2032 the rate of ERTMS fitment accelerates and therefore the overall safety benefit obtained TPWS will diminish further. The level of expenditure that would be reasonably practicable to spend on TPWS will therefore be lower than the figure quoted above.

Significant change to the ERTMS fitment programme, in particular deferment of substantial elements, would necessitate a review of the conclusions above.

### **3 Compliance with the regulations**

The implementation of TPWS was scoped to deliver compliance with the Railway Safety Regulations 1999 using the interpretations provided in HMRI documentation and Railway Group Standard GE/RT8030 (now superseded by GE/RT8075).

There are currently no known areas of non-compliance with the regulations except where specific exemptions have been granted.

#### **Summary of the strategy for compliance with regulations**

- The industry will ensure that for both new signalling layouts and modifications to existing layouts, TPWS will continue to comply with the requirements of the 1999 Railway Safety Regulations and the relevant exemptions<sup>12</sup>.

### **4 TPWS on the infrastructure**

#### **4.1 Regulated fitment**

The Railway Safety Regulations 1999 required TPWS fitment at the main aspect signals protecting junctions, some permanent speed restrictions (PSRs) and all buffer stops at stations. This section considers the strategy to be applied to the regulated TPWS fitments.

##### **4.1.1 Main aspect signals protecting junctions**

All main aspect signals protecting junctions on the mainline (circa. 13,000) were fitted, in accordance with the 1999 Railway Safety Regulations and the relevant exemptions, as part of the original fitment of TPWS including those with the additional fitment of TPWS+.

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<sup>11</sup> The safety benefit provided by TPWS on the routes not fitted with ERTMS will remain the same.

<sup>12</sup> The ORR expects these regulations to be recalled and replaced in 2015 (ORR, 2015).

Network Rail is responsible for managing the risk at the signals protecting junctions and reducing it to a level that is as low as reasonably practicable. To achieve this Network Rail established, through its company standards, a process for the prevention and mitigation of overruns<sup>13</sup> through the use of the Signal Assessment Tool (SAT) and Detailed Assessment (DA) methodologies. These methodologies consider the current level of risk at each signal taking into account the conditions specific to the signal and considers any modification (including TPWS) that may be reasonably practicable.

To date all signals protecting junctions have been subject to a SAT assessment, and where necessary DA, with all results and conclusions being recorded in a central database. A second round of assessments (as well as assessments for other reasons, such as proposed changes to a layout, a high risk SPAD or timetable changes) were conducted using the SAT.

To further enhance signal risk assessment, Network Rail have now developed the Signal Overrun Risk Assessment Tool (SORAT) that has now replaced the SAT-DA methodologies. SORAT went live in July 2013 and the introduction of it has improved the signal risk assessment process by:

- Improving the algorithms based upon current knowledge and experience to give improved predictions of risk at signals
- Increasing data input automation thereby reducing data collection/input time
- Including the DA questions in the process and improving aspects of TPWS effectiveness (taking account of freewheel time, train braking rates etc, and converting the outputs to Fatalities and Weighted Injuries)
- Removing the need to hold DAs for signals identified as requiring assessment by:
  - Using the standards now in place to design the layouts to reduce the probability of SPAD and consequences
  - Including the DA questions in the signal sighting process to identify any issues that would increase the probability of a SPAD and managing them as part of the signal sighting process instead of having an additional review meeting to discuss the same issues.
  - Involving the stakeholders both internal to Network Rail and external in the process from the outset and holding a final review meeting with key

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<sup>13</sup> Network Rail Company Standard 'Prevention and mitigation of overruns – risk assessment of signals' NR/L2/SIG/14201 Issue 2 August 2008

stakeholders to agree that the risk has been reduced to a level that is as low as reasonably practicable.

This process will provide confidence on an ongoing basis that the risk presented by all the individual main aspect signals protecting junctions is assessed and mitigating actions, which may include changes to TPWS, are taken to ensure risk is reduced to a level that is SFAIRP.

### **Additional ALARP considerations for main aspect signals protecting junctions**

The original design basis for TPWS assumed that all trains operating on the network have an emergency braking rate of 12%g. This assumption defines the positioning of the TPWS OSS loops and the safe overrun distance achievable at each signal. It is known that a significant percentage of trains, particularly on the higher speed routes above 100 mph, have emergency braking rates less than 12%g such that for these trains TPWS does not provide the highest level of protection that could be achieved.

As part of the development of the TPWS strategy, a detailed risk assessment and cost-benefit analysis was initiated by RSSB to assess the benefits/dis-benefits to be gained from changing the design basis of TPWS to better reflect the emergency braking rate for the trains operating on a particular route. The analysis considered the strategy for both new/modified signalling scheme design as well as routes currently operating trains with less than 12%g emergency braking.

The analysis has shown that where TPWS fitments at main aspect signals protecting junctions are modified to provide the same level of protection for trains with less than 12%g emergency braking, as that currently provided for trains with 12%g emergency braked trains, there would be:

- Safety benefit for all trains using the modified signals, including trains with 12%g or higher emergency braking rates
- Little or no operational performance dis-benefit
- A reduction in the number of SPADs particularly where higher emergency braking rate trains use the modified signals
- A small increase in track worker risk

The cost of the modifications would be less within new scheme designs (£7,000 per signal) than for existing signal locations (£20,000 per signal). The benefit to cost ratio for changing the design criteria for all new schemes designs to 9%g emergency braking is around 0.3 and it is therefore not considered to be reasonably practicable to adopt 9%g as a national design criterion for TPWS for all new scheme designs. It is very likely that it would be reasonably practicable to modify some individual signals within new scheme designs to better reflect the emergency braking rates of the trains that will continue to use the signals into the future.

The benefit to cost ratio for modifying all existing TPWS fitments at signals protecting junctions to 9%g emergency braking is around 0.1 and it is therefore not considered to be



reasonably practicable to adopt 9%g as a national policy. It is very likely that it would be reasonably practicable to modify some individual existing signals to better reflect the emergency braking rates of the trains that will continue to use the signals into the future.

## **Recommendations**

From the analysis and conclusions above the TPWS Strategy Group made the following recommendations, which were endorsed by the V/TC&C SIC at their meeting on 16 February 2011. These have been published in Guidance Note GE/GN8675:

1. For new scheme designs, taking due account of future ERTMS fitment:
  - a. Network Rail to continue to apply the design principle that calculates the number of loops necessary to protect 12%g trains, and then optimise the design on a site by site basis to maximise the protection provided by that number of loops, so that it provides better protection for lower braking rate trains that will continue to use the routes into the future.
  - b. Network Rail to use the development of the TPWS effectiveness calculator within the SORAT process and apply it on a signal by signal basis to new scheme designs to determine if it would be reasonably practicable to implement an extra OSS loop based on the improvement in the effectiveness (and hence the potential safety benefit) it delivers.

Network Rail will demonstrate to the TOCs that they have applied these principles when undertaking the joint review of signalling scheme plans prior to their final approval.

2. For existing signals:
  - a. Following the provision of the necessary signalling asset data and train usage data from Network Rail, RSSB to supply Network Rail with a risk ranked list of signals for which it may be reasonably practicable to consider modifications to the TPWS set-up at that signal.

As part of Network Rail's five year review programme for each junction signal (prioritised based on the RSSB risk ranked list) and taking due account of future ERTMS fitment:

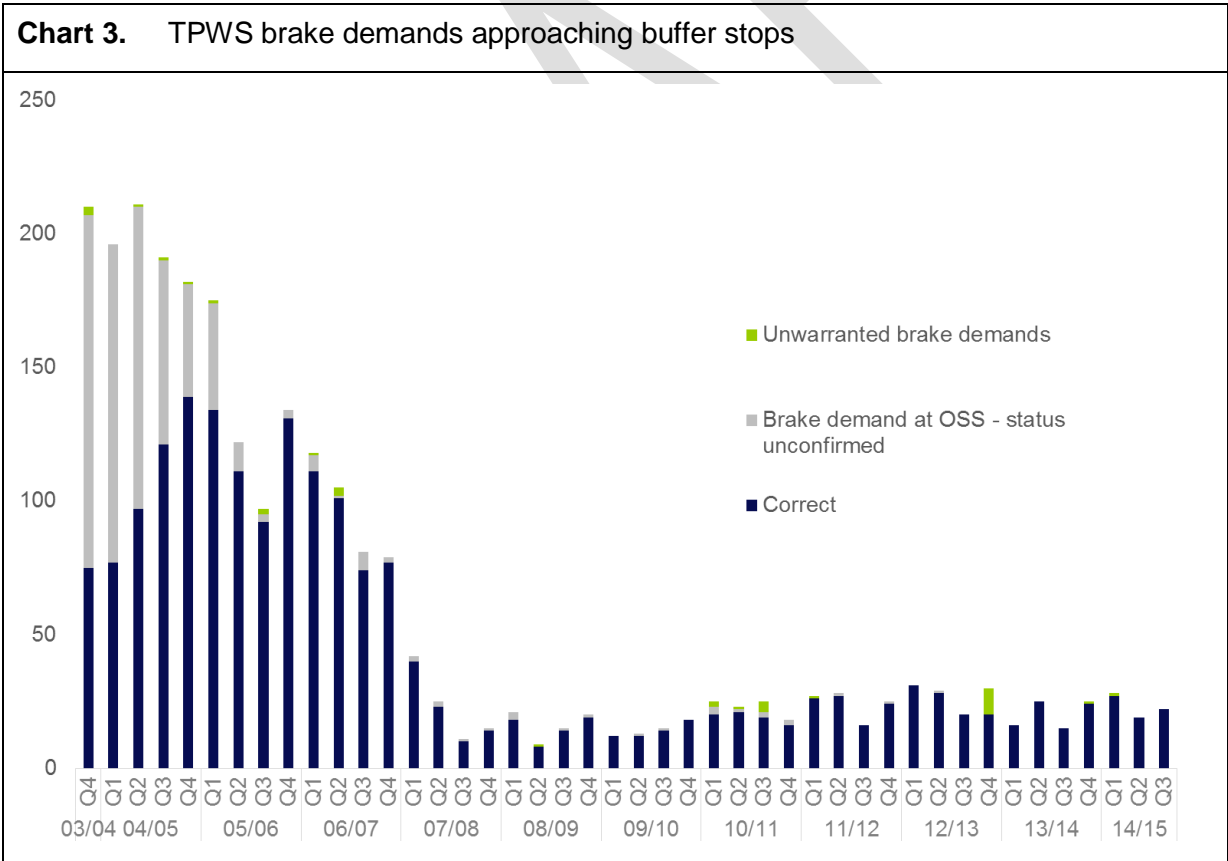
- b. Use the development of the TPWS effectiveness calculator within the SORAT process and apply it to determine if it would be reasonably practicable to implement an extra OSS loop based on the improvement in the effectiveness (and hence the potential safety benefit) it delivers.

## **Summary of the strategy for main aspect signals protecting junctions**

- Continue with the application of the SORAT signal risk assessment process, taking account of the recommendations from the TPWS design criteria assessment, to main aspect signals protecting junctions to provide assurance that the risk is ALARP.

**4.1.2 Buffer stops**

Since TPWS fitment at buffer stops was completed there have been two major changes to these TPWS fitments. The first change was associated with changing the TPWS loops for a smaller ‘mini-loop’ design to reduce the number of incorrect brake demands due to field distortion. The second change took place in 2007 when, following a detailed risk assessment and cost-benefit analysis, Network Rail initiated a programme of work to modify the TPWS margin to trip at the 660 buffer stop sites to enable trains to approach the buffer stops at an indicated 10 mph 50m from the buffers stops and reduces the number of unnecessary TPWS brake demands while retaining the majority of the safety benefit provided by TPWS. This project has now been completed and the number of TPWS brake demands at buffer stops has been reduced significantly as shown in Chart 3.



From Version 8 of the Safety Risk Model the current level of residual risk at buffer stops that could be influenced by TPWS is estimated to be low at 0.10 FWI/year.

With only a small level of residual risk remaining and a minimal level of unnecessary TPWS brake demands it is not considered reasonably practicable to pursue any further modifications to TPWS at the 660 buffer stop locations.

### **Summary of the strategy for buffer stops**

- No further change is currently foreseen to the configuration of the TPWS fitments on the approach to buffer stops.

#### **4.1.3 Speed restrictions**

TPWS was originally conceived as a train collision mitigation tool for use in reducing the severity of SPADs and subsequent accidents. TPWS was not initially intended to provide protection from overspeeding. However it was subsequently suggested that TPWS could also be used to mitigate the risk from train derailment caused by overspeed at locations other than signals. As a result the 1999 Railway Safety Regulations included the requirement to fit TPWS overspeed sensors to:

- a) all PSRs where the normal speed is greater than or equal to 60 mph and there is a required reduction of 1/3 or more to the permitted speed through the PSR
- b) Temporary Speed Restrictions (TSRs) with similar speed reduction requirements as PSRs and which have been in operation for greater than 3 months<sup>14</sup>

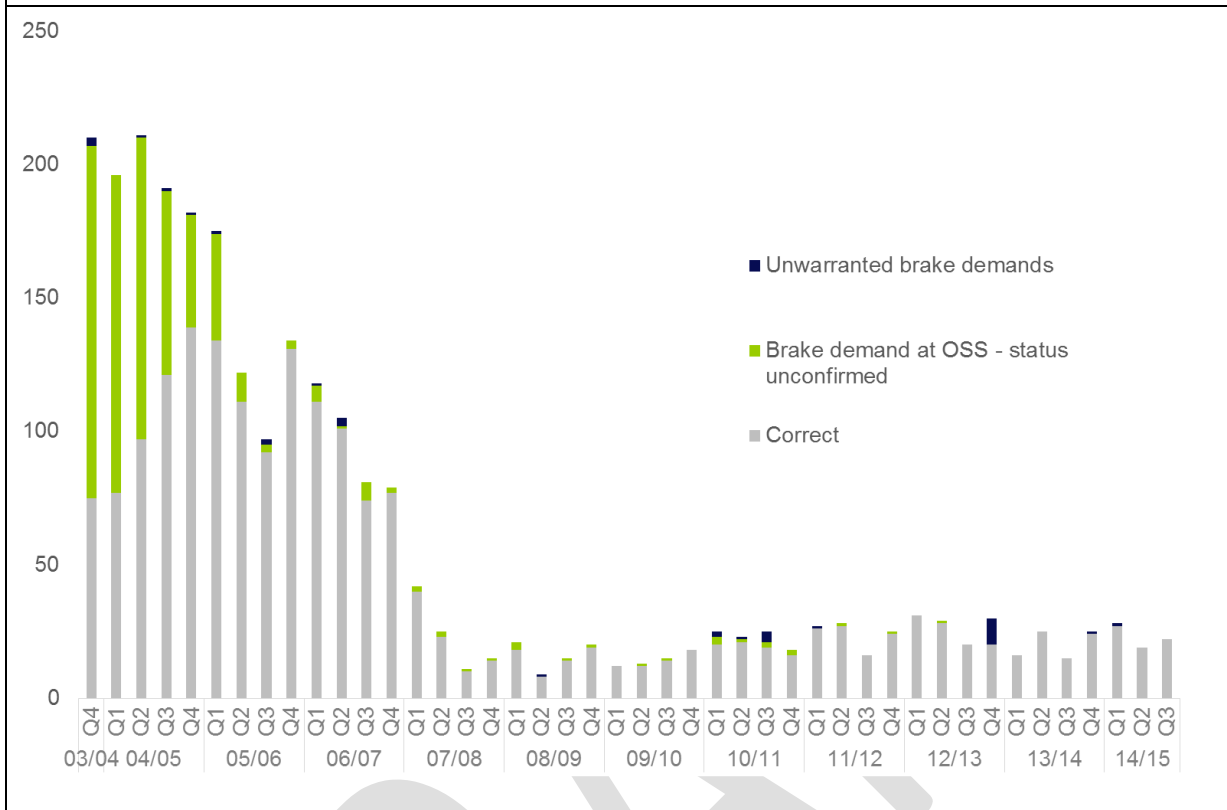
This resulted in the mandatory fitment of TPWS to around 1150 PSRs and 50 TSRs

The TPWS concept works well on the final approach to a signal at danger where there is a common expectation of a gentle brake application to bring the train to a halt just before the signal. Such a 'one size' concept does not work well when there is a wide range of different variables affecting the 'acceptable speed on approach', as is the case with the application of TPWS at PSRs. This has resulted in many occasions per month when unnecessary TPWS brake demands occur due to incompatibility with the rolling stock using the route as shown in Chart 4 below.

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<sup>14</sup> TSRs which have been in operation for up to 12 months are currently exempt from the Regulations.  
TPWS\_Strategy\_Issue 2\_draft\_1.doc 19

**Chart 4. TPWS brake demands approaching PSRs**



From Version 8.1 of the Safety Risk Model the current level of residual risk associated with over speeding is estimated to be low at 0.02 FWI/year, only a proportion of which occurs at the PSRs fitted with TPWS.

Of more concern has been the high number of unnecessary TPWS brake demands having a detrimental effect on the perception of TPWS and the possible link between this and the propensity for the driver to reset and continue following a category A SPAD.

In 2005/06 a large amount of analysis work was done which concluded that:

- a) To have a significant effect on the propensity for reset and continue the number of unnecessary TPWS brake demands at PSRs would have to be reduced by more than 50%.
- b) The TPWS fitments at up to 400 PSRs could be removed at PSRs where the cant deficiency was less than 11.5°, thereby significantly reducing the number of unnecessary TPWS brake demands.

