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Automating high risk road works processes - quantifying the benefits

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Executive Summary

The automation of works activities and operations has become increasingly prevalent. The efficiency and safety benefits achievable are well documented across many different sectors; advancements in technology and computing have brought about new practicable options for automating activities within the traffic management sector.

Through the investigation of reported incident data, stakeholder consultation, and a comprehensive review of published literature, several high risk traffic management works activities suitable for automation have been identified. Any potential automation solution that can be used to reduce the likelihood or severity of incidents during these works activities should be investigated.

To achieve zero harm to individuals travelling or working on the road network, focus needs to be placed on the safe development and application of such solutions. The investigations detailed in this interim report outline that operational activities around the protection of temporary traffic management have resulted in the highest number of collision type incidents involving impact protection vehicles reported in the last three years, resulting in injuries to operatives driving the aforementioned protection vehicles.

By automating the installation and removal of temporary traffic management, through the use of technology, the requirement for operatives to be present on the carriageway can be reduced. Removing the operatives would then remove the requirement for dedicated impact protection vehicles and thus reduces the likelihood of collisions between road users and such vehicles.

Several such technology solutions currently exist, be it in development or market ready form. These solutions are currently being mapped by Highways England as part of several separate investigations.

1 Introduction

1.1 Background

Impact Protection Vehicles (IPVs) are used extensively across the Strategic Road Network (SRN) to reduce the risk associated with collisions between road users and vehicles, plant or hazards present on or off the live carriageway during traffic management operations (Wood *et al.*, n.d.). The implementation of these operations and the use of IPVs expose IPV operatives and road users to the risk of collisions with IPVs on a daily basis, potentially resulting in both damage and injury.

Highways England has the intent that by 2020, no-one should be harmed when travelling or working on the SRN, with considerable support being given to safety innovations to achieve this goal. A reduction in the probability of incidents involving IPV collisions and the severity of injuries sustained (by parties involved) could well be achieved through the automation of traffic management operations and works activities.

1.2 Wider investigation

It is intended that these investigations seek to understand which activities are most suitable for the introduction of automation and to support innovation planning targeted towards reducing or eliminating the requirement for operatives to work in high risk situations.

This wider investigation includes the following work areas:

1. **Defining a case for action**: by reviewing incident data across the strategic road network, focusing on incidents involving collisions with IPVs.
2. **Selecting the optimum solution**: by identifying high risk activities which could benefit from automation through the use of outputs from the previous work area.
3. **Engaging with stakeholders**: to understand their views regarding automation, as well as seeking ratification of findings from both previous work areas.
4. **Map implementation**: of the identified optimum solutions whilst focusing on; performance requirements, timescale to implementation, cost and potential benefits.
5. **Scope proof-of-concept**: for a real-world trial of the optimal solutions, clearly defining monitoring requirements, success criteria and risk management processes for a future investigation.

1.3 Contents of this report

This report summarises the findings from the first three work areas of TRL's investigation into the potential automation of high risk road works processes. These areas are: outlining the results from the investigation into the datasets, summarising the findings from stakeholder engagement and outlining which high risk activities should be taken forward into later work areas.

1.4 Terminology

In line with previous investigations by TRL investigating collisions involving IPVs, IPVs are referred to as vehicles equipped with a Lorry Mounted Crash Cushion (LMCC) complying with TD49/07, Requirements for Lorry Mounted Crash Cushions (Highways England, 2007). These vehicles include, but may not be confined to, Incident Support Units (ISUs), dedicated IPVs and Traffic Management Vehicles that are equipment with an LMCC (Wood *et al.*, n.d.).

Further to these vehicle types, for the purpose of this report, vehicles used to provide protection to recovery services within temporary traffic management have been included.