Following this extensive analysis work an exemption from the 1999 Railway Safety Regulations for PSRs on plain line curves that do not have switches and crossings (S&C) within the curve and have a cant deficiency of less than 11.5° was granted by

the ORR. Subsequent work based on detailed asset data by Network Rail indicated that in reality only a small number of PSRs on such plain line curves meet the specification for removal. This conclusion also applies to the TPWS fitments at PSRs on plain curves in which S&C are located that were part of the original analysis but not included in the exemption by the ORR. The data in Chart 4 indicates that in the time since the original analysis work the average number of PSR brake demands per month has reduced by 39% from 59 per month (two year period January 04 to December 05) to 36 per month (two year period November 12 to October 14). This has resulted from Train Operator/driver awareness of vulnerable sites and altering driving styles accordingly. With a lower average monthly rate the likelihood of achieving further significant reductions in the number of unnecessary brake demands at TPWS fitments on plain line curves decreases.

The only other category of PSRs which offers the potential for removal is the 184 asset protection PSRs (category J(ii)). However there is no evidence that these types of PSR are the cause of multiple unnecessary TPWS brake demands and therefore their removal does not present an opportunity for a significant reduction in the number of unnecessary TPWS brake demands.

It is therefore concluded that there is little scope for the removal of TPWS fitments from these categories of PSRs that would lead to a greater than 50% reduction in the number of unnecessary TPWS brake demands at PSRs. It is therefore considered that the programme for the removal of TPWS fitments at these PSRs should not be progressed further as part of the strategy for TPWS.

It is noted, however, that the exemption relating TPWS fitment at PSRs on plain line curves continues to apply to new or remodelled lines providing the cant deficiency is less than 11.5°.

The strategy is now focussed on a programme to monitor the unnecessary brake demands at PSRs (multi-trip sites on the network with three or more trips in one year) and optimising the fitment of the TPWS to minimise the propensity for unnecessary TPWS brake demands.

### **Summary of the strategy for speed restrictions**

- Network Rail will cease to progress the removal of TPWS equipment at plain line curves where it was previously believed they may fall within the exemption criteria.
- No further submissions will be made to the ORR to extend the nature of the exemption to:
  - a) embrace plain line curves in which S&C are located, or
  - b) seek the removal of equipment at the asset protection (Category J(ii)) sites

- Network Rail will continue to focus on a programme to monitor and optimise the TPWS installations at multi-trip sites on the network (three or more trips in one year) to minimise unnecessary TPWS brake demands.

## **4.2 Unregulated fitment**

For all types of signal fitment for which TPWS fitment is not required by the 1999 Railway Safety Regulations there is an ongoing review of the number of SPADs and risk ranking scores derived from SPADs, together with the outcomes of accident/incident investigations, to identify potentially higher risk signals. Where appropriate Network Rail subject these signals to a defined signal risk assessment and cost-benefit analysis methodology to determine if it is reasonably practicable to fit or modify TPWS at the signal or apply or modify other control measures. If such analyses demonstrate that TPWS fitment is reasonably practicable for a particular signal, Network Rail will also ensure that the implications for similar signals are considered.

Some specific cases of unregulated signal fitment are discussed below.

### **4.2.1 Plain line signals**

There are around 17,000 to 18,000 plain line signals on the network which were not required to be fitted with TPWS as part of the 1999 Railway Safety Regulations.

The underlying level of risk at plain line signals is around 0.29 FWI/year. However the Cullen - Uff Inquiry after the accident at Ladbroke Grove required the industry to consider fitment of TPWS to plain line signals.

In 2006 Network Rail reviewed methodologies for identifying the characteristics of plain line signals that would make them higher risk plain line signals. It was found to not to be possible to identify classes of plain line signals that should be fitted. In consultation with the Train Operators a small number of signals were identified and these have been fitted with TPWS.

If the fitment of TPWS requires both an OSS and a TSS the cost per fitment will be around £25,000 per signal. Given the current level of risk from plain line signals of 0.29 FWI/year this would justify the fitment to around 630 signals assuming that all the residual risk at plain line signals that could be influenced by TPWS is mitigated, which would clearly not be the case. With this low level of safety benefit and the earlier work done by Network Rail it has been concluded that it will not be possible to identify general classes of plain line signals that could be proposed for TPWS fitment and therefore no general fitment strategy will be pursued. However, in certain locations, modular signalling may provide a TSS as part of the fitment.

### **Summary of the strategy for plain line signals:**

- It is not anticipated that any general classes of plain line signals will be fitted with full TPWS, however modular signals may provide a TSS.
- The ongoing monitoring and assessment strategy outlined in Section 4.2 above will apply

#### **4.2.2 Signals protecting level crossings**

At certain types of level crossings such as manually controlled gate and barrier crossings and AOCL and ABCL crossings signals provide protection to the crossings by preventing the train reaching the crossing before the crossing is closed to the road. The current level of risk from signals protecting level crossings is 0.014 FWI/year.

If the fitment of TPWS requires both an OSS and a TSS the cost per fitment will be around £25,000 per signal (£50,000 per twin track level crossing). Given the current level of risk from level crossings signals SPADs of 0.014 FWI/year this would justify the fitment to around 15 twin track level crossings assuming that all the residual risk at level crossing signals is mitigated, which clearly would not be the case. With this low level of safety benefit it has been concluded that it will not be possible to identify general classes of signals protecting level crossings that could be proposed for TPWS fitment and therefore no general fitment will be strategy will be pursued.

A RSSB research project (T1007) is underway as of 2014 to develop a model to assess SPAD risk at signals protecting level crossings, including the use of TPWS where appropriate. The tool will use inputs from SORAT and ALCRM, along with other data sources to estimate the SPAD risk at specific level crossings.

### **Summary of the strategy for signals protecting level crossings:**

- It is not anticipated that any general classes of signals protecting level crossings will be fitted with TPWS.
- The ongoing monitoring and assessment strategy outlined in Section 4.2 above will apply
- T1007 will produce a methodology for analysing SPAD risk at signals protecting level crossings.

#### **4.2.3 Other types of signals**

There are a number of other types of signals/signal locations for which TPWS fitment may be reasonably practicable such as:

- Ground position lights protecting access onto main lines

- Limit of Shunt Signals to prevent trains running away in the wrong direction.
- Other shunting signals which act as a Limit of Shunt.
- Plain Line 'Outer Signals' where the TPWS is part of the 'higher speed' intervention arrangement for an 'Inner Signal' immediately protecting a junction.
- Junction directing signals where there is a possibility of a train running away into a siding or other place where trains may be stabled.
- Junction directing signals where, when there is no route set the though junction, where there is the possibility of a train running away to collide with another train standing waiting to use the junction in the opposite direction.
- Provision of additional TSS (which may be timed) or an additional OSS (where appropriate) at Platform Starting signals where either no overlap exists or the overlap has timed off.

### Summary of the strategy for other types of signals

- It is not anticipated that any other general classes of unregulated signals will be fitted with TPWS.
- The ongoing monitoring and assessment strategy outlined in Section 4.2 above will apply.

## 4.3 Reliability of infrastructure equipment

The availability of track based equipment has been calculated at 99.94% from an in depth analysis using data obtained from the Network Rail Failure Management System (FMS) for the period 1<sup>st</sup> July 2007 to 28<sup>th</sup> February 2008.

A simpler analysis of more recent data was undertaken, A total of 15156 records, for the period 1<sup>st</sup> January 2009 to 31<sup>st</sup> December 2014, were assessed. The breakdown in results was as follows:

<b>Fault diagnosis</b>	<b>Qty % of total</b>	
Modules	<b>7848</b>	51.82%
No Fault Found (NFF) including vehicle faults not confirmed	<b>3656</b>	24.14%
Train faults confirmed	<b>176</b>	1.16%
Loop faults	<b>1032</b>	6.81%
Cable faults	<b>724</b>	4.78%
Other	<b>1710</b>	11.29%
<b>Total</b>	<b>15146</b>	<b>100.00%</b>

Modules – In total there are five modules used on TPWS these are:

1. Power Supply and Interface Module (sometimes referred to as a SIM)
2. Overspeed Sensor Unit – Normal direction
3. Train Stop Unit – Normal direction
4. Overspeed Sensor Unit – Wrong direction
5. Train Stop Unit – Wrong direction



It is not possible to break down the module category to individual module types because of the way that data was entered onto the FMS system. For example for a TPWS system fault a module may be identified as faulty but the record does not always identify which type of module or which part of the system.

NFF – This means that the installation was fully tested showing no fault.

Loop and Cable faults – These are predominantly damage, vandalism or theft. Most damage occurs during of track possessions.

Others - Covers a very wide range of miscellaneous faults from lightning strikes through to the failure of controlling equipment and circuits.

A less detailed assessment of module repairs shows that the majority returned to the manufacturer (<65%) were found to be in good working order. In some cases they will have been removed as a precaution (e.g. when several incidents are reported at the same signal but no fault is identified by testing). In many cases they are likely to be the result of a poor contact at the plugboard connection.

Where trends can be established Network Rail will instigate investigation of the failure mechanism.

Records of TPWS Interventions and Activations following Category A SPADs over the period January 2002 to April 2013 show that a total of 1,770 Category A SPADs have occurred where TPWS was fitted to both the train and the signal where TPWS should have initiated a brake demand. Out of these, the system was noted not to operate as it should have done on five occasions. Three of these were associated with infrastructure issues and two with in-cab equipment.

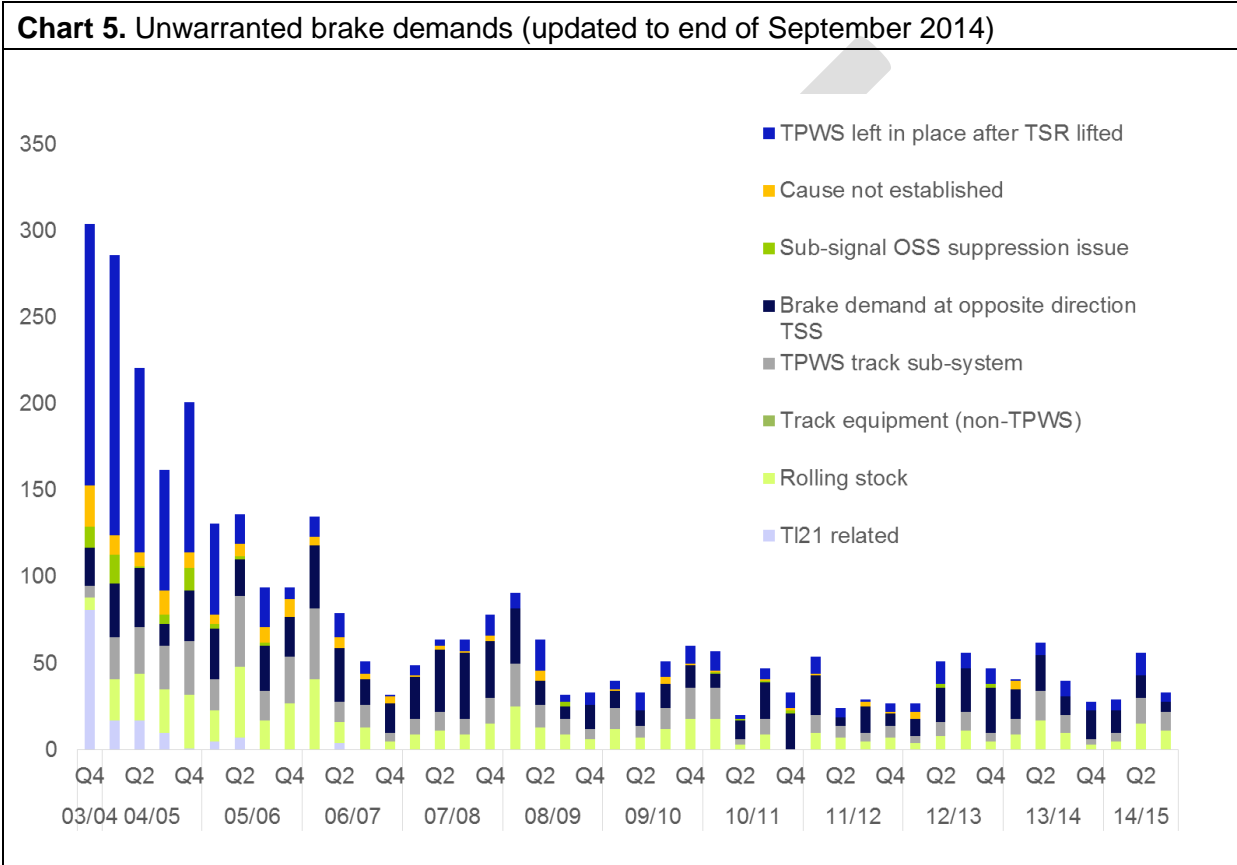
Of the three infrastructure events:

1. One was due to an S&T team member incorrectly removing a fuse.
2. One was due to power failures resulting in the signal being blank and TPWS not being available at that signal.
3. One was cause unknown.

Given that the system design is such that TPWS will not work when a signal is blank and the incorrect removal of a fuse is not a system failure, the probability of an undetected, infrastructure system failure *on demand* is  $1/1,770 = 0.0006$ , indicating an unavailability of around 0.06%, which is less than the 0.1% unavailability requirement for the track sub-system required by Railway Group Standard GE/RT8075. Given that only one undetected equipment failure was recorded, the statistical significance of the estimate is low, but it is indicative of good performance in response to 1,770 demands related to Category A SPADs.

An estimate of the unavailability of the track based TPWS equipment can also be made from an analysis of Network Rail's FMS data. Using data from 2009 to 2014, the analysis indicated that the likely level of unavailability being achieved is actually around 0.003%, which is much less than the 0.1% unavailability requirement.

Chart 5 below shows the number of unwarranted brake demand resulting from both track based equipment and rolling stock.



The strategy for maintaining the reliability of the TPWS track based equipment will be for Network rail to continue to monitor the reliability of the equipment and respond where appropriate to meet the requirements in GE/RT8075.

Network Rail will consider the feasibility of using its fleet of track measurement trains to detect damaged, displaced and missing TPWS track equipment on main routes.

The industry will cooperate to improve reporting and monitoring of TPWS component failures, including the development of a Defect Recording and Corrective Action system (DRACAS).

## **Summary of the strategy for infrastructure based equipment reliability:**

- Network Rail continuously review the TPWS infrastructure equipment reliability data and failure modes considering both wrongside and rightside failures. These reviews will also seek to reduce the underlying causes behind no fault found reports. This will require co-operation with the train operators on investigating unresolved incidents.
- Network Rail will consider the feasibility of using its fleet of track measurement trains to detect damaged, displaced and missing TPWS track equipment on main routes.
- The industry will cooperate to improve reporting and monitoring of TPWS component failures, including the development of a Defect Recording and Corrective Action system (DRACAS).

### **4.4 Obsolescence of infrastructure equipment**

The TPWS equipment is likely to have to remain in-service for the next 25 to 35 years. Obsolescence of track based equipment over this period is likely to be an issue. The manufacturers of the track based equipment Thales have provided evidence that they have adequate company processes in place to manage obsolescence and mitigate its consequences before it would impact on the reliability and availability of the equipment on the network.

Network Rail has in place a process to warn of impending obsolescence issues. Stocks of spare parts at both Network Rail and Thales are considered to be adequate to enable availability of the system to be maintained. The control of changes required as a result of obsolescence will be carried out using the “Product Introduction and Change” procedure NR/L2/EBM/029. This is a well established and robust process capable of assessing changes at component, replacement unit or at system level.

### **4.5 Information available on infrastructure based TPWS equipment**

When TPWS was first established the TAMAR database was developed to record all the information relevant to TPWS fitments at signals, PSRs and buffer stops. On completion of the TPWS project the use of database ceased. There is now no central source of information available for track based TPWS equipment which can be accessed and easily read by persons without specialist railway knowledge. Currently, the repository of the as built information on lineside signal assets are the signalling plans – and this includes all TPWS track assets. In addition, information on track based assets is available from surveys from Network Rail’s Measurement Train.

Network Rail is committed to having readily available definitive data for all of its assets. As such 'asset information' is considered to be an asset in itself. During CP5, Network Rail will establish a reliable and unique repository for all relevant asset information, which will be capable of being used in a variety of scenarios including: cost benefit analysis, safety related failure analysis, etc. This will include asset information relating to the as built status of signal assets. This work is being carried out under the ORBIS programme.

See also the comments on DRACAS in section 4.3

## **4.6 Infrastructure equipment configuration control**

Network Rail controls the configuration of TPWS equipment through the standard "Product Introduction and Change" NR/L2/EBM/029. Both new product and changes to current approved products are controlled through this process. On completion of the process a certificate is issued, or re-issued, detailing the production issue status of each item. Network Rail works closely with suppliers to ensure that only conforming product is supplied to the railway. When changes take place they are introduced in a controlled manner with information disseminated to all levels of the organisation as appropriate to that change. All TPWS installations are in accordance with this standard.

## **4.7 Relationship of TPWS infrastructure equipment with ERTMS**

The relationship of TPWS with ERTMS is more of an issue for the on-train equipment which is discussed in Section 5.7 below.

There is no direct functional interaction between the track based TPWS and ERTMS equipment as TPWS equipment will not generally be installed on ERTMS routes, except in the case of dual equipped routes which are intended to allow the passage of both ERTMS fitted and non ERTMS fitted trains. In this case, ERTMS fitted trains will not respond to track based TPWS equipment when they are operating in ETCS Level 1, 2 or 3. However, ERTMS fitted trains will respond normally to TPWS track based equipment if they are unable to proceed normally and must fall back to Level 0 or Level STM operation.

The TPWS/AWS and ERTMS track to train coupling mechanisms use entirely different transmission techniques which are widely separated in terms of carrier frequency and modulation method. There are no known compatibility issues between the TPWS/AWS track equipment and ERTMS:

- The only element of the ERTMS/ETCS system installed in the track is the Eurobalise transponder (balise). These are normally installed in groups of two or more at approximately 1km intervals. The Eurobalise is an entirely passive

device and is only able to transmit in response to energy received from the 27MHz telepowering signal from the trainborne Eurobalise antenna. Hence, there is no risk of interference to the TPWS/AWS equipment on trains not equipped with ERTMS. .

- The train borne ERTMS equipment is not expected to experience any interference problems from the TPWS/AWS trackside loops and magnets. There are no specific minimum proximity requirements applicable to the trackside TPWS/AWS and ERTMS equipment.

Although there is no functional interaction between the two systems, there are some practical installation constraints which need to be taken into account. The first obvious limitation is that it will not be possible to physically co-locate Eurobalises with existing TPWS loops and AWS magnets on dual equipped routes. In general, Eurobalises can be installed at any convenient location as the information they contain can be offset from the location where the information is intended to acted upon. Hence, a Eurobalise can be installed on the approach to a given geographic feature as the corresponding distance to run to the particular feature is coded as part of the Eurobalise telegramme. The only exception to this general principle is the case of switchable balises in ETCS Level 1 applications which must be installed within specified distance limits of the associated signal replacement train detection boundary (block joint/axle counter). Some restrictions may also apply to the location of balises used to enforce ERTMS shunting limits. Additional restrictions are also applicable in relation to proximity of Eurobalises to check rails and large metallic objects between the running rails, e.g. bridge structures.

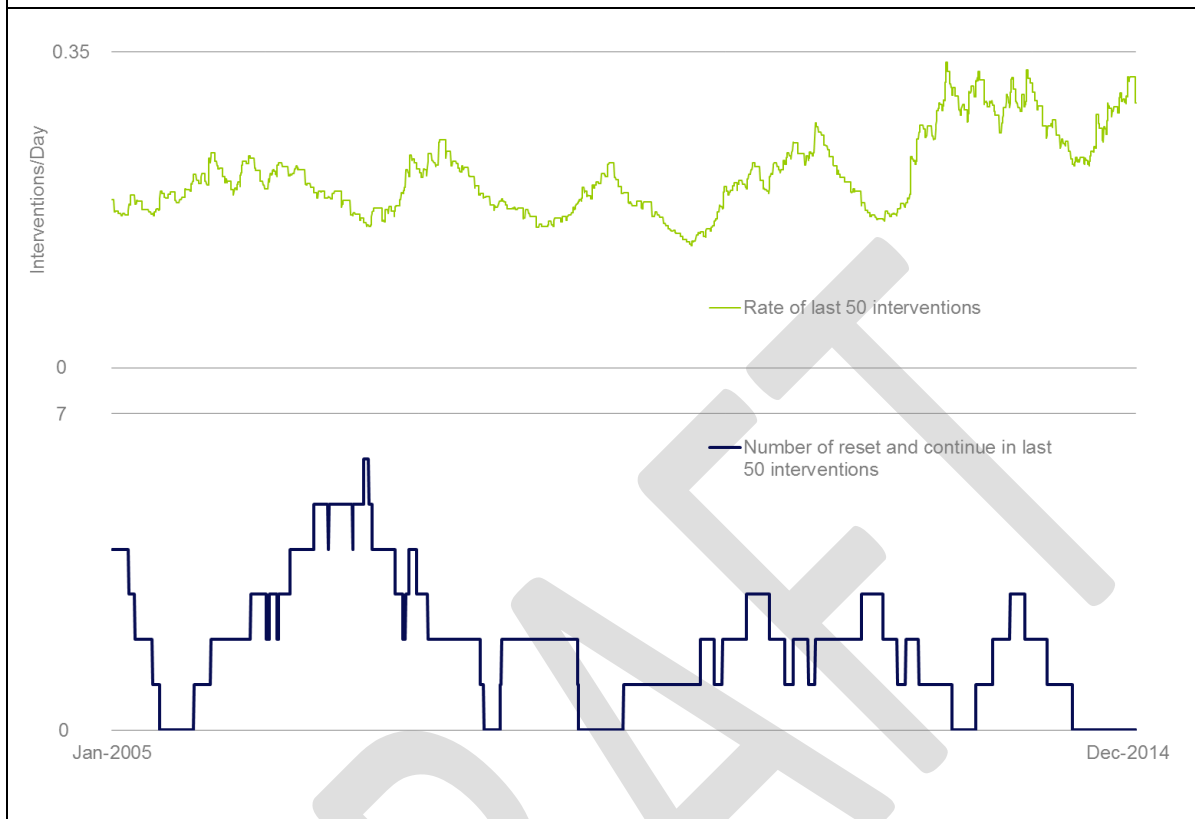
## 5 TPWS on the trains

As noted in Chart 1 TPWS has played a significant role in reducing SPAD risk over the last 12 years. However TPWS reset and continue remains an outstanding issue for the train, freight and on-track machine operators. There are also outstanding issues relating to the identification of TPWS faults while the train is in-service, the reliability of train borne equipment, and the obsolescence of the train borne equipment.

### 5.1 Reset and continue

From the time TPWS was commissioned to the end of 2014 there had been 41 reset & continue events following 929 category A SPADs where TPWS has intervened and stopped a train in absence of train driver action. However the profile of occurrence has not been uniform. Chart 6 shows the number of the last 50 TPWS interventions following Category A SPADs that were reset and continue events, and the rate of the previous 50 interventions.

**Chart 6.** Number of recorded TPWS 'reset and continue' events (updated to end of 2014)



The average rate of interventions from January 2005 to December 2014 has been 0.20 interventions a day. On 31 December 2014 the last 50 interventions had occurred at a rate of 0.29 a day. It is worth noting that whilst the rate of interventions has been higher over the last two years the total number of TPWS brake demands has remained relatively constant as the number of activations has decreased.

A working group led by ATOC considered potential solutions for addressing reset and continue for both new trains and existing trains. The analysis of the options indicated that while for new trains the incremental cost of using a modified TPWS Driver-Machine Interface (DMI) would be minimal, for existing trains it would not be reasonably practical to carry out such modifications. The decision relating to existing trains was made individually by each company taking into account their own circumstances and business case.

This analysis has been updated to take account of updated costs and any changes to the risk profile to enable train operators and the industry to re-evaluate whether it is cost-beneficial to retro-fit the Mk3 or Mk4 TPWS unit to their fleets.

### 5.1.1 New trains

The design of the TPWS DMI for new trains has been incorporated into a Railway Group Standard GE/RT8075. This standard addresses the issue of interfacing TPWS with on-train ERTMS equipment.

#### **Summary of the strategy for addressing reset and continue on new trains:**

- The DMI on all new trains that are required to operate on TPWS fitted lines, will incorporate the new TPWS '3 indicator light' functionality that is specified in Railway Group Standard GE/RT8075.

### 5.1.2 Existing trains

As the fitment of a modified design of TPWS DMI for existing trains was shown not to be reasonably practicable it was an individual company decision whether to incorporate the change or mitigate the risk in other ways.

TOCs will continue to place emphasis on driver training and briefing to raise awareness of reset and continue and its potential consequences, see Section 6 below

#### **Summary of the strategy for addressing reset and continue on existing trains:**

- RSSB and the train operating companies will re-evaluate whether the TPWS DMI on existing trains should be modified to incorporate improved functionality as described by GE/RT8075.
- Where trains are upgraded to include ERTMS consideration should be given to incorporating the TPWS '3 indicator light' functionality that is specified in the Railway Group Standard GE/RT8075.

## 5.2 TPWS timer settings

One option considered by the strategy group for improving the performance of the TPWS at signals and speed restrictions was altering the TPWS timer settings onboard the trains with an emergency braking performance less than 12%g such that the trains would have to approach the OSSs slower thereby limiting the overrun following a SPAD.

Altering the timer settings on the trains with an emergency braking rate less than 12%g would require different driving styles for different types of stock which is against the current philosophy of driving policies within the TOCs. Given that slower approaches would also have to be made to PSRs and buffer stops it was considered that there would be the potential for a significant effect on performance. It was also considered that there may be a negative impact on safety as drivers of the trains with less than



12%g emergency braking trains would inevitably encounter more TPWS trips, particularly initially, and could therefore lose faith in the system leading to the potential for more reset and continue events.

While altering the timer settings would provide additional protection at the Signal Train Stops, PSRs and buffer stops, it would not provide any additional overspeed protection at signal OSSs. The current (12%g) speed setting for OSSs on lines with train speeds greater than 100 mph is 46 mph and this provides protection for overspeeds up to 75 mph where there is a Safe Overrun Distance of 200m. For a 9%g emergency braked train the equivalent overspeed protection would be around 65 mph. If the timer settings were altered for a 9%g emergency braked train the OSS setting would effectively reduce to around 40 mph but the overspeed protection would remain at 65 mph as the OSS remains in the same position.

In addition to the above there would need to be controls in place to ensure that the right train had the right timer settings.

It was also considered the potential for trains with emergency braking rates better than 12%g to have different timer settings so they could approach signals, PSRs and buffer stops faster than the standard, giving a potential performance gain. As for the poorer braked trains this would require a different driving style and would reduce the current level of safety provided for these trains at signals, PSRs and buffer stops. It was not thought that the performance gain would be sufficient to justify the proposal.

Given the above factors altering the train timer settings is not a viable option and will not be progressed as part of the TPWS strategy.

### **5.3 Reliability of train equipment**

On-train TPWS equipment is currently provided by three suppliers namely Thales, Unipart and STS Rail. Thales have by far the largest share of the fitments accounting for some 95% of cabs.

There is no central source of reliability information relating to on-train equipment, see Section 5.5, which can be used to determine the overall reliability of this equipment. However information obtained from the manufacturers suggests that in relation to equipment returns, which have been confirmed to have a fault, the on-train TPWS control units have achieved a Mean Time Between Failure (MTBF) of around 40,000 hours. Thales has also predicted that their new Mark 3 control unit will have improved reliability with an MTBF of around 80,000 hours.

Records of TPWS Interventions and Activations following Category A SPADs over the period January 2002 to April 2013 show that a total of 1,770 Category A SPADs have occurred where TPWS was fitted to both the train and the signal where TPWS should have initiated a brake demand. Out of these, the system was noted not to operate as it should have done on five



occasions. Three of these were associated with infrastructure issues and two with in-cab equipment.

Of the two in-cab events:

1. One occurred when TPWS was isolated following failure of the AWS button.
2. One occurred when TPWS was isolated following a TPWS aerial failure.

In both cases, the failure had already been detected and the equipment had been isolated when the SPADs occurred so should not be classified as a TPWS system failure on demand.

Based on this data, the probability of an undetected, in-cab system failure on demand is likely to be less than  $1/1,770 = 0.0006$  (0.06%), which is less than the 0.1% unavailability requirement for the train sub-system required by Railway Group Standard GE/RE8075. Given that no undetected failures were recorded, the statistical significance of the estimate is low, but it is indicative of good performance in response to 1,770 demands related to Category A SPADs.

The TPWS reliability and availability study (RSSB, 2015) concluded that the unavailability of the on-board TPWS equipment due to control units failures is around 0.01% which is lower than the 0.1% system requirement. This low figure is derived from the fact that the system is tested on average about every 4 hours when a cab power up test is initiated. However it should be noted that other failures such as aerial failures are not included in this data. It would take of the order of 3 failures per year per cab for the system not to meet its availability requirement.

Chart 5 shows the current level of unwarranted TPWS brake demands based on rolling stock faults.

### **Summary of the strategy for addressing reliability of on-train TPWS equipment**

The strategy for the ongoing monitoring of the reliability of the on-train equipment will be the primary responsibility of the train operators to ensure the requirements of GE/RT8030 are met. The V/TC&C Technical Subgroup and the manufacturers will also review TPWS reliability. The strategy will be to:

- Continuously review TPWS on-train equipment reliability data and failure modes considering both wrongside and rightside failures.
- When TPWS control units are provided for new trains and where upgraded on existing trains the TPWS control units will include in-service testing functionality to alert the driver if a fault occurs during train running.
- Consider methods for further reducing unwarranted TPWS brake demands due to train based equipment faults.

## **5.4 Obsolescence of train equipment**

The manufacturers of the TPWS on train equipment (Thales, Unipart and STS Rail) have provided evidence that they have adequate company processes in place to manage obsolescence and mitigate its consequences before it would impact on the reliability and availability of the equipment on the trains.

## **5.5 Information available on train based TPWS equipment**

Centrally based information on TPWS component failures is only available through ATOCs Component Tracking system but it is not utilised sufficiently at the time of writing this strategy.

TPWS related events during train operations are recorded in the Safety Management Information System (SMIS). SMIS does not provide a means of recording, monitoring and tracking component failures that are identified during maintenance and testing.

The outputs from R&D project T906 set out the specification for a Defect Recording and Corrective Action System (DRACAS) for GSMR and ERTMS equipment failures under GE/RT8106. The DRACAS working group is currently developing a forward programme of work to support the proposed implementation of a CCS DRACAS. This could include the development of a CSS DRACAS central coordinating system.

### **Summary of the strategy for addressing reliability of on-train TPWS equipment**

- The industry will cooperate to improve reporting and monitoring of TPWS component failures, including the development and implementation of a Defect Recording and Corrective Action system (DRACAS).

## **5.6 On train equipment configuration control**

The vehicle owner should employ a system that records the status of the TPWS configurable equipment; this will record the serial number of the equipment and the painted vehicle number to which it is fitted. The system will also record the modification level of the equipment.

Train operators will inform the vehicle owners of changes to equipment modification level and when equipment is allocated to different vehicle numbers during repairs etc.

## **5.7 Relationship of train equipment to ERTMS**

When ERTMS/ETCS is introduced to UK trains, trains fitted with ERTMS/ETCS will need to operate using ERTMS/ETCS when on fitted infrastructure and with the existing Class B protection systems (TPWS/AWS) when running on unfitted infrastructure (ETCS level 0). The outputs from R&D project T906 (RSSB, 2015) defined how the ERTMS/ETCS system should interact with TPWS/AWS and how the

transitions between the two systems will need to be managed. This defined the requirements of the TPWS/AWS indications and controls when in parallel or integrated with the ERTMS/ETCS DMI.

The train borne ERTMS equipment is not expected to experience any interference problems from the TPWS/AWS trackside loops and magnets. There are no specific minimum proximity requirements applicable to the trackside TPWS/AWS and ERTMS equipment.

There will be a need for the TPWS to work with the ERTMS team to develop a suitable transitions approach. RSSB research project T1091 will be looking into transitions between conventional aspect signalling and ERTMS operation with a view to understanding more about the impact of transitions between signalling systems on driver performance/risk.

## 6 Operational Concept

As part of the development of the strategy, a TPWS Operational Concept has been produced (reproduced in Appendix 2). This document explains conceptually how TPWS operates today from the point of view of its direct users (drivers and signallers). It also sets out how the operation of TPWS could be strengthened by considering the operational lifecycle of TPWS such as the operational rules in normal and degraded modes; the way TPWS should be trained and how the use of the TPWS system can be monitored.

The main elements of the future operational strategy contained within the TPWS Operational Concept are summarised below:

- Improving the TPWS driver machine interface – as described in section 5.1 of this strategy document (section 6.1 of the TPWS Operational Concept)
- Increasing the effectiveness of the TPWS track-borne equipment – as described in section 5 of this strategy document (section 6.2 of the TPWS Operational Concept)
- On new rolling stock Train Operators to introduce systems (such as XDM) to monitor AWS and TPWS brake demands (section 6.3 of the TPWS Operational Concept)
- Amending the operational rules so that they are easier to comply with, reduce repetition and strengthen the communication link between drivers and signallers (section 6.4 of the TPWS Operational Concept)

- Driver training to be scenario based enabling the underpinning knowledge of TPWS rules to be consolidated such that it is applied correctly (section 6.5 of the TPWS Operational Concept)
- Future integration of TPWS and ERTMS as described in section 5.7 of this strategy document (section 6.6 of the TPWS Operational Concept)

## **7 Investigation and study recommendations relating to TPWS**

Over the life of TPWS a number of recommendations have been made regarding TPWS from the following accident investigations and studies:

1. The Cullen – Uff Inquiry
2. V/TC&C Technical Subgroup TPWS Status report
3. TPWS Joint Technical Working Group
4. RAIB Investigation into the signal passed at danger at Purley on 18 August 2006
5. RAIB Investigation into the signal passed at danger at Didcot North on 22 August 2007)

These recommendations and their current status are presented in Appendix 3.

### **Summary of the strategy for recommendations relating to TPWS**

- All outstanding recommendations will continue to be reviewed and closed out via the normal industry/company recommendations management processes.

## References

RSSB, 2015. *TPWS Availability and Reliability* London: RSSB

RSSB, 2009. *The strategy for the Train Protection and Warning System (TPWS) – Issue 1* London: RSSB

Office of Rail and Road, 2015. *ORR Consultations*. [online] Available at: <<http://orr.gov.uk/consultations/policy-consultations/closed-consultations/closed-consultations-2014/revising-railway-safety-regulations>> [Accessed 06 May 2015].