The terms used to describe the types of operational works conducted by IPVs are as follows:

- **Mobile lane closure**: this includes all mobile lane closure works on motorways and high-speed dual carriageways. Works to be conducted at a constant low speed or with repeated movement and periodic stops in which an IPV is used in the live carriageway to provide protection to works vehicles and is supported by mobile advanced warning signs.
- **Temporary traffic management**: this includes all standard and relaxed planned static works on motorways and high-speed dual carriageways. Works to be conducted to deploy and retrieve planned lane closures in which an IPV is used either in the live carriageway or on the hard shoulder to provide protection to works vehicles and/or operatives and is supported by static advanced warning signs.
- **Impact protection**: this includes works on motorways and high-speed dual carriageways in which an IPV is used on the hard shoulder to provide protection to works vehicles or operatives, works to be conducted at a constant low speed or with repeated movement and periodic stops.
- **Incident support and recovery**: this includes works on motorways and high-speed dual carriageways in which an IPV or ISU is used to provide protection either in the live carriageway or on the hard shoulder for emergency traffic management or vehicle recovery. Although vehicles used for incident support and recovery roles vary, this study considered only those collisions involving vehicles fitted with LMCCs.
- **Short term closure**: this includes all short-term work activities of up to 45 minute durations on motorways and high-speed dual carriageways. Works to be conducted include small scale planned maintenance activities where live lane working would be a method normally considered, in which an IPV is used in the live carriageway to provide protection to works vehicles and/or operatives.

An IPV's primary role is to provide clear direction to approaching traffic on how to navigate around an obstruction in the carriageway. This is achieved through the use of authorised traffic signs mounted on the rear of the vehicle.

The size and nature of the vehicles used to carry these authorised signs pose additional risks to road users in the event of a collision. LMCCs were introduced to reduce the risks posed to road users from these collisions.

Dual vehicle working requires the use of two vehicles operating with a separation distance of 50-100m as specified in guidance (DfTt / Highways England, 2016). The introduction of dual vehicle working provided a marked increase in safety benefits for road works operatives working on or around high speed carriageways. By moving the operatives away from the vehicle carrying the signage and placing them in a secondary vehicle, the risks posed to said operatives from collisions with road users was reduced.

2 Incidents involving impact protection vehicles

2.1 Data collection

Data regarding collisions involving IPVs on Highways England's SRN were obtained for the period from 1st January 2016 to 31st December 2018 from the following sources:

- Highways England databases:
  - Accident Incident Reporting System (AIRSWeb)
  - National Incident Liaison Officer (NILO)
- Datasets of IPV collisions identified in previous research investigations

2.1.1 Research dataset

Previous exploratory risk investigation into IPV collisions concluded that, at the time, the most comprehensive nationwide source of incident data available was the AIRSWeb database (Wood *et al.*, n.d.). After seven years, a similar conclusion can be drawn as it is still the primary incident reporting system used by Highways England and its supply chain. For this reason, the AIRSWeb dataset was selected to be used as a baseline dataset. Other sources, such as NILO, were then compared to the baseline set. This resulted in a number of additional incidents being added to the dataset.

The search criteria used to investigate these datasets focused around the following list of search terms; "IPV", "TMIPV", "Cushion", "Impact Protection", "TMA", "traffic mounted attenuator", "LMCC", "Dual vehicle". As the investigation made use of the free text descriptions within the AIRSWeb dataset, searches were expanded to include case sensitive versions of the aforementioned search terms.

In total there were 76 unique reported incidents involving collisions with IPVs from 1st January 2016 to 31st December 2018, of which 45 were recorded in AIRSWeb and 31 further incidents were documented within NILO reports.

During the current investigation, several incidents involving collisions with IPVs were identified that were located off the SRN, on minor or local authority roads. These incidents have been excluded from the main comparisons however details have been outlined within Section 2.3 later in this report.

2.1.2 Dataset issues

AIRSWeb held records regarding 45 incidents involving a collision with an IPV in operational use (59% of the research dataset). Guidance for reporting incidents in AIRSWeb (Highways England, 2018) details that all incidents involving injuries, damage or high potential near misses should be reported on AIRSWeb within 24hrs of the incident occurring. Suppliers then have 10 working days to upload full incident investigation reports along with action plans and safety alerts (where applicable) to AIRSWeb.

The aforementioned guidance is intended to relate to all incidents involving Highways England's supply chain, ensuring Highways England can fulfil its duties to improve safety. Therefore, all incidents involving collisions with IPVs should have been reported. The difference seen between all collisions and those reported via AIRSWeb indicates the potential for improving the level of reporting and, therefore, the value of the data source. Inconsistencies in what suppliers report or identify as an incident or near miss has likely contributed to significant levels of under reporting.

Aside from the comprehensiveness of the data sources, a number of other issues surrounding the AIRSWeb dataset have been established:

- No direct marker to indicate if the LMCC on the IPVs was in use
- Varying levels of comprehensiveness and accuracy for free text entries
- Information on the activity being undertaken during the time of the IPV collision is often absent
- Information on the types of vehicles involved in incidents is also often missing
- Information of the injuries sustained and their severity is missing for both the IPV driver as well as the occupants of the other vehicle.

2.2 Data analysis

The following sections present the key findings from the analysis of collision and exposure data, three main areas were considered:

- The trend in the number of collisions with IPVs, including consideration of the activity associated with each IPV operation
- The most common activity types involved in collisions with IPVs
- The types of collisions with IPVs which are most injurious.

2.2.1 Trend in collisions

Figure 1 displays the number of collisions with IPVs by year. Where available, data from AIRSWeb and NILO have been combined to provide a total number of collisions involving IPVs on the SRN.

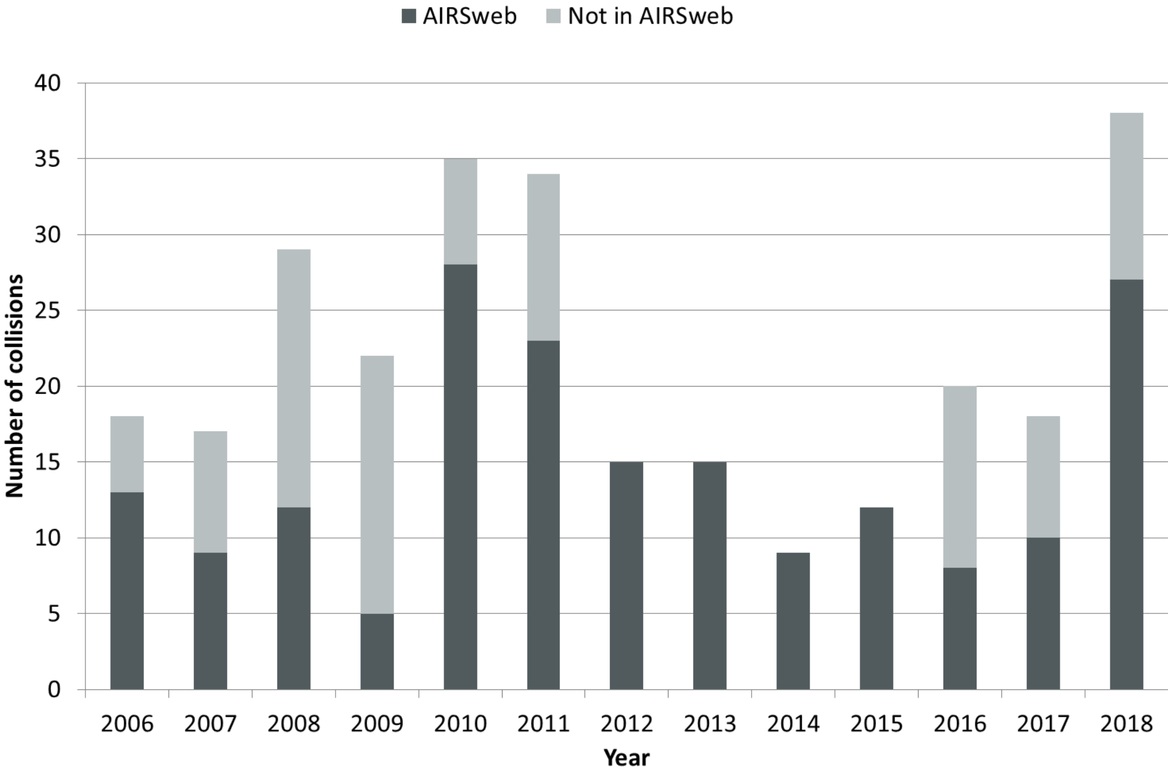

Figure 1: Collisions involving IPVs on the SRN

Due to the reported issues, missing years of data and the limited confidence in the accuracy of the datasets caution should be taken when identifying trends in the number of reported collisions involving IPVs on the SRN. It appears that 2018 saw the highest number of reported collisions involving IPVs in the last 12 years.