RSSB, 2015 *ERTMS/ETCS driver machine interface options for future train cab design* [online] Available at: <http://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=1170> [Accessed 06 May 2015]

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# Appendix 1. Train Protection Strategy Group Remit

## Train Protection Strategy Group (TPSG)

### Remit

Issue No. 1

23 July 2014

## 1 Introduction

- 1.1 The Train Protection and Warning System (TPWS) Strategy Group was established to monitor the implementation of the TPWS Strategy approved by RSSB Board in November 2009. Following a proposal from the V/T&C SIC to extend the scope of the TPWS Strategy Group to become the Train Protection Strategy Group (TPSG) this remit has been revised to take into account other train protection systems and the longer term migration of train protection systems to ERTMS.
- 1.2 The remit reflects the working arrangements for the V/TC&C System Interface Committee (SIC), which provides the focus for train control and communication issues, in accordance with the SIC Protocol. See Appendix A for V/TC&C Governance structure.
- 1.3 This remit is issued by the V/TC&C SIC to the TPSG.
- 1.4 The TPSG will not duplicate or undertake the work of the ERTMS programme but will review the approach in respect of train protection strategy.

## 2 Scope of the SIC / sub-group

- 2.1 The purpose of the Train Protection Strategy Group shall be to:
  - 2.1.1 Review the use of the TPWS system as information about the implementation of ERTMS becomes available.
  - 2.1.2 Develop the industry Train Protection Strategy as the risk changes and the mitigations available to mitigate identified risks change.
  - 2.1.3 Review the proposed migration of train protection systems to ERTMS, making recommendations as / if necessary.
  - 2.1.4 Undertake research on behalf of V/TC&C SIC on train protection systems, as directed.
  - 2.1.5 Comply with direction and guidance from the RSSB Board.
- 2.2 The RSSB Board has requested the group to specifically consider:
  - 2.2.1 Whether the existing train protection system continues to comply with the relevant regulations and advise the industry as appropriate to ensure continued compliance with the Railway Safety Regulations.
  - 2.2.2 Whether the train protection systems remain fit for purpose in the long term given that, on the basis of the implementation plan for new train protection systems (ERTMS), the existing train protection systems may be in operation for some decades to come and well beyond their initial life expectancy.

- 2.2.3 Review and advise the industry if the risk controlled by the current train protection systems remains ALARP and if it is likely to remain so in the future, notwithstanding technical evolution.
- 2.3 The group must propose funding arrangements for any actions recommended.
- 2.4 The TPSG should monitor the risk associated with failure of the train protection systems including the recognition that:
- a Not all existing train protection systems fail safe
  - b Not all existing train protection systems guarantee a train will stop in the overlap following a SPAD
  - c Human-machine interfaces for the train protection systems can lead to the driver misinterpreting the reason for an intervention
  - d Train protection systems suffer from obsolescence and ageing
  - e There will be transitions between different train protection systems
  - f There is a need for backward and forward compatibility
  - g There may be other risks that are identified.
- 2.5 The group's success will be determined by the extent to which industry and its stakeholders are satisfied that train protection strategic issues are being proactively managed in a satisfactory way.
- 2.6 Specific responsibilities of the group to ensure that the principal requirements are properly specified, include:
- Safety requirements;
  - Non-safety requirements;
  - Partitioning of requirements between stakeholders

### **3 Working arrangements for the TPSG**

#### **3.1 The Rail Technical Strategy**

- 3.1.1 The SIC Protocol requires that SICs support the development and implementation of the 2012 Rail Technical Strategy (RTS) by working with FutureRailway to define and take forward research and innovation projects in pursuit of the RTS vision.
- 3.1.2 V/TC&C SIC is the control, command and communication industry portfolio champion.
- 3.1.3 The work of the TPSG should align with the strategies being developed for the RTS.

#### **3.2 Work plan**

- 3.2.1 TPSG shall develop an action plan that outlines its activities.

#### **3.3 Conditions under which the sub-group will cease activity**

- 3.3.1 The group will cease to exist if V/TC&C SIC so determines. This is likely to occur once remaining strategic issues are either concluded or robust plans produced which meet with industry stakeholders' agreement, in particular the ORR.



## 4 Membership of TPSG

- 4.1 The stakeholders who are concerned, influential and accountable for the Train Protection systems are as follows:
- Infrastructure Manager
  - Train Operating Companies (TOCs) including Infrastructure Manager Plant
  - Train Owners (RoSCos)
  - Freight Operators
  - National Operating Strategy Programme
- 4.2 The Group needs a balance of engineering and operational experience of train protection systems
- 4.3 Suppliers will be invited when required to attend as observers.
- 4.4 Other relevant parties who are concerned with the management of Train Protection systems are:
- Rail Safety & Standards Board (RSSB)
  - ORR Industry experts as necessary
- 4.5 The group representation will comprise of both the stakeholders and other interested parties as detailed below:
- Infrastructure Manager
  - Railway undertaking representatives
  - Train Protection Strategy Group Chair
  - RSSB Technical Expert
  - RSSB Safety Knowledge & Planning Expert
  - RoSCos
- 4.6 The membership and alternates list is managed by RSSB and will be available for review at meetings.

## 5 Specialist Skills and Knowledge

### 5.1 Disclosure of Interests

- 5.1.1 Disclosure of interests applies to both SICs and sub-groups. The SIC Protocol states:

*'If a member, or a person for whom that member works, has a direct or indirect personal interest in a matter to be discussed by the committee, as distinct from a common interest of the industry category as a whole, the member shall declare that interest to the Chairman of the committee of which they are a member at the earliest opportunity:*

- a) On the first occasion at which the matter is discussed, or*
- b) If a member is not aware of an interest at that time, at the next committee meeting after which they become aware of that interest, regardless of whether the matter is being discussed at that meeting.*



*Once disclosed, an interest need not be disclosed again.*

*When a member declares an interest, the other members shall decide whether that member may continue to participate in discussions on the matter concerned or whether that member shall be excluded from the meeting while the matter is discussed.'*

5.2 While each individual stakeholder's areas of expertise will vary, they all fall within the following general areas:

- Equipment Design / Engineering ;
- Equipment Operation / Isolation ;
- Equipment Maintenance ;
- Equipment Performance (operational and safety);
- Configuration Control;
- Equipment Migration.
- TPWS, ATP, ERTMS and/or TVM430 expertise
- Human factors

## **6 Delegation of Authority**

### **6.1 Decision making**

6.1.1 The meeting should endeavour to agree a consensus on matters discussed. If consensus cannot be achieved the meeting should clearly document why a consensus could not be achieved and report to V/TC&C SIC.

### **6.2 Meeting quorum**

6.2.1 A meeting quorum must exist of 1 x Railway Undertaking, 1 x Infrastructure Manager, 1 x RSSB, 1 x Chairman.

6.2.2 If the meeting is not quorate, absent members will have two weeks after the distribution of the draft minutes to make an objection to any decision taken in the meeting. If no objections are made the decision will stand. The group will seek endorsement from the V/TC&C SIC on decisions made.

6.2.3 RSSB will facilitate the meeting in consultation with the Chairman of the meeting.

## **7 Process to nominate and appoint a new Chairman or new members**

7.1.1 The process to nominate and appoint a new Chairman or new members is set out in the SIC Protocol.

## **8 Governance**

### **8.1 Reporting / Recommendations**

8.1.1 The Train Protection Strategy Group will report to the V/TC&C SIC which is accountable to RSSB Board for the group's activity, a formal report is to be provided every six months.

- 8.1.2 Membership shall be from Railway Undertakings, or their nominees, Infrastructure Managers, Vehicle Owners, the NOS Programme, the RSSB (as secretariat).
- 8.1.3 The activities of the TPSG will be monitored by the V/TC&C SIC.

## **9 Support provided by RSSB**

- 9.1 Support provided by RSSB shall be in accordance with the SIC Protocol.
- 9.2 Funding for specific activity may be made available from RSSB subject to support from the V/TC&C SIC.

## **10 Organisation and Operation of Meetings**

- 10.1 The meeting will operate to a pre-agreed agenda with two meetings a year as minimum.
- 10.2 If there are insufficient agenda items to be discussed at any single meeting the Chairman will, with consultation, cancel the meeting with six working days' notice.

## **11 Administration**

### **11.1 Minutes**

- 11.1.1 Draft minutes will be reviewed by the RSSB technical specialist, RSSB R&D member and then by the Chair before distribution to the group.
- 11.1.2 Care must be taken to ensure the approved published minutes and any associated papers do not contain commercially sensitive information.
- 11.1.3 Where requests are made to distribute approved published minutes and any associated papers beyond the intended audience (for example RIA distribution to their members) the relevant Chairman is to be made aware and their authorisation is to be sought, to ensure the papers do not contain information they would not wish to share beyond the group. Requests will be made via the Senior Stakeholder Support Manager, RSSB.
- 11.1.4 The draft minutes will be made available to the group via the extranet.
- 11.1.5 The approved minutes of each meeting will be made available to the group via the extranet.

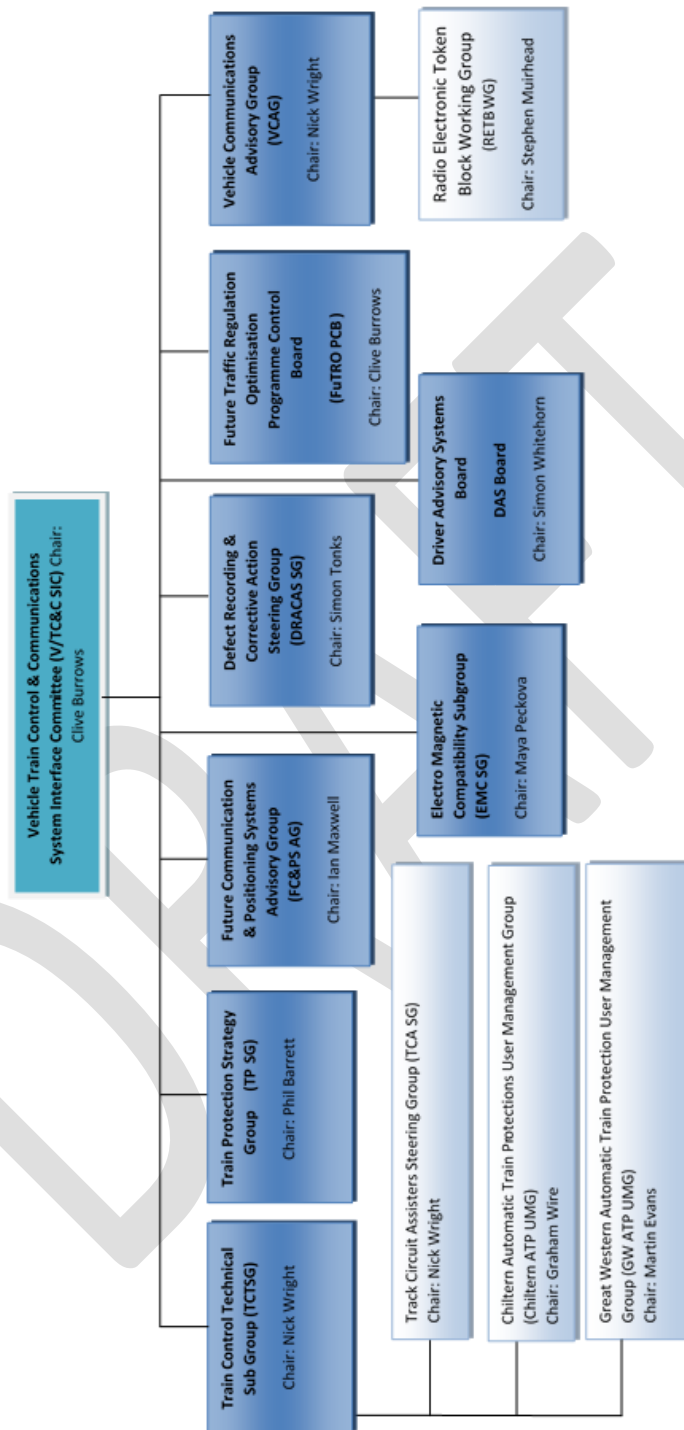
### **11.2 Meeting Documentation**

- 11.2.1 The meeting documentation will be provided to the group no later than five working days prior to the meeting.
- 11.2.2 The meeting documentation will be made available to the group via the extranet.

### **11.3 Remit Review**

- 11.3.1 This remit shall be reviewed by the TPSG at least once every 12 months.

## Appendix A: V/TC&C SIC Governance Structure



**Appendix 2. TPWS Operational Concept**  
**(Whole document inserted)**

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# **TPWS OPERATIONAL CONCEPT**

**Produced by: Traffic Operation and Management Delivery Unit**

**October 2009**

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## **1 Introduction**

### **1.1 Purpose**

The purpose of the TPWS Operational Concept is to explain conceptually how TPWS operates from the point of view of its direct users. Generally it does not describe technical details unless they are important to understanding the concept.

The Operational Concept is not mandatory in itself but does enable supporting standards to be developed (which may be mandatory) in line with the concept. The existence of an Operational Concept means that a holistic approach can be taken to ensure that the engineering system, the user and the rules are in balance to achieve optimum performance. The Operational Concept reflects existing requirements and may therefore be subject to revision, particularly as a result of any research work undertaken.

A TPWS Strategy document has been developed in parallel with this Operational Concept. The aim of the Strategy document is to review TPWS and describe the long term strategy for the future of TPWS.

## **1.2 Structure**

Section 2 describes the background to TPWS including the evolution of TPWS from AWS; the influence of Southall and Ladbroke Grove on TPWS and how TPWS has reduced SPAD (signal passed at danger) risk.

Section 3 provides a system description of TPWS from a user's perspective, including limitations for track-borne, train-borne and signalling centre equipment.

Section 4 describes the user's (driver and signaller) experience of TPWS.

Section 5 discusses training, competence and management issues associated with TPWS.

Section 6 highlights the areas where operational activities can feed into the long term strategy for TPWS.

## **2 Background**

### **2.1 The evolution of TPWS**

During 1994 following the decision by British Rail not to retrospectively fit Automatic Train Protection (ATP) across the railway network, the former company Railtrack (now Network Rail) set up a project to examine alternative ways of preventing and reducing SPADs, including a more cost-effective method of providing train protection. An output of this work stream was the development of the Train Protection and Warning System (TPWS).

TPWS evolved from the Automatic Warning System (AWS) which was introduced to the UK railway in the 1950s to help train drivers observe and respond to signals. AWS provides indications to the train driver about the aspect of the next signal in the form of an audible alarm and a yellow and black segmented visual indicator in the train cab (known as the 'sunflower'). If a signal being approached is displaying a clear aspect (green), the audible alarm will be a 'bell' sound and the sunflower will remain all black. If the signal being approached is restrictive (red, single yellow or double yellow) a warning horn will sound until the driver acknowledges the horn by pressing the AWS reset button on the drivers' desk. At this point the sunflower changes to a yellow and black segmented display which acts as a reminder to the driver that the last signal passed was at caution. If the warning horn is not acknowledged within 2 seconds (high speed trains) or 2.7 seconds (lower speed trains), an automatic emergency brake application occurs, and the train is brought to a stand. When the



brake application occurs, the brake demand indicator on the TPWS Driver Machine Interface (DMI) flashes in the same way it does when TPWS initiates a brake demand.

AWS can also be used to warn the driver when approaching permanent speed restrictions as well as at all temporary and emergency speed restrictions.

Trials of the TPWS system took place between 1997 and 1999 with widespread fitment of TPWS beginning in early 2000 to meet the Railway Safety Regulations 1999. The Regulations required that no person shall operate, and no infrastructure controller shall permit the operation of a train on a railway unless a train protection system is in service in relation to that train and railway.

## **2.2 The influence of Southall and Ladbroke Grove**

Following the collision at Ladbroke Grove (1999), Sir David Davies, then President of the Royal Academy of Engineering, was asked by the Deputy Prime Minister to undertake an independent review of possible forms of Automatic Train Protection suitable for fitting to infrastructure and rolling stock to achieve improvements in railway safety and protection against SPADs.

Sir David's conclusion was that in the longer term the solution lay in adopting the European Train Control System (ETCS), but that the best solution irrespective of cost to maximise safety by minimising the possibility of SPAD-related accidents over the next 10 to 15 years (written in 2000) was to fit TPWS.

In the short term it was expected that the development of TPWS +, addition of enhanced emergency braking on trains, defensive driving policies and a small change in regulation rules at junctions would give added benefits.

The Joint Inquiry into Train Protection Systems chaired by Professor Uff who had led an Inquiry into the collision at Southall (1997) and Lord Cullen who chaired an Inquiry into the Ladbroke Grove collision, was established shortly after the Ladbroke Grove accident and reported in 2001. The authors acknowledge that Sir David Davies' report and his evidence to the Inquiry were significant. The body of the report included a number of detailed observations concerning the risk level from SPADs, the effectiveness of TPWS and its limitations, a summary of which can be found in Appendix A.

Fitment of TPWS was accelerated following the Ladbroke Grove Rail accident under regulatory requirements. The fitment programme was completed during 2003.