Overall there is too much variation in the reported numbers of collisions year on year to identify any particular trend. Though natural statistical variation will in some part account for this, fluctuations in levels of under reporting and updates to AIRSWeb during 2016 also need to be considered when viewing the difference in reported numbers of collisions.

2.2.2 Activity types involved in collisions with IPVs

Where possible, the details of the operational role of the IPV on the carriageway when it was struck were identified; a full list of these operational roles are outlined in Section 1.4 of this report. Figure 2 shows the breakdown by year, of the activity being carried out by the IPV at the time of the collision.

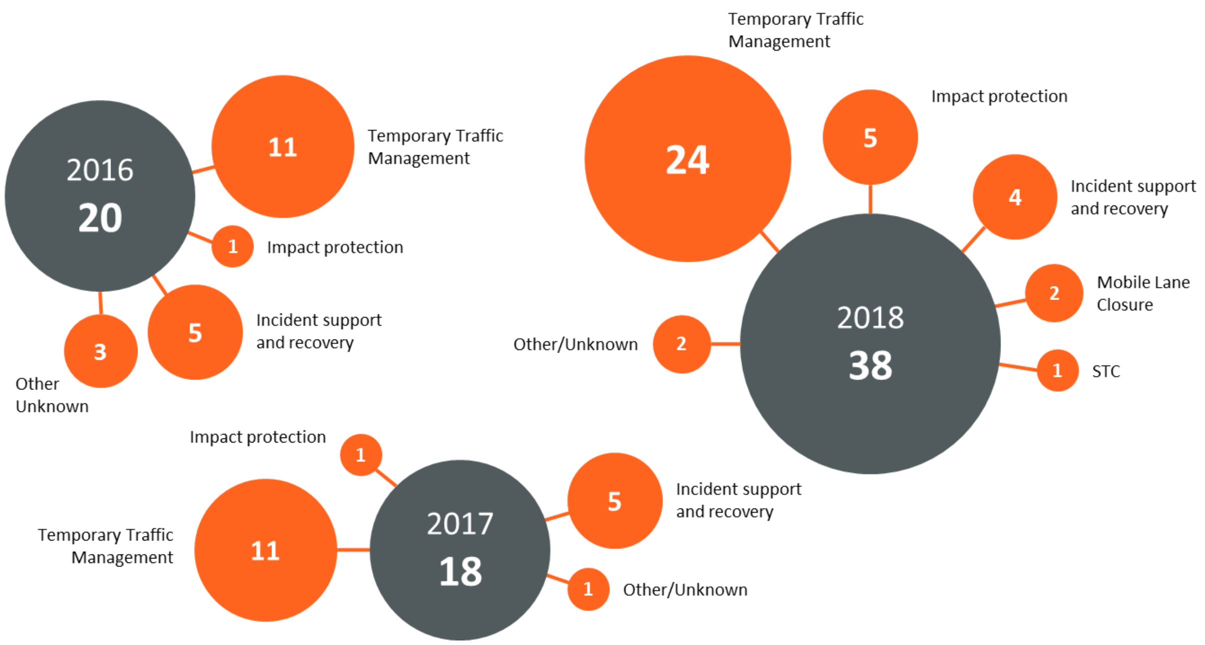

Figure 2: Operational activity being undertaken at time of IPV collision

Across the three years included in this study, it is clear that IPVs are struck most frequently when they are undertaking temporary traffic management activities (61%). Numbers of reported incidents involving other operational activities were relatively low across the same period of time. It is unknown how many times an IPV was used to undertake these specific operational activities during the three year period. However, as temporary traffic management operations are likely to be the most common type of activity undertaken, it is also likely that there would be higher numbers of reported incidents when compared to the other operational activities.

Whilst providing protection to temporary traffic management was the most common activity being undertaken during a reported IPV collision on the SRN, it cannot be assumed that this is the highest risk activity. In order to determine the risk rating of an activity, information regarding the frequency of the activity being conducted is needed alongside the total number of reported incidents and the severity of those incidents. In order to understand the potential frequency of incidents, consultation with industry stakeholders was undertaken; details of this consultation can be seen within Section 3 later in this report.

2.2.3 Severity of injuries resulting from collisions with IPVs

In order to identify high risk activities, an understanding of both the probability of an incident occurring and the severity of any injuries resulting from those incidents would need to be identified. The NILO dataset helps further this understanding, specifically regarding the severity of injury sustained by the IPV drivers involved in the incident. Information on the injury sustained to the IPV driver could also be found within the free text of AIRSWeb occasionally, but not always. Information on the number or severity of injuries sustained by other parties, road users and workforce, was not reliably included in either of the data sets used for this study.

The complete NILO dataset contained information on a total of 66 incidents involving collisions with IPVs, of which 34 can be matched to incidents on AIRSWeb. Figure 3 shows the severity of reported injuries suffered by the IPV drivers when the IPV was struck.

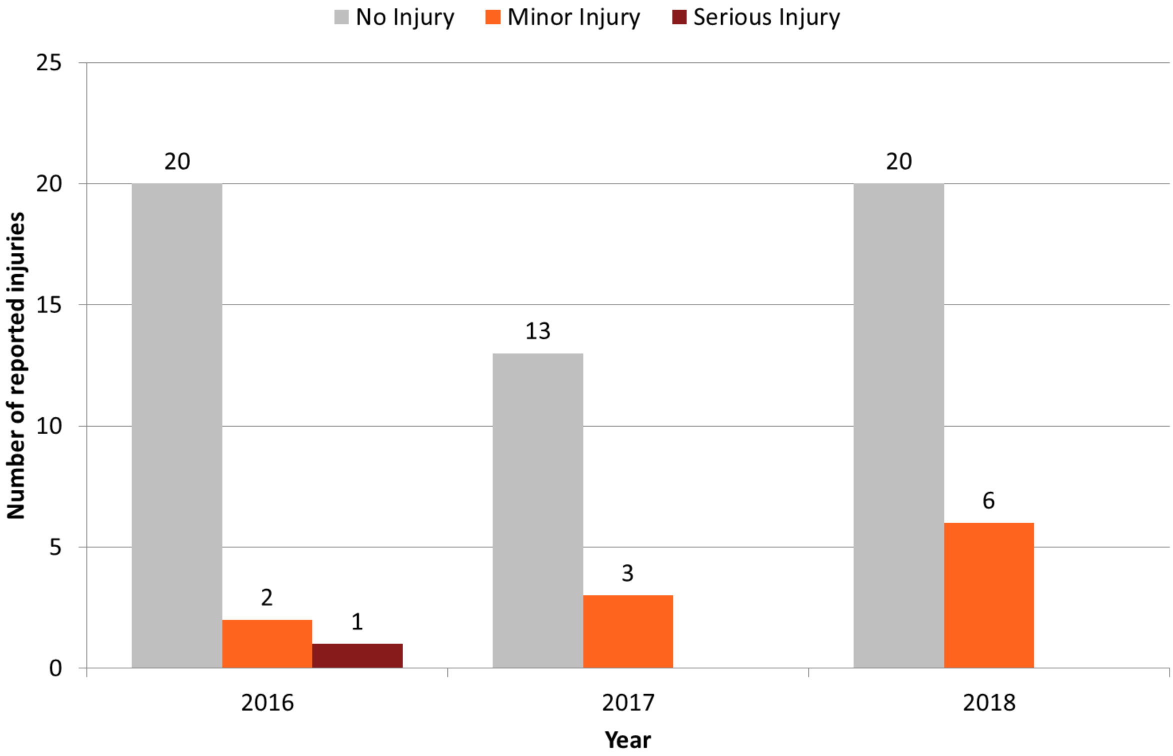

Figure 3: Severity of injuries resulting from collisions with IPVs

During the three year period investigated, only a single reported incident was documented as resulting in a serious injury to an IPV driver. The number of reported minor injuries to IPV drivers was also relatively low over the same period in question. The remaining incident reports indicated that 'No injury' was sustained by the IPV drivers involved.

Of the 12 injuries sustained by IPV drivers, 10 minor and one serious injury occurred while the IPV was carrying out temporary traffic management operational activities. The remaining reported minor injury occurring during an unknown operational activity.

As outlined earlier, the highest numbers of reported incidents resulting in collisions with the IPV were during temporary traffic management operational activities, around 60% of reported collisions. It is, however, unusual that this activity is over represented in the number of reported injuries, around 90% of reported injuries. The total numbers of reported injuries make up a small proportion of the total number of reported incidents.