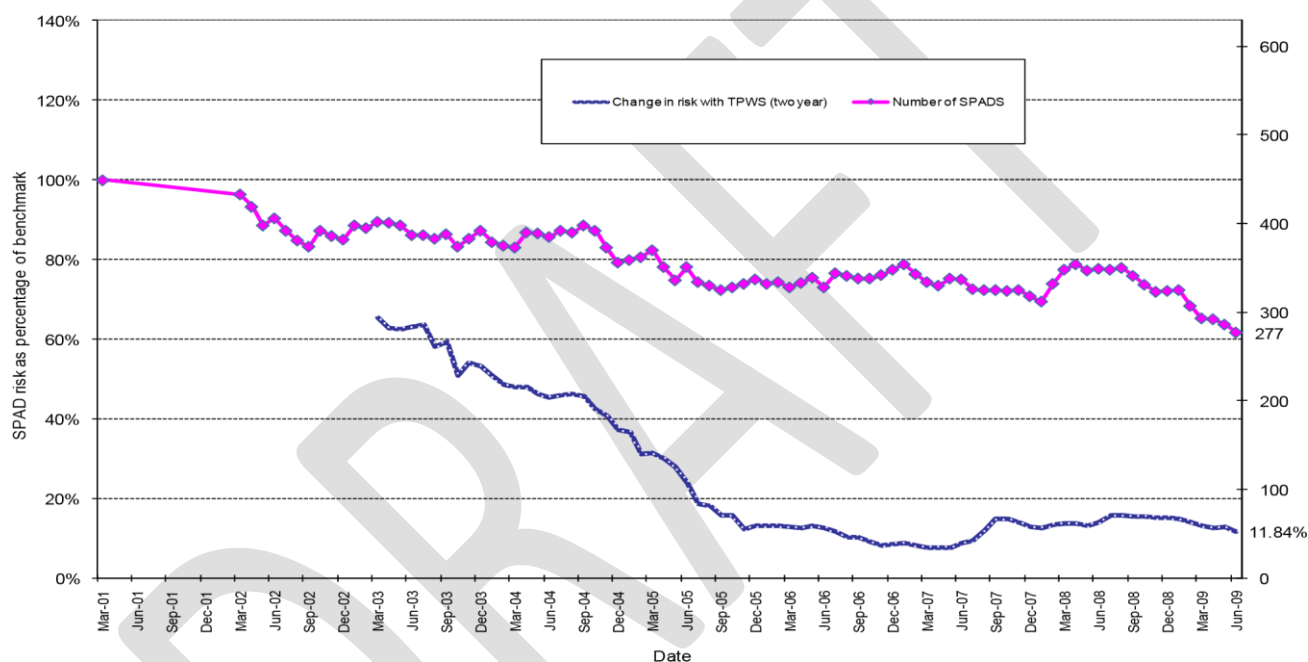
## **2.3 The effect of TPWS on SPAD risk**

The introduction of TPWS has brought about a significant reduction in SPAD risk. Figure 1 shows the number of SPADs (the dotted pink line) that occurred during the previous 12-month period, known as the 'annual moving total' (AMT) measured against the right-hand axis. The solid blue line, measured against the left-hand axis, is based on two years' data and shows the change in risk, accounting for the benefits of TPWS. It can be seen that the

AMT for 'all SPADs' has been decreasing since reaching a peak, in April 2008. As at the end of June 2009 this AMT had fallen to 277, which is its lowest recorded figure<sup>15</sup>.

Ten years ago, prior to the Ladbroke Grove collision (5 October 1999), the figure was 674 (having reached a peak of 881 at the end of 1989). When train miles are taken into account, this gives a national SPAD rate of 2.67 SPADs per million train miles. In comparison with the SPAD rate of 0.66 as at the end of Q2-2009, this represents a decrease of 75%. The chart also indicates that SPAD risk is currently 11.8% of the baseline (March 2001) level.

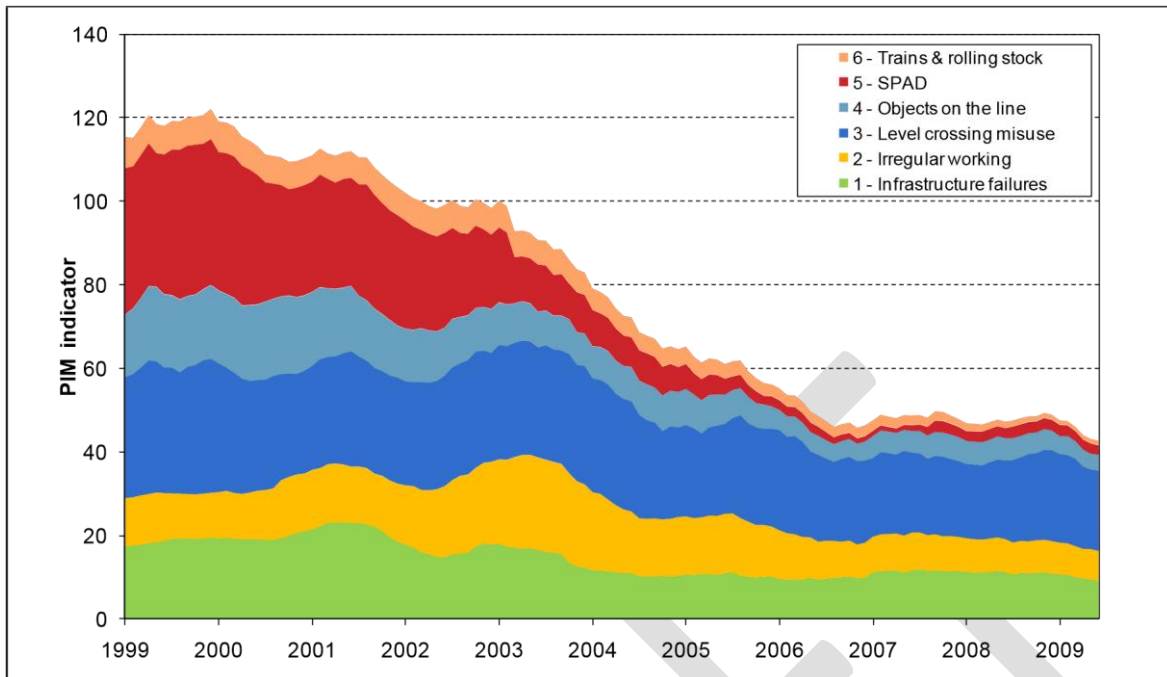
This significant reduction in SPAD risk has come about as a result of three major initiatives: the focus by the rail industry on category A SPADs, the installation of TPWS at all junction signals throughout the network and the removal of the Mark 1 rolling stock.



**Figure 1 – SPAD risk as at 30 June 2009 (from the Q2 2009 RSSB SPAD report)**

As a proportion of overall train accident risk, the risk contribution from SPADs has reduced markedly since TPWS was implemented (Figure 2).

<sup>15</sup> Since the systematic collection of SPAD data started in 1985.



**Figure 2 – Trends in train accident risk from the Precursor Indicator Model (from the 2008 RSSB Annual Safety and Performance Report)**

Despite this significant decrease in SPAD risk, TPWS reset and continue following a category A SPAD (where TPWS has intervened and stopped a train in absence of train driver's action) remains an area that the industry is endeavouring to address.

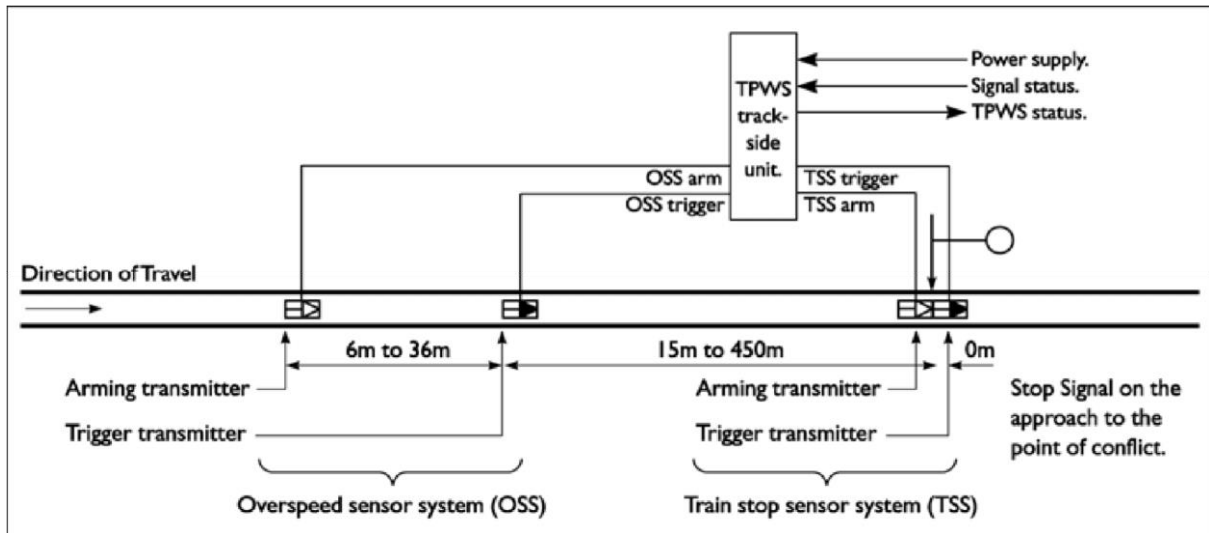
With the development of the implementation plan for the European Rail Traffic Management System (ERTMS), with its Automatic Train protection functionality, it is clear that TPWS will be a core railway system for several decades to come, longer than its anticipated life span. The industry has been developing a long term strategy for TPWS, which includes operational aspects which are discussed in section 6 of this document.

### 3 System Description

#### 3.1 Track-borne equipment

TPWS uses transmitters mounted in the centre of the track which, when active, transmit one of 6 different frequencies in the range 64 kHz to 67 kHz. The frequencies emitted by these transmitters are detected by a receiver mounted on the train.

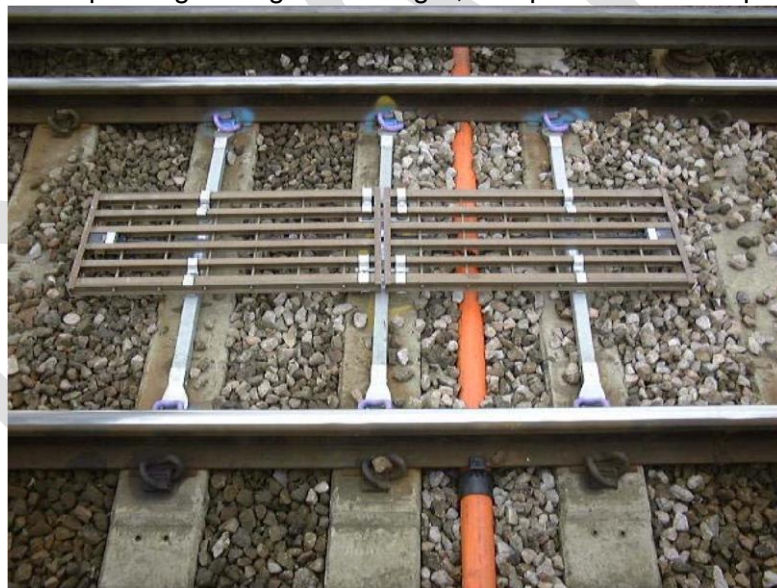
Figure 3 shows a typical layout of the TPWS equipment installed on the approach to, and at a signal.



**Figure 3 - TPWS typical layout for track-borne equipment** The

TPWS equipment installed at a signal generally consists of two elements:

- a) The train stop sensor system (TSS) (Figure 4): this consists of two adjacent transmitters (the arming transmitter and the trigger transmitter), positioned at the signal. These transmitters are energised whenever the signal is at red, and will apply a brake application on a train passing the signal at danger, irrespective of train speed.



**Figure 4 – Typical TPWS TSS**

- b) The overspeed sensor system (OSS): this consists of two transmitters located on the approach to the signal (normally between 15 metres and 450 metres from the signal), and separated by a distance between 6 and 36 metres. The OSS operates on the principle of measuring the time taken for a train to pass between two points on the track. The distance between the arming transmitter and the trigger transmitter, in conjunction with a delay timer on the train (which is set to different values for passenger and freight trains), determines the 'set speed' of the overspeed transmitters. The two transmitters

are energised when the signal is required to be at danger, and will initiate a brake application on a train which passes over the OSS above the 'set speed'.

At locations other than signals, such as on the approach to a speed reduction or buffer stop, where TPWS is required to be installed to ensure trains have sufficiently reduced their speed, an OSS alone is installed. This will be permanently energised so that it will initiate a brake application on any train passing above the 'set speed'.

### 3.1.1 Limitations

There are limitations associated with the track-borne TPWS equipment in terms of its design and deployment:

- Not all signals are fitted with TPWS (the exemptions include signals not protecting conflicts on passenger lines, shunt signals on passenger lines solely used for shunting, signals where a SPAD will result in a train being derailed/diverted, signals protecting nontrain conflicts (eg level crossings) and signals which only protect the rear of a preceding train).
- TPWS cannot provide continuous speed supervision and therefore only provides limited mitigation in the case of a train that accelerates after passing an OSS below the intervention trigger speed.
- TPWS installations associated with buffer stops are usually positioned at a standard fixed distance from the buffer stop. If triggered by a train travelling in excess of 13mph, it will stop the train before it reaches the buffer stop. However, at speeds between 14mph and 20mph the system may not prevent the collision and only guarantees that the speed of collision will be contained below the maximum impact speed at which the buffer stops are designed to arrest the train in a controlled manner.
- Where an OSS transmitter is installed on the approach to a designated permanent speed restriction (normally where the permissible speed on approach is greater than 60mph and the restriction requires a speed reduction of one third or more) the system does not ensure compliance with the restriction. It will only intervene to reduce the speed of the train to a level below which the immediate risk of the train overturning is considered minimal. This level is approximately 50% above the published speed of the speed restriction. Whilst the system in these circumstances effectively controls immediate catastrophic risk it does not prevent excessive speed that causes premature degradation of track components and structures. Additionally, where the set speed would impact a freight train travelling at a legitimate speed, the loop is moved (with higher set speed) or even eliminated to avoid unwarranted interventions.
- The initial project was optimised for cost effective, speedy fitment with a substantial reduction of risk. This concentrated on managing SPADs by passenger trains (management of freight trains were a secondary benefit) assuming that all overlaps would be the full length (180m), that conflicts would not normally be immediately beyond the end of the overlap and that trains would brake at 12% gravity (or 'g'). This leads to a templated design which is effective for speeds up to ~75mph provided the conflict is ~180m beyond the signal.
- The system is optimised for trains capable of achieving a 12%g emergency braking rate, generally passenger trains built since the late 1990s, and cannot provide differential



speed control for slower trains other than a single step difference of 20%. This means that trains capable of achieving greater than 12%g emergency braking rates (certain recent designs of high speed passenger trains) and higher speed freight services (normally intermodal services permitted to operate at more than 60mph) have to be driven well within their normal brake capability envelope if unwarranted TPWS interventions at the OSS are to be avoided.

- The OSS and TSS together are intended to stop the train reaching the potential point of conflict beyond the signal. However, this can only be guaranteed under certain conditions where the speed of the train is less than 75mph and the train braking system is capable of achieving a 12%g emergency braking rate. In certain cases, to improve the effectiveness at speeds greater than 75mph, an additional OSS may be provided at a greater distance from the signal, typically 750 metres. This arrangement is referred to as “TPWS+”.
- TPWS+ was added to the top 100 sites to manage the risk of trains exceeding the normal ~75mph effectiveness limit on a risk based selection process. However, TPWS+ (in standard configuration) is only fully effective to about 105mph.
- The infrastructure equipment was never designed to be fail-safe. However, its operation is monitored and used to provide warning indications and restrict previous signals. There is no protection if the trackside equipment is displaced (but not disconnected), incorrectly positioned or fails after the train has passed the previous signal.

### 3.2 Train-borne equipment

The TPWS equipment which is visible to the driver is the TPWS panel and the isolation switches. Figure 5 shows the position of the TPWS panel in two different train cabs. Figure 6 is a close up of a typical TPWS panel.



Figure 5 – TPWS panels in two different train cabs



**Figure 6 - Typical TPWS panel**

The TPWS panel has different functionalities which are described below.

### 3.2.1 Brake demand indicator

When a TPWS brake demand is initiated, the brake demand indicator flashes and the brake demand timer is commenced. When the driver presses the TPWS/AWS reset button on the drivers' desk the brake demand indicator reverts to a steady state. The brake demand indicator extinguishes and the brakes are released after the reset button has been pressed and the brake demand timer has expired.

### 3.2.2 Temporary isolation

The temporary isolation switch (figure 7) is operated either for operational reasons, eg, when a series of signals at danger are to be passed or in response to a fault eg, a faulty TPWS antenna. Operating the temporary isolation switch disables the train stop and overspeed sensor functions. When temporary isolation is selected, the temporary isolation/ fault indicator will illuminate (steady) on the TPWS panel. Operating the temporary isolation switch will not clear an existing TPWS brake demand, except where the train has stopped with the TPWS aerial directly over the active train stop sensor and more than 59 seconds have passed since the start of the brake demand. A temporary isolation will be cleared if the equipment is powered down and up again.



**Figure 7 - Typical temporary isolation switch**

### 3.2.3 Fault indication

If the TPWS self test fails, the temporary isolation / fault indicator will flash on the TPWS panel. In this situation it will be necessary for the driver to operate the temporary isolation switch. For some TPWS equipment suppliers, the temporary isolation/ fault indicator will flash if a fault is detected whilst the train is in-service.

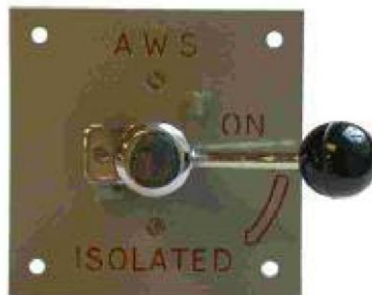
### 3.2.4 Train stop override

The train stop override button is operated when a train is required to pass a signal at danger under the authority of the signaller. When the train stop override function is active, it prevents the train stop function from braking the train. To activate the train stop override functionality, the driver presses and releases the train stop override button. When active, the train stop override button is illuminated. The train stop override is automatically cancelled when a TPWS fitted signal at danger is passed or after 20 seconds (for passenger trains or 60 seconds for freight trains) have elapsed since the button was pressed. The train stop override indicator extinguishes when the functionality is cancelled. Once the 20 or 60 second period has started, it cannot be extended by operating the train stop override button again.