Not all reported collisions have data outlining the severity of injury to the IPV driver. It therefore cannot be determined if the higher proportions of reported injuries seen in collisions involving IPVs during temporary traffic management operations are as result of:

a. these collisions posing a higher risk of injury to IPV drivers, or

b. under reporting of injuries sustained during other operation activities.

If collisions involving IPVs during temporary traffic management operations do pose a higher risk of injury to IPV drivers, this operation would be considered of highest risk compared to the other four (mobile lane closures, impact protection, incident support and recovery, short term closures). The identification and classification of operations, in terms of risk is outlined in the following sections of this report.

2.3 Incidents off the SRN

The focus of this investigation has been to understand the number and severity of incidents involving IPV collisions on the SRN. During the investigation incidents which occurred off the SRN, on local authority or private roads, have been identified.

Between 2016 and 2018, a total of 26 additional incidents involving IPVs were reported as taking place off the SRN. These incidents were not considered in the main analysis as they were not on the SRN; however, these incidents contribute to around 25% of all reported incidents involving IPV collisions in the data reviewed.

2.3.1 Activity types involved in collisions with IPVs off the SRN

Where possible, the details of the operational role of the IPV when it was struck were identified; a full list of these operational roles was outlined in section 1.4 of this report. Figure 4 shows the breakdown by year, of the activity being carried out by the IPV at the time of the collision.

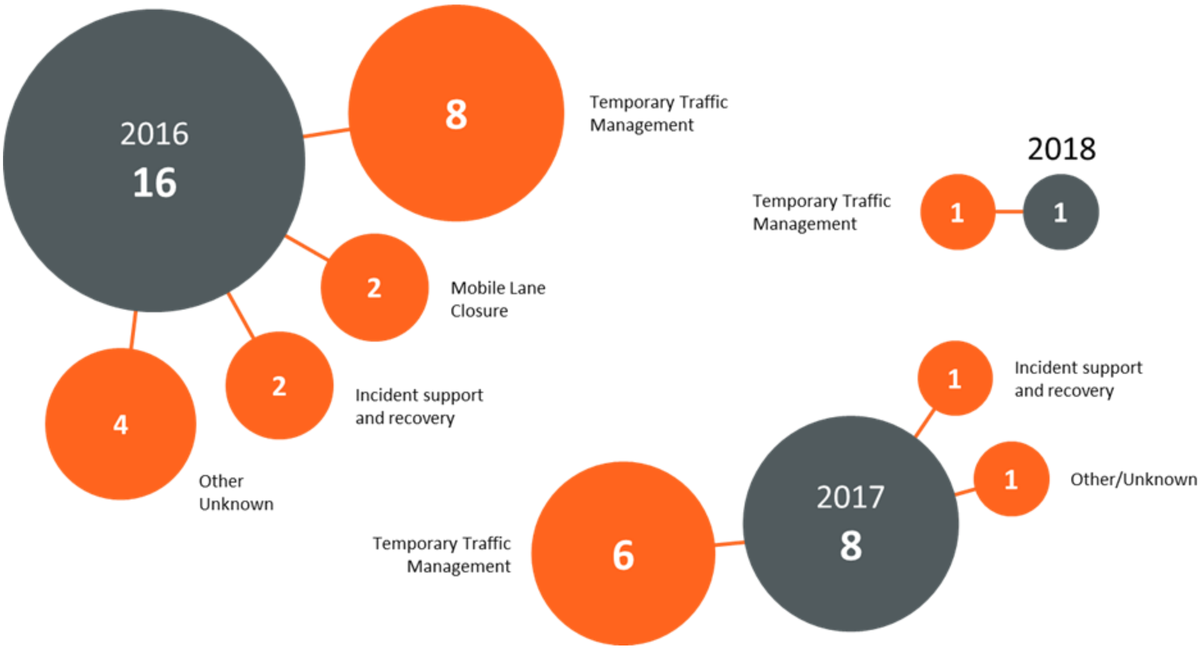

Figure 4: Operational activity being undertaken at time of IPV collision off the SRN

Across the three years included in this study, on and off the SRN, IPVs are struck most frequently when they are reported to be undertaking temporary traffic management activities (60%). Numbers of reported incidents involving other operational activities were relatively low across the same period of time.