### 3.2.5 Full isolation

If the full isolation switch (figure 8) is operated, this will isolate the AWS train-borne equipment and the TPWS train-borne equipment. The full isolation switch is operated under fault conditions such as when the brakes will not release, the AWS audible indications will not silence or a number of spurious responses are obtained from the AWS or TPWS. Operating the full isolation switch will cancel any existing TPWS brake demand and will remove power from the control unit.

If the TPWS has been fully isolated, the train should only proceed normally if operation is confined to a route where no TPWS is provided. Otherwise the train is allowed to proceed at a maximum speed of 40 mph (subject to any lower permissible speeds) to a location where another competent person can be provided to accompany the driver. The train can then proceed at normal permissible speeds (or a maximum of 40 mph during fog or falling snow) as far as the location specified in the train operator's contingency plan where the formation will be adjusted, or the train taken out of service. If no competent person can be provided, the train must only proceed as far as that 'contingency plan' location at no more than 40 mph.



**Figure 8 - Typical full isolation switch**

### 3.2.6 Limitations

There are limitations associated with the onboard TPWS equipment:



- The same indication (flashing brake demand indicator) is provided to the driver irrespective of whether a brake demand is caused by a SPAD (train stop), an overspeed or a 'late to cancel AWS'.
- There is no audible alarm provided for a brake demand caused by a SPAD.
- The position of the TPWS panel in the cab varies greatly across different classes of train (figure 5). The flashing brake demand indicator could therefore be missed by the driver.
- For most train-borne equipment its operation is only verified at power up of the train cab. Some TPWS suppliers however, do have in-service fault monitoring functionality.
- Following a brake demand due to TPWS or AWS, the brakes are automatically released after 60 seconds if the driver has pressed the AWS/TPWS reset button. The brake demand indication will extinguish at this point. The limitation is that the driver might not have noticed the flashing brake demand light and not realise that a TPWS initiated brake demand has occurred.
- A driver can cancel a brake application caused by TPWS by powering the driver's desk down and back up again potentially enabling 'reset and continue' to occur.

### 3.3 Signalling Centre Equipment

Signallers have an important role in monitoring the state of the TPWS equipment and in some cases performing tests. In the most modern signalling centre installations TPWS equipment faults are indicated separately by blue 'fault' indications on the signalling panel or VDU workstation.

On many signalling panels, in order to avoid a substantial modification to the panel, a TPWS fault at a signal is indicated via a simulated 'lamp out' fault at the signal lamp indication repeater circuit. Indications are provided to indicate to a signaller that a signal lamp is or is not displaying an aspect to a train. These existing circuits have been utilised in order to additionally provide a TPWS status indication. During a failure of the TPWS track equipment, the signal indication on the panel will appear blank whilst the signal is displaying a red aspect and its associated TPWS is therefore required to intervene to stop the train. If, however, the signal is displaying a 'blank' aspect because of a loss of power supply, it is likely that the loss of power will result in the TPWS equipment not functioning.

During a fault of TPWS at a signal in colour light areas, the signal next in rear will be held at danger until such time as the affected signal is displaying a proceed aspect and its TPWS is no longer required to intervene.

In mechanical boxes TPWS is conditioned to operate by the position of the signal lever being normal or reverse. That is if the lever is normal in the frame, then the associated signal will be at danger and its TPWS equipment will be armed. If the lever is reversed, the associated signal will be clear and its TPWS equipment is not required to intervene.

In mechanical signalling it is considered too restrictive to require the signal next in rear to be held at danger in the event of a TPWS fault as that signal may be worked by another box and

be many miles away. Therefore to monitor the status of TPWS, Failure Indication Units (FIU) are provided (figure 9).



**Figure 9 – Failure indication unit**

The FIU indicates that power is available to the TPWS by displaying a steady white light. In the event of the primary supply failing a back up (battery) supply will continue to operate the equipment. The white light will flash and the signaller must advise the technician to investigate.

In the event of a failure to TPWS at an individual signal, an audible alarm will sound and a blue light will flash. When the audible alarm is cancelled, a steady blue light is displayed.

An important role of the signaller in a mechanical signalbox is to perform a test to establish that the FIU is capable of detecting a fault. This test must be performed at least every 12 hours and is carried out by signallers at each shift change or when the signalbox opens. The result of the test must be recorded in the Train Register Book.

The signaller is required to carry out appropriate instructions when any failure of TPWS occurs. In summary, the requirements are as follows:

- If it is not possible to tell from the failure indicated whether the failure is of TPWS equipment, a signal lamp out, or of indications only, then until this can be established a train must not be allowed to approach the signal unless it is known to be correctly showing danger, known to be showing a correct aspect, or the driver has been told and the line is kept clear up to the overlap of the next stop signal ahead (or alternative 'double-block' arrangements apply).

- If a TPWS train stop has failed and is causing brake applications when it should not, the driver must be instructed to operate the train stop override button.
- If a TPWS overspeed sensor has failed and is causing brake applications when it should not, the driver must be told that this may happen.
- If TPWS equipment fails at a signal and will not cause a brake application, the signal must be cleared, or if this cannot be done, each driver must be told to approach the signal at caution.
- If TPWS equipment fails at somewhere other than a signal and will not cause a brake application, the driver must be told before approaching the buffer stops or reduction in speed.
- If a signal on the approach is held at danger by any failure, it is also necessary to authorise a driver to pass that signal at danger.

### 3.3.1 Limitations

There are limitations associated with the signalling centre equipment:

- Apart from in the most modern signalling centres, there is no separate indication for failed TPWS equipment.
- The signalling panel may not show which signals are fitted with TPWS. The special box instructions contain this information which the signaller is required to learn.
- TPWS installed at buffer stops or PSRs is not normally monitored by the signalling systems and only the technician can discover a fault there.

## 4 Users' Experience of TPWS

### 4.1 Drivers

The introduction of modern passenger rolling stock with improved braking capabilities and better acceleration has seen a change to speed and braking profiles, allowing drivers to approach signals and speed restrictions slightly faster, albeit equally as safely, than with previous rolling stock. This change to the braking characteristics has led to a number of instances of TPWS brake interventions. Because of the improved braking capabilities of modern trains, it would often be the case that drivers believed that train speed and deceleration at the time of intervention was such that they would be able to stop at the target location or reach the target speed. This left drivers feeling frustrated, wondering why the TPWS equipment had intervened. Data analysis often showed marginal differences in the train speed and the trigger speed of the equipment ie, 1 or 2 mph. Some drivers felt that there had been mis-placement of the transmitters resulting in unnecessary brake applications when the driver felt they had full control of the train.

A further frustration began to emerge from the fitment of TPWS approaching buffer stops. Quite a number of interventions occurred when the equipment was first installed until drivers became accustomed to approaching buffer stops extremely cautiously.

A further consequence of brake applications from TPWS is the process of reporting the incident to the signaller and the resulting incident investigation process. Some factors, such as the possibility of disciplinary action, act as a disincentive for drivers to report certain events. There have also been cases where a TPWS incident has been reported as a failure to cancel AWS (sometimes this was a false belief that late cancellation of AWS had actually occurred). Reset and continue events additionally provide evidence that non-reporting occurs.

A combination of factors could lead a driver to not report a brake demand. A lack of understanding of the system could result in drivers not realising the potential risks involved in not reporting. Other factors could be time pressures placed on drivers, or cultural issues surrounding the way that incidents are investigated and managed.

Technology exists which results in 100% detection of TPWS incidents, in real time. This means that most drivers are more likely to report TPWS incidents, as they would know they would otherwise be 'found out' (the consequences of not reporting are likely to be more severe than reporting).

The management of TPWS incidents also has consequences for training and competence of drivers. Does involvement in a TPWS incident necessarily mean that a driver is incompetent and requires remedial training? If so, what training is appropriate? Could it be that the learning outcomes could affect all drivers over that route, rather than just the one involved in the incident?

## **4.2 Signallers**

Signallers recognise that installation of TPWS has been a positive step forward in relation to safety, and recognise that positive reductions in risk have been achieved.

TPWS does not alter in any way a signaller's decision making process, as fitment at any location does not provide any easement in what is allowed by the interlocking, nor is it a condition that allows a more 'relaxed' alternative procedure to apply.

It is possible to overlook the full extent of TPWS fitment within a signaller's area of control, particularly where OSS associated with PSRs are in close proximity to signal fitments. This may result in confusion as to which equipment has intervened to stop the train or a driver reporting an 'intervention' being at least initially told that there is no TPWS equipment in that immediate area, although generally the existence of a relevant TSS is usually recalled.

There are cases in which the need to remind a driver that a signal is equipped with TPWS before authorising him/ her to proceed can be overlooked, resulting in the driver not overriding or temporary isolating and being 'tripped'.

Essentially, a signaller would regard TPWS as a system that exists in the background, only calling attention to its existence by activating, or giving a failure indication, both of which then require action to be taken.

## 5 Training, Competence and Management of TPWS

### 5.1 Training and competence

During initial training, signallers' responsibilities in relation to TPWS are covered fully. Where signalling simulators are available at training centres, the mechanical frame includes a failure indication unit and the NX panel can be set up to demonstrate both the 'blue light' and 'lamp out' indications. The periodic re-examination of signallers' knowledge through the Cognisco system includes extensive material on dealing with TPWS events.

For existing drivers, training was initially carried out as either part of driver briefing day content or a bespoke, one off session at a training centre. The content was based upon the broad technical aspects of the system ranging from the track mounted equipment, trainborne equipment, its functionality, associated faults and rules procedures.

At the time TPWS was introduced, few train operating companies had driver training simulators at their disposal. As TPWS is usually a passive system, there was no opportunity to practice TPWS scenarios and as a result, the training was delivered mainly as theory sessions only.

In recent years, particularly following the enquiry to the accident at Ladbroke Grove, there has been an increasing focus on compliance with regards to training. Companies have focused on ensuring they can demonstrate that rules and procedures have been trained and assessed. This has encouraged an approach that predominantly trains the task from the rules. Using this approach is unlikely to develop all the technical or non-technical skills (eg, situation awareness, error management and workload management) necessary to operate TPWS safely.

Even where photographs and annotated diagrams were used, along with videos specifically about TPWS, this tended to focus on technical knowledge and skills, rather than discussing a wide range of scenarios, possible errors and ways of mitigating error through use of nontechnical skills.

Companies who have since procured simulators are now finding that practical scenarios are highlighting common errors when dealing with TPWS incidents. During the first 'run' of TPWS scenarios by one railway undertaking on their driver training simulator, common errors made by drivers on receiving a brake demand were:

- Not realising that TPWS had initiated the brake demand
- Not pressing the TPWS/AWS cancellation button to acknowledge the brake demand
- Shutting down the desk and reopening it (which resets TPWS)
- Pushing the train stop override button
- Isolating TPWS or AWS

- Incorrect actions arising from the completion of the RT3188 form. For example, when the signaller asks the driver 'Have you isolated TPWS?', a common response from the driver would be, 'No, I'll go and do it now', when it is not appropriate to do so.

These errors are not necessarily due to a lack of underpinning knowledge of the TPWS rules. Instead, drivers are failing to recognise how and when these rules need to be applied practically. In addition, once on their own in a driving cab (even a simulated version), there are a number of operational pressures and distractions to deal with.

## 5.2 Management of TPWS interventions

A number of railway undertakings were consulted to find out more about their management of TPWS interventions. This revealed that TPWS interventions are managed in a fairly consistent way throughout the industry. The following is a reflection of the current practices that exist:

- Driving policies do not tend to specify a particular driving technique or target speeds approaching signals at danger where such signals are equipped with TPWS.
- Specific briefing for multi-tripped TPWS locations is not usually provided, although one operator does brief drivers on two specific locations where interventions are common place.
- There seems to be a common belief that multi-tripped TPWS locations should be discussed at OPSRAM (Operations Reduction and Mitigation) in the same way multiSPAD locations are.
- Railway undertakings place a high degree of emphasis on the management and investigation of TPWS interventions, especially through download analysis from on train data recorders.
- There is little evidence to suggest that railway undertakings are carrying out auto-analysis of download data as a pro-active method of monitoring TPWS interventions and driving techniques. However, Section 6.4 describes an approach by one train operator to the management of TPWS brake demands.

## 6 TPWS Operational Strategy

TPWS has played a significant role in reducing SPAD risk however, TPWS reset and continue remains an outstanding issue for the train, freight and on-track machine operators. To the end of 2008 there have been 30 reset and continue events following category A SPADs. There are also open issues relating to the identification of TPWS faults while the train is in-service.

This section considers potential developments for TPWS in the future from an operational perspective. These activities feed into the TPWS long term strategy and some of these activities are already underway.



## 6.1 Improving the TPWS driver machine interface

RSSB research project T725 ('Justification of TPWS modifications identified in reset and continue research') tested a range of new TPWS panel options for the driver's cab, in addition to the existing TPWS panel. The new panels were designed to improve the indications (visual and audible) that the driver receives following a brake demand due to TPWS or AWS. The existing TPWS panel does not differentiate between brake demands caused by TPWS or AWS. The new panels also prevent the brakes from being released by the driver shutting the driver's desk down and powering it back up again. These improved indications and prevention of brake release mitigate against 'reset and continue'.

The '3 indicator' panel (figure 10) tested in the trial was the most preferred panel from a human factors perspective and was recommended for the introduction to new trains. The '3 indicator' panel provides speech warnings when the train experiences a SPAD or overspeed event. Railway Group Standard GE/RT8030 will include the mandatory requirements for the '3 indicator' panel for new trains.



Figure 10 – '3 indicator' panel

A '2 indicator' panel tested in the research was also recommended for existing trains (nonmandatory), where fitment is judged to be reasonably practicable. A Railway Industry Standard will be developed to specify these requirements.

Both the '3 indicator' and '2 indicator' panel designs include requirements for fault detection whilst the train is in service.

## 6.2 TPWS track-borne equipment

Developments to TPWS have tended to focus on the on-train equipment. This section considers potential improvements in the provision of TPWS track-borne equipment.

Section 3.1 identified a number of limitations associated with the current design and deployment of the track-borne equipment. A review of the criteria for fitment will potentially lead to the provision of TPWS at additional signals where a SPAD will result in an identifiable risk but which are outside the scope of the existing requirements (eg, signals protecting level crossings, signals on plain line where there is likely to be a train stopped in the section ahead).

A review of the braking rates assumed in the calculation of TPWS track transmitter positions, in relation to the actual braking rates achieved by trains has the potential to allow the positioning of the TPWS transmitters to be optimised. This would increase the system's

effectiveness in stopping trains before a point of conflict while minimising the occurrence of unwarranted interventions.

### **6.3 Monitoring TPWS and AWS brake demands**

A recent approach adopted by one train operator to TPWS and AWS brake demands has been to make use of software that can interrogate the train's 'black box'. The software has the capability to identify any brake demand caused by TPWS or AWS. When the software was first used by the operator, it was found that a significant number of AWS and TPWS brake demands captured by the train software were not being reported by the train drivers involved. The train operator developed a work instruction for the management of TPWS and AWS brake demands. The work instruction detailed a consistent and objective approach that could be applied to the investigation of TPWS and AWS brake demands.

The work instruction required the use of the following resources:

- train software (known as XDM)
- OTDR information
- professional driving policy relating to braking practice
- signalling infrastructure measurements (eg, distance of transmitter loops from the signal) obtained via Network Rail
- brake retardation calculations
- classification scale which categorises the severity of risk associated with the event (1 being most severe and 4 being least severe)

The output of the work instruction is to classify the brake demand into a category which relates to risk. The appropriate action arising from the event is at the discretion of the investigating officer. It was reiterated by the train operator that the category of the event does not automatically determine the resulting action, ie, driver errors do not necessarily result in disciplinary action.

The train operator has been monitoring the train software daily for the fleet to which the software is available. Since this policy has been introduced, the number of unreported brake demands from drivers has decreased practically to zero. In addition, the approach has enabled sites to be identified where the positioning or settings of the infrastructure equipment have been identified as being inappropriate.

### **6.4 Review of the Rules**

In November 2008, when TOM SC was considering a proposal to amend RGS GE/RT8030 to reflect the '3 indicator' TPWS panel (and potentially the '2 indicator') it was identified that there was potential impact on the Rule Book which as the minute states was to be ascertained. Approval of the proposal has given rise to reviewing the current rules, particularly as this 'impact' has been interpreted as an overall view of the appropriateness in present circumstances of each rule.

The existing rules have been largely unchanged since they were initially drafted at a time prior to the introduction of TPWS. As such their content does not benefit from practical



experience of TPWS in operation, and it is possible that in some respects the emphasis may be incorrect, and the structure less than ideal.

The present rules relating to TPWS/ AWS are seen as complex, and may blur the actual actions needed to be carried out by the user.

It is necessary to ensure that rules address the operational problems appropriate for what is now a well established safety system with proven track record in ensuring system safety.

The rules should ensure the correct identification and management of the reason for a train having been stopped and support and guide the driver and signaller in handling the problem in a manner that maintains system safety.