2.3.2 Severity of injuries resulting from collisions with IPVs off the SRN

Figure 5 shows the severity of reported injuries suffered by the IPV drivers when the IPV was struck off the SRN.

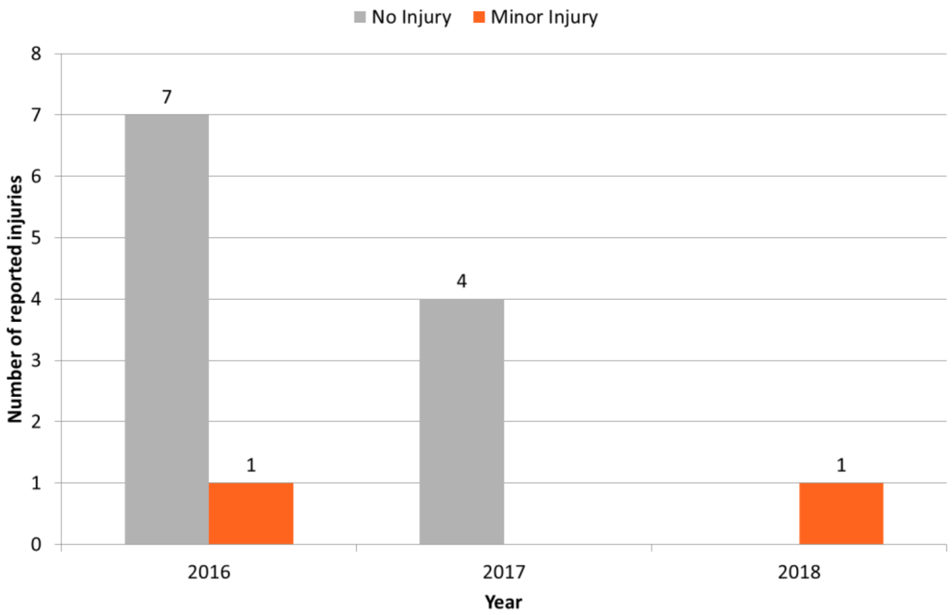

Figure 5: Severity of injuries resulting from collisions with IPVs off the SRN

As with previous injury severity data, only reported injuries to the IPV driver were known. During the three year period investigated, no serious injuries to IPV drivers were reported. The number of reported minor injuries to IPV drivers was relatively low over the same period in question. ‘No injury’ was reported for 15 of the remaining incidents, with the final nine reported as injury severity being unknown.

As these incidents pose a real risk to both operatives in Highways England’s supply chain and road users, it would be recommended that further work be undertaken to reduce their likelihood in the future.

2.4 Identifying high risk activities on the SRN

The processes for the identification and management of safety risks when undertaking any activity that does or can have an impact on safety on Highways England’s motorway and all-purpose trunk roads, either directly or indirectly, is set out by GG 104 requirements for safety risk assessment (Highways England, 2018).

The framework this document provides offers a standard for the classification of risk values based on the likelihood and severity of outcomes from hazardous events. In order to identify high risk activities involving IPVs, a similar approach to the classification of risk values was undertaken to assess the operational activities identified earlier in Section 2.2.

2.4.1 Risk matrix

Prior to scoring the risk value for each operational activity, an IPV specific risk matrix was developed. Based on similar tables outlined within GG 104, the developed risk matrix used in this investigation can be seen below in Table 1. Several changes were made to make the matrix more specific for the evaluation and scoring of high risk activities involving collisions with IPVs on the SRN. These include: the alignment of consequence severity descriptions with those used in NILO, a change to the frequency of probability to better reflect the reported frequency of incidents within AIRSWeb, and a change to the risk values to reflect the two previous changes.

Table 1: Risk value, likelihood and severity of outcomes

		Consequence severity			
	5 x 5 Matrix	**No injury** Minor damage or loss	**Minor injury** Moderate damage or loss	**Serious injury** Substantial damage or loss	**Fatal injuries** Major damage or loss
Probability of occurrence	**Almost certain** An event that is almost certain to happen once a week or more	**Medium** Additional control measures needed to reduce risk	**Medium** Additional control measures needed to reduce risk	**High** Activity not permitted	**High** Activity not permitted
	Likely An event that is likely to happen once every 1-4 weeks	**Medium** Additional control measures needed