Although firm proposals will require industry input, including formal consultation, potential for change to the rules concerning AWS and TPWS has already been identified in the following areas:

- Removal of existing instructions that merely describe the operation of a system, but do not define actions to be taken, the former type being conveyed solely through training.
- Correction of an incorrect inference that the driver alone can determine that no AWS equipment exists at a location.
- A simplified statement of why TPWS may cause a brake application.
- Simple and consistent instructions for any operation of TPWS.
- A review of the instructions concerning temporary isolation of TPWS.
- Removal of an instruction concerning 'spurious' TPWS operation which is now understood to be technically impossible.
- Enhance the instructions dealing with abnormal brake applications to emphasise the need to establish whether AWS or TPWS is the cause.
- Reconsider the existing requirements when the DSD or vigilance equipment becomes defective to ensure that the protection of AWS or TPWS is always obtained.
- Review the occasions on which AWS is allowed to be isolated, which isolates TPWS, to ensure the benefits are not lost.

The review of rules is as yet at an early stage, and further opportunities may well be identified.

## **6.5 Training and competence**

Instead of TPWS training being delivered as a discrete module, an integrated approach based on a risk-based training needs analysis would enable learning from a risk-based perspective.

TPWS has different uses in normal, degraded and emergency operation. What are the tasks that need to be carried out by various roles? How difficult is it to use in each of these situations? How often is it used and most pertinently, what are the consequences of using it incorrectly?

A focus on the higher risk tasks for those who use TPWS would inform the nature of the initial and frequency of refresher training. An understanding of the way the system works and what it means from a risk point of view would also encourage drivers to 'do the right thing', for safety reasons.

Recent adult learning research (T718) shows that most drivers are 'analytic' in their cognitive style, ie not geared towards seeing the bigger picture. Future training is required to help drivers identify risk by seeing the bigger picture. This means thinking about what is happening outside the cab, rather than just focussing on what is happening inside. The bigger picture is also important for signallers, particularly regarding their interaction with drivers.

The most recent training material has been developed by RSSB, sponsored by the Operations Focus Group, in the form of an interactive DVD, 'TPWS in Practice'. This DVD draws together TPWS training across roles in the industry, particularly between drivers and signallers. Through a series of scenario-based exercises, trainers are encouraged to challenge the learner to think about how to apply knowledge, technical and non-technical skills. The DVD can be used for both refresher training and for use within basic training courses. Industry has been actively encouraged to conduct joint signaller/ driver briefing sessions where the DVD could be used as an interactive session to examine both driver and signaller roles and how they respectively deal with different situations. In particular, degraded and emergency (ie, activation/intervention) scenarios for TPWS are high risk, in that they occur infrequently and have serious consequences if skills and knowledge are lacking or applied incorrectly.

Through scenario-based training, the underpinning knowledge of TPWS rules can be consolidated, such that it is applied correctly. For companies without driver training simulators, this can be achieved through a range of learning methods including: use of portable TPWS transmitters within depots, e-learning (including DVDs, videos and computerbased training) and paper-based exercises. Crucial to the success of all of these is identifying which elements of the training are best trained using which methods, ensuring that the tasks which stand the highest risk of being carried out incorrectly are given the most prominence.

The challenge for the industry is to find workable mechanisms within competence management systems that will encourage drivers to regularly refresh the application of their knowledge of TPWS to practical scenarios. If drivers are actively encouraged to 'own' their competence with regards to TPWS, they will stand a better chance of dealing with TPWS related situations when they occur.

## **6.6 Integration of TPWS with ERTMS**

When ERTMS is rolled out across the UK, there will be a long period of time during which both ERTMS and TPWS/AWS will be required to exist together. This is because trains fitted with ETCS will have to operate over unfitted infrastructure (in level 0 or level STM as applicable) and therefore TPWS and AWS will still be necessary. The requirements for the interaction of these two safety systems therefore need to be defined.

One option for interfacing onboard ERTMS and TPWS/AWS equipment is to use a Specific Transmission Module (STM). With this option, operation over unfitted infrastructure takes place in level STM. The STM replicates the functionality of the onboard class B safety systems (TPWS/ AWS). This means that the TPWS and AWS user interface is presented to a train driver via the ETCS DMI (driver-machine interface). The human factors requirements for the presentation of the class B systems on the ETCS DMI need to be defined. The alternative to an STM is to retain the existing class B onboard equipment, including the standard TPWS/ AWS DMI, and operate over unfitted infrastructure in level 0. This option requires an interface to the ETCS onboard equipment to allow the TPWS/ AWS indications to be temporarily suppressed when operating within ETCS equipped routes (levels 1-3) to avoid potential conflicts with ETCS.

A research idea has been submitted to RSSB to undertake the requirements work and will include the human factors requirements necessary for the development of a user-focussed driver machine interface. These requirements would ultimately feed into the relevant Railway Group Standard.

## 7 Summary

The introduction of TPWS has significantly reduced SPAD risk. However, TPWS will remain in existence for decades to come and there are still issues to be addressed associated with 'reset and continue'. This document describes how TPWS operates from a User's perspective whilst also recognising limitations of the track-borne, train-borne and signalling centre equipment. This operational concept has identified activities that could feed into the TPWS long term strategy which include: improvements to the TPWS DMI, consideration of track-borne equipment, the monitoring of brake demands, a review of the rules, training and competence of users and how TPWS will integrate with ERTMS.

## Appendix A Summary of observations from Sir David Davies's report and the Joint Inquiry into Train Protection Systems (Uff and Cullen 2001)

The reports contain a number of key items in relation to the expectations from TPWS at that time.

TPWS in its basic form was intended to apply to multiple unit stock with an emergency braking rate of 12%g. A train passing over the OSS at a speed of up to 75 mph, or a train travelling at up to 40 mph on passing over a train stop at a signal at danger, would be stopped within the overlap of the signal. A freight train could only be guaranteed to stop within the overlap, if approaching at lower speeds than these.

Enhanced braking performance was required as well as TPWS, and defensive driving techniques could usefully be adopted at the same time. Enhanced emergency braking could not be applied to all trains; TPWS would be about 70% effective in avoiding accidents that

could be prevented by the successful adoption of an idealised perfectly operating ATP system.

TPWS + could be effective for speeds of up to 100 mph. which would equate to avoiding about 75% of ATP-preventable accidents whilst ATP would be assumed to prevent 98%. It was impossible to predict with any degree of certainty what will be the statistical effect of TPWS, although whatever the speed and braking capability, the collision speed will be reduced to some extent.

Further examination was recommended of a proposed technique for fitting TPWS to freight locomotives to provide an enhanced warning at OSS's. It appeared technically possible to provide a third OSS loop to cater for approach speeds in excess of 100 mph, although Sir David preferred to await the availability of an ETCS solution rather than explore the feasibility of a further TPWS enhancement. However, an altered approach to regulation at junctions so that higher speed trains that cannot be fully protected by TPWS are given priority would potentially increase TPWS effectiveness by 5%.

Between 1967 and 1999, 76 ATP-preventable accidents leading to 304 fatalities had occurred, the majority arising from SPADs, six related to excessive speed, and two were buffer stop collisions at stations. Over the period 1992/3 to 1998/9, fatal accidents resulting from SPADs averaged one per year, with an average of 2.2 fatalities. Over the period 1985-1992, about 88% of SPADs led to no damage, and only 1% to injuries or fatalities. SPADs continued to have the potential for catastrophic consequences, and statistics based on averages cannot be a guide to the consequences of any particular event in the future.

The intention in 1992 was to provide TPWS in association with selected speed restrictions and those signals that protect junctions and crossing movements (about 40% of all signals). Work published in 2000 demonstrated that SPADs at locations where there are conflicting movements were increasing at the rate of about 1.4% per annum, whereas plain line SPADs were decreasing by approximately 10% per annum. This emphasised the importance of countering the effect of SPADs at junctions, with those on plain line being a lower priority. Plain line SPADs could be shown to represent only about 5% of the total SPAD risk. The same work extrapolated historic data and forecast that from 2000 to 2029 there would be 25 train accidents involving 88 fatalities, of which 18 accidents (71%) and 63 fatalities could be avoided by an 'ideal' train protection system. The basic TPWS proposed would not provide protection against the following types of SPAD:

- At signals on plain line
- SAS SPADs, in the absence of an effective overlap
- By trains unable to deliver 12%g emergency braking
- By freight trains having a long brake build up time
- By trains exceeding 75 mph at the OSS
- When adhesion conditions do not allow trains to deliver 12% g emergency braking.

If TPWS was to become the principal means of protection against SPADs it would be important to note the limitations of the system, which relate primarily to the speed of the train, but also to the fact that many signals would not be fitted. In approximate terms, if TPWS was capable of eliminating up to two-thirds of ATP-preventable fatalities, SPAD reduction and

mitigation (SPADRAM) must be relied upon to avert the rest. The pursuit and development of SPADRAM measures to minimise further the possibility of accidents resulting from SPADs (not TPWS preventable) would remain important. A number of initiatives were being pursued, in particular:

- Research into multi-SPAD signals and causes.
- Dissemination of information and design and implementation of mitigation measures following multiple-SPADs to be kept under review. Analytical methods of identifying signals which pose the greatest risk to be pursued with urgency.
- Research into human factors to be pursued, with particular emphasis on driver selection, training and management, and signal sighting issues.
- A proposal for research into the possibility of conflict between defensive driving and punctuality.
- Use of the DRA to be standardised and work on the automatic version pursued.

The principal issue concerning TPWS was whether even more complex variants on the system should be developed and put into use. Related to this issue was the question of limitations on the ability of the system to provide effective train protection and what measures should be taken to improve its effectiveness.

A study in 1997 showed that 90% of the risk would be removed by fitting TPWS in association with 15 to 18% of signals. The requirement in the 1999 Regulations to fit all signals protecting junctions represented between 40 and 50% of all signals on the network.

The effect of developing TPWS+ was not quantified, but trains with different braking characteristics and travelling at different speeds would be protected to varying degrees, depending on the location of the additional OSS. OSS loops placed to arrest the speed of trains with lower braking characteristics would unnecessarily reduce the speed of trains with higher braking capability.

It was important to keep in view the original objective of TPWS to provide a quick and cheap stop-gap solution. More than one expert at the Joint Inquiry had expressed the view that TPWS was becoming too complicated for the benefits it could produce.

Apart from the possibility of enhancing the basic model TPWS, the report considered other means of enhancing its performance, which would improve the performance of any train control system. These included:

- Enhanced emergency braking
- Improved adhesion devices
- Altered track layouts to increase the length of overlaps

A concern remained that the effectiveness of TPWS is least where the risk is greatest, namely on high-speed trains with braking capability falling well below the optimum.

A further concern was the decision to fit TPWS to all junction signals, with plain line signals awaiting a later risk assessment. The authors preferred to see fitment generally based on risk

assessment. Should TPWS+ prove successful, its fitment should be concentrated on lines carrying high-speed trains and on lines carrying other trains which cannot be stopped by the basic TPWS.

DRAFT

**Appendix 3. Review of recommendations with relevance to TPWS**

DRAFT

<b>Cullen – Uff Inquiry</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
<b>12.5 Train protection and warning system (TPWS)</b>			
4. The current mandated fitment of TPWS-A to trains and track should not be reversed (para 11.15).	<b>RT &amp; TOCs</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
5. Track fitment should include all multi-SPAD signals unless they present no risk (para 11.16).	<b>RT</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
6. Risk assessments should be carried out on plain line signals, initially on those considered by TOCs to pose significant risk (para 11.16).	<b>RT &amp; TOCs 01/01/03</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
7. Track fitment should include plain line signals where the risk from SPADs is established to be significant (para 11.16).	<b>RT 01/01/04</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005



8. Risk assessments should be carried out to identify junction signals where the risk from SPADs is insignificant. Consideration should be given to obtaining exemptions for such signals from track fitment (para 11.16).	<b>RT &amp; TOCs 01/01/02</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005

<b>Cullen – Uff Inquiry</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
<b>12.6 TPWS+</b>			
9. Trials should be carried out on TPWS+ using single and multiple additional Over Speed Sensors (OSS) with the aim of drawing up a design standard and measuring the effect of additional OSS on different types of train and on driving techniques (para 11.20).	<b>RT &amp; TOCs 01/01/03</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
10. If proved to be feasible, a full appraisal of the effect of one or more additional OSS on all traffic passing a signal should be carried out before fitment of additional OSS (para 11.20).	<b>RT &amp; TOCs 01/01/04</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
11. Fitment of TPWS+ should be concentrated on lines carrying High Speed Trains and on lines carrying other passenger trains which cannot be stopped within the normal overlap by TPWS-A (para 11.20).	<b>RT From 2004</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
<b>12.7 TPWS-E</b>			

12. No recommendation is made for continued testing or fitment of TPWS-E (para 11.19).			
<b>12.8 TPWS Fitment</b>			
13. Fitment of TPWS-A should continue in accordance with the currently accelerated	<b>RT &amp; TOCs</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining

<b>Cullen – Uff Inquiry</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
programme (para 11.17).			recommendations from Rail Public Inquiries – HSC November 2005
14. All parties should co-operate in the production and updating of a resource allocation programme directed towards the matching of track and rolling stock fitment, in order to maximise the early attainment of TPWS protection (para 11.17).	<b>RT &amp; TOCs HMRI 01/01/02</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005
15. The accelerated programme should be reviewed and updated to ensure that it is compatible with the early attainment of TPWS protection and that any adverse consequences do not outweigh the benefits of accelerated fitment (para 11.17).	<b>RT &amp; TOCs HMRI 01/01/02</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005

16. Steps should be taken to ensure that TPWS fitment is completed in such time and manner as not to delay fitment of ETCS (see recommendation 27 below) (para 11.11).	<b>RT &amp; TOCs HMRI 01/01/02</b>	Completed	As reported in HSC report on overall progress as of April 2003 on the remaining recommendations from Rail Public Inquiries – HSC August 2003
17. For the fitment of train-borne TPWS. AWS components should be replaced to maximum extent practicable. For this purpose the ATOC TPWS Executive should draw up a standard for the replacement of AWS in train-borne TPWS equipment (para 6.18).	<b>ATOC ROSCOs 01/06/01</b>	Completed	As reported in HSC report on overall progress as of March 2005 on the remaining recommendations from Rail Public Inquiries – HSC November 2005

<b>V/TC&amp;C Technical Subgroup</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
<b>TPWS Status report</b>			
<b><u>Summary of Recommendations</u></b>			
<b>RECOMMENDATION 1</b>			
The V/TC SIC Technical Sub Group recommends that before any new train protection system is employed on the UK railway, detailed analysis of system performance is required to ensure that a repetition of performance constraint issues (e.g. TPWS “buffer stop” issues) are avoided.	<b>VTC&amp;C SIC</b>	Accepted and managed by individual duty holders SMS.	TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB.
<b>RECOMMENDATION 2</b>			

The V/TC SIC Technical Sub Group recommends that the system should be life extended until it can be replaced by an alternative system. In its current form the Technical Sub Group believes it can be life extended to make it compatible with the Network Rail medium and long-term signalling replacement programme and to meet the current timescales of ERTMS roll out in 2040.	<b>VTC&amp;C SIC</b>	Accepted	TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB. Issue now widely recognised and being closely monitored by HMRI.
<b>RECOMMENDATION 3</b>			
The V/TC SIC Technical Sub Group recommends that opportunities to introduce new suppliers of TPWS equipment should be considered. In particular, consideration should be given to systems	<b>VTC&amp;C SIC</b>	Accepted	TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB.

<b>V/TC&amp;C Technical Subgroup</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
where enhanced safety features and functionality could be provided within the existing system architecture.			
<b>RECOMMENDATION 4</b>			
The V/TC SIC Technical Sub Group recommends that the V/TC SIC encourage the vehicle owners and operators to provide information of the OTMR interfaces to facilitate resolution of the relay 1 – 12 issue.	<b>VTC&amp;C SIC</b>	Closed	TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB. Supply industry has resolved this issue with both new and existing technology.
<b>RECOMMENDATION 5</b>			

<p>The V/TC SIC Technical Sub Group seeks support from the V/TC SIC to encourage the industry members listed in TIP (Technical Advice Pamphlet) 003 (Appendix B) to capture those remaining “at risk” TPWS control units, which may be in fleet operation.</p>	<p><b>VTC&amp;C SIC TOCs and ROSCOs</b></p>	<p>Accepted and Risk Managed</p>	<p>TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB. The majority of at risk TPWS control units have now been accounted for. Those remaining, are believed to be fitted to mothballed rolling stock. Part of the recommissioning of such stock includes a TPWS Control Test and serial number check to expose any at risk units.</p>
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<b>V/TC&amp;C Technical Subgroup</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
<b>RECOMMENDATION 6</b>			

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<p>The V/TC SIC Technical Sub Group recommends the following course of action in relation to the current issues with regards of the of the electronic single strength receiver :</p> <ul style="list-style-type: none"> <li>○ For trains operating only over routes with standard strength AWS magnets the sensitivity of the AWS receivers should be set in line with the appropriate Group Standard requirements.</li> <li>○ For trains operating only over routes with extra strength AWS magnets the sensitivity of the AWS receivers should be set in line with the appropriate Group Standard requirements.</li> <li>○ No retrospective action should be imposed for trains currently operating, with single sensitivity receivers, over routes with both standard and extra strength AWS magnets although the following mitigation should be pursued: <ul style="list-style-type: none"> <li>• These trains should be set as the priority for undertaking vehicle characterisation as soon as the depot test equipment being developed by STS is available.</li> </ul> </li> </ul>	<p><b>VTC&amp;C SIC TOCs and ROSCOs</b></p>	<p>Accepted Ongoing</p>	<p>TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB. Derogations to the Group Standard to support single strength receivers have been sought and granted by a number of operators. Issue needs to be considered and incorporated in the next version of the GS.</p>
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V/TC&C Technical Subgroup	Responsibility	Status	Comments
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<ul style="list-style-type: none"> <li>• The industry should monitor and keep accurate records of : <ul style="list-style-type: none"> <li>▪ any occurrences of AWS failures (which should be acted upon) that could be related to receiver sensitivity, and;</li> <li>▪ measurements taken with the STS AWS testing equipment.</li> </ul> </li> <li>○ Applications for new rolling stock and changes to route availability of existing rolling stock, using a single strength sensitivity receiver over extra and standard strength AWS magnets, should not be permitted to use the existing noncompliances as demonstrations of compliance but must make individual applications for non-compliance for the class of vehicle.</li> <li>○ Applications for new rolling stock and changes to route availability of existing rolling stock, using a single strength sensitivity receiver over extra and standard strength AWS magnets, should not be permitted to use the existing noncompliances as demonstrations of compliance but must make individual applications for non-compliance for the class of vehicle.</li> </ul>			
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V/TC&C Technical Subgroup	Responsibility	Status	Comments
<ul style="list-style-type: none"> <li>o No changes should be made to Group Standards until such time as the effect of any performance degradation is established and the tolerability considered.</li> </ul>			
<b>RECOMMENDATION 7</b>			
<p>The Technical Sub Group recommends that the V/TC SIC should encourage TOCs / FOCs / Plant Operators to undertake a programme of fitting composite aerial harness, solid state receiver, and control unit at modification 4, in order to increase availability of the TPWS systems and enhance performance.</p>	<b>VTC&amp;C SIC</b>	Accepted Closed	<p>TPWS Report accepted by SIC and distributed throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB. Proactive retro fitment of composite aerials and Mod 4 control units has occurred in the majority of cases. Remaining Mod 3 or earlier Control Units still at risk will be slowly changed through defect repair or system upgrade.</p>
<b>RECOMMENDATION 8</b>			
<p>The Technical Sub Group recommends that a measurable and repeatable AWS testing process is developed and approved to replace the existing practices.</p>	<b>AWS Working Group</b>	Ongoing	<p>Based on the current progress of RSSB T804 &amp; 808 Research Projects, the AWS Working Group should be in a position to offer the TOCs and relevant maintenance facilities a new repeatable and measurable AWS testing regime, which would be suitable for use on a significant proportion of the national fleet towards the end of Summer 2010.</p>
<b>RECOMMENDATION 9</b>			



The V/TC SIC Technical Sub Group recommends	<b>VTC&amp;C SIC</b>	Accepted	TPWS Report accepted by SIC and distributed
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<b>V/TC&amp;C Technical Subgroup</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
that the V/TC SIC strongly encourages the train operators, vehicle maintainers and equipment suppliers, to participate in, and promote the sustained use of the ARTTT database.	<b>HMRI</b>	Ongoing	throughout the industry including suppliers. SIC membership includes RIA, ATOC, ROSCOs and RSSB. Despite continued pressure being applied by industry, usage of the ATOC Component Tracker (formally called the ARTTT) is still not as high as desired. The HMRI are closely monitoring the situation and have written to TOCs on the matter.
<b>RECOMMENDATION 10</b>			
The Technical Sub Group Recommends that this report is made available to the industry to enable users and purchasers of the equipment to make informed ALARP (As Low As Reasonably Practicable) choices of system / manufacturer.	<b>VTC&amp;C SIC</b>	Closed	The Report was circulated to all relevant industry player and other interested parties, both in the UK and abroad.

<b>TPWS Joint Technical Working Group</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
4. The recommendations			
<b><u>Recommendation 1</u></b>			

Cross talk much be prevented in antenna feed cable by independent screening on any new build or major overhaul.	Nick Wright	Ongoing, to be included in next issue of System Guidance Note	Recommendation is not a functional requirement; it is more concerned with reducing risk and employing good engineering practise. Thus, it will be difficult to incorporate them into a Group Standard or NNTR. It is proposed that these 2 recommendations should be included in a relevant System Guidance Note.
<b><u>Recommendation 2</u></b>			
Train borne TPWS equipment should be able to provide confirmation that the wiring integrity from the TPWS antenna has been compromised whilst in service.	RSSB	Ongoing	This functionality is being incorporated into the design of the new TPWS control units specified in the RGS for new trains and RIS for existing trains.
<b><u>Recommendation 3</u></b>			
TPWS and AWS antennas should be co-located wherever physically possible.	Nick Wright	Ongoing to be included in next issue of System Guidance Note	Recommendation is not a functional requirement; it is more concerned with reducing risk and employing good engineering practise. Thus, it will be difficult to incorporate them into a Group Standard or NNTR. It is proposed that these 2 recommendations should be included in a relevant System Guidance Note.
<b>TPWS Joint Technical Working Group</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
<b><u>Recommendation 4</u></b>			

A regular in-service test of the functionality of the system should take place.	RSSB	Ongoing	This functionality is being incorporated into the design of the new TPWS control units specified in the RGS for new trains and RIS for existing trains.
<b><u>Recommendation 5</u></b>			
The railway industry needs to confirm fully that a detected in-service failure should not result in a system initiated brake application.	RSSB	Ongoing	This functionality is being incorporated into the design of the new TPWS control units specified in the RGS for new trains and RIS for existing trains.
<b><u>Recommendation 6</u></b>			
An in-service failure must result in a conspicuous, unambiguous warning to the driver whether visible or audible or both it should be the same was the warning for a start up failure.	RSSB	Ongoing	This functionality for a visual indication is being incorporated into the design of the new TPWS control units specified in the RGS for new trains and RIS for existing trains.
<b><u>Recommendation 7</u></b>			
A simple and robust go/no-go test device of a minimum specified signal strength proving the physical location and sensitivity of the antenna and system is required. This testing should be undertaken regularly (C Examination would be appropriate).	Nick Wright, FGW	In development	What the HMRI is require is, in essence a TPWS Go/No Go tester which can simulate the weakest signal the trackside system could transmit, which would still be received and acted upon by the onboard system. In other words an onboard receiver sensitivity check. This initially sounds simple to achieve, however in reality it is

<b>TPWS Joint Technical Working Group</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
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			<p>somewhat more complex. We should not implement a TPWS trackside test system such as the AWS test depot magnet as this would trip every train traversing over such a magnet when entering or leaving a depot, which would then actively promote a legitimate reset and continue event. What is required is a truly portable test device which does not require individual output settings, which are potentially different between system applications and vehicle classes. STS Signals have been looking at the development of such a device but currently it is still rather cumbersome. No forecast date has been provided as to when this development might complete.</p>
<b><u>Recommendation 8</u></b>			
<p>Modifications to existing equipment to meet the above recommendations must be fully compatible with any imminent modifications for reset and continue risk reduction.</p>	RSSB	Ongoing	<p>This is recognised in the design of the new TPWS control units specified in the RGS for new trains and RIS for existing trains.</p>
<b>RAIB Recommendations - Purley: (T172 passed at danger, 18 August 2006)</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>

2 EWS should deliver a specific TPWS training module for all drivers and assessors; new and experienced. This should include the correct procedures in the case of TPWS intervention (paragraphs 175 and 181).	DB Schenker	Closed	
4 RSSB should make a Proposal, in accordance with the Railway Group Standards Code, to amend Railway Group Standards as appropriate to: I mandate that in-cab TPWS should specifically identify a TPWS activation associated with a SPAD, (if reasonably practicable)(paragraph 133); and I prevent the use of the driver's reverser key to reset TPWS once activated (Appendix E).	RSSB	Closed	RSSB has conducted a significant amount of work on the subject of the issue of resetting TPWS in support of the industry, and has drawn some conclusions that are relevant to the RAIB recommendation. In particular, three modifications to TPWS equipment have been examined and a recommendation was made to the RSSB Board in July 2007. The first of the three modifications considered included specifically the two elements of Recommendation 4. The RSSB Board considered the paper at its meeting on 26 July, and concluded that it is not reasonably practicable for the two modifications recommended in the RAIB report to be mandated through group standards. Although the clear decision was taken that it is not reasonably practicable to make the changes to standards suggested in the RAIB report, RSSB
<b>RAIB Recommendations - Purley: (T172 passed at danger, 18 August 2006)</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>

			<p>was asked by its Board to support the train operating community in considering whether there is an overall business case for the modifications recommended on the basis of non-mandatory fitment. Subsequent to the Board decision ATOC Operations Council has picked up the consideration of this issue, with RSSB support. We can confirm that we are supporting the train operating community who are actively considering whether they wish to adopt the modification for existing stock and future.</p>

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RAIB Recommendations - Didcot North (signal passed at danger, 22 August 2007)	Responsibility	Status	Comments
<p>2 Network Rail should, in consultation with train operators, review its existing risk assessments for all existing junction signals in order to verify that:</p> <p>a) the actual braking performance of trains signalled by that route has been and;</p> <p>b) proper consideration has been given to any reasonably practicable measures identified.(paragraphs 234b and 236) When addressing this recommendation Network Rail should ensure that risk assessors are competent and have access to accurate input data (paragraph 230).</p>	Network Rail	Ongoing; on target for completion by 31/12/09	<p>TSG19/1/09.Network Rail cannot ensure that risk assessors are competent and have access to accurate input data, however the recommendation will be addressed as follows: Completion of recommendations 3 and 9 are precursors to being able to undertake the review. These will have been addressed by early 2010. The review of existing risk assessments to address;</p> <ul style="list-style-type: none"> <li>• the actual braking performance of trains signalled by that route has been correctly taken into account; and</li> <li>• proper consideration has been given to any reasonably practicable measures identified,</li> </ul> <p>will be undertaken as part of the 5-yearly cycle of signal risk assessment reviews, concluding by 31st October 2016.</p>
<p>3 In support of Network Rail's assessment of risk at junction signals (see Recommendation 2), RSSB should make a 'proposal', in accordance with the Railway Group Standards Code, to amend Railway Group Standards to require train operators, in consultation with rolling stock owners, to publish and disseminate to Network Rail any detailed data they may possess relating to the actual braking performance of the trains they operate on the national network (for a range of typical train formations). This should include the distance to stop from a range of speeds (or the duration of any freewheel time and the subsequent rate of deceleration) (paragraphs 242 and 243).</p>	RSSB	Closed	<p>In support of Network Rail's assessment of risk at junction signals (see Recommendation 2), RSSB should make a 'proposal', in accordance with the Railway Group Standards Code, to amend Railway Group Standards to require train operators, in consultation with rolling stock owners, to publish and disseminate to Network Rail any detailed data they may possess relating to the actual braking performance of the trains they operate on the national network (for a range of typical train formations). This should include the distance to stop from a range of speeds (or the duration of any freewheel time and the subsequent rate of deceleration). We consider that provision for the above already exists under the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS), the Duty of Cooperation and Railway Group Standard 8270. The latter in particular provides a process by which 'data sharing' can be facilitated. We consider this recommendation to be closed.</p>

<b>RAIB Recommendations - Didcot North (signal passed at danger, 22 August 2007)</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
4 RSSB, in consultation with industry stakeholders, should review the practicability of enhancing the minimum emergency braking performance mandated for new passenger trains in Railway Group Standards. The objective of any such enhancement shall be to improve consistency between the minimum braking performance of new passenger trains and the design of train protection systems in use on the network. If shown to be reasonably practicable, RSSB should make a 'proposal', in accordance with the Railway Group Standards Code, to amend	RSSB	Closed	RSSB consider that all new rolling stock requirements will be addressed by the European Technical Specifications for Interoperability (TSI). The existing Railway Group Standards already offer adequate provision until the TSIs come into force. RSSB consider this recommendation to be closed.



<p>5 Network Rail should review its management processes with the objective of ensuring that: a) the findings of signal and layout risk assessments (using tools such as SAT) are translated into reasonably practicable measures to address the risk identified (paragraph 236); and b) relevant risk assessments are properly considered when reviewing the actions to be taken in response to recommendations made following investigations (paragraph 237).</p>	<p>Network Rail</p>	<p>Closed; we believe we already have adequate processes in place, and that these are the subject of regular review</p>	<p>TSG 19/1/09-Accept &amp; close Network Rail cannot ensure that</p> <ul style="list-style-type: none"> <li>the findings of signal and layout risk assessments (using tools such as SAT) are translated into reasonably practicable measures to address the risk identified (paragraph 236); and</li> <li>relevant risk assessments are properly considered when reviewing the actions to be taken in response to recommendations made following investigations (paragraph 237), however the recommendation has been addressed as follows: <ul style="list-style-type: none"> <li>Re the findings of signal and layout risk assessments: Company Standard NR/L2/SIG/14201 sets out the process and tools that Network Rail uses to comply with the Railway Group Standard GI/RT7006, Prevention and Mitigation of Overruns – Risk Assessment, and its associated Guidance Note GI/GN7606. Specifically the standard mandates: <ul style="list-style-type: none"> <li>The structured approach to signal overrun, i.e. “Signal Passed at Danger” (SPAD) risk assessment on Network Rail Controlled Infrastructure.</li> <li>The appropriate strategies, tools, and techniques to be applied under the variety of operational and developmental situations that lead to a requirement for a signal overrun risk assessment to be undertaken.</li> <li>A clear approach to SPAD risk assessment, which is to be</li> </ul> </li> </ul> </li> </ul>
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<b>RAIB Recommendations - Didcot North (signal passed at danger, 22 August 2007)</b>	<b>Responsibility</b>	<b>Status</b>	<b>Comments</b>
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			<p>standardised throughout Network Rail. This standard applies to anyone given the responsibility by Network Rail for conducting overrun risk assessments of railway signals forming part of track layouts and fixed block signalling systems on Network Rail Controlled Infrastructure. They may be either Network Rail employees or appointed contractors/consultants acting on behalf of Network Rail. It is used for the assessment of safety risk:</p> <p>During the design of new/altered layouts and fixed block signalling systems on Network Rail Controlled Infrastructure Arising as a result of the operation of layouts and signalling. In determining whether the identified mitigation options are reasonably practicable to implement the requirements of the Operations Manual Procedure NR/L3/OCS/041/5-14 titled 'Determining the Reasonable Practicability of SPAD Reduction and Mitigation Works' apply.</p> <ul style="list-style-type: none"> <li>• Re proper consideration of relevant risk assessments: Work Instruction NR/L3/INV/0302 sets out the process for the management of recommendations and local actions arising from inquiries and investigations. This has been reviewed and reissued since the Didcot North incident and specifically mandates that recommendations review panels (at a national and route level) shall be established, and that following the review of recommendations those that are accepted, are to have lead managers allocated, implementation timescales assigned and that each recommendation is risk ranked. The work instruction further requires that progress of recommendations is tracked at an appropriate level (national or route) and that any timescale extension shall take into consideration the review panel's ranking of the recommendation, i.e. in the case of a recommendation ranked as 'high' the review panel should ask the lead manager to identify any mitigation measures that may be needed until the recommendation is implemented.</li> </ul>
<p>9 Network Rail should ensure that its methodology and computer systems for assessing the risk associated with signal overruns correctly take into</p>	<p>Network Rail</p>	<p><b>Closed; this has been addressed</b></p>	<p>TSG 19/1/09-The current SAT-DA methodology used for undertaking signal overrun risk assessment requires an evaluation of TPWS effectiveness to be made. The Excel spreadsheet supplied with the SAT-DA application allows average decelerations of 7%g, 9%g and 12%g to be</p>

RAIB Recommendations - Didcot North (signal passed at danger, 22 August 2007)	Responsibility	Status	Comments
<p>account the actual braking performance of all trains scheduled to pass a signal. This should allow for freewheel time and the subsequent average deceleration (paragraph 242).</p>		<p>by issue 3 of Technical Instruction TI095 (issued 25/09/09) entitled "Signal Overrun Risk Assessment"</p>	<p>used. 'Freewheel time' is not taken into account. To remedy this further, spreadsheets have been produced to supplement the one supplied within the application. The version used by O&amp;CS allows for a 'freewheel' time of 2 second and braking rates of 4%g, 6%g, 7.5%g, 9%g and 12%g. A more recent version produced by Engineering allows 'freewheel time' to be entered separately for passenger and freight stock. It also calculates the stopping distance for the same range of braking rates.</p> <p>To date the data relating to the 'freewheel time' and average deceleration for each train operating on the network has not been readily available.</p> <p>Recommendation 3 of the RAIB report seeks to address this issue through recommending that RSSB should collate this information on the Industry's behalf.</p> <p>RSSB have declined to accept this recommendation and therefore Network Rail will need to seek this information from the TOC/FOCs (who in turn may need to request it from the ROSCOs and/or manufacturers) under the provisions of GE/RT8270 (Duty of Co-operation).</p> <p>This will take time to request, obtain and collate. Completion of this action is a precursor to being able to meet the requirements of this recommendation.</p> <p>Network Rail is currently in the process of completing the specification for a new signal overrun risk assessment tool known as SORAT.</p> <p>Provision has already been made within the specification for the inclusion of 'freewheel time' and average deceleration for a number of speed 'bands'.</p> <p>The Invitation to Tender is planned to be issued in Mar 2009 and subject to satisfactory design, development, implementation, testing and training, go-live of the system is scheduled for end-Summer 2010.</p> <p>Risk Assessments for New Schemes undertaken using the SORAT methodology will meet the requirements of this recommendation from October 2010.</p> <p>Risk Assessments for Existing Layouts will use the SORAT</p>

RAIB Recommendations - Didcot North (signal passed at danger, 22 August 2007)	Responsibility	Status	Comments
			methodology when they are next assessed (on a 5 yearly cycle). It is therefore reasonable to assume that the requirements of this recommendation will be met by 31 October 2016; although this date has some uncertainty as it several years into the future.

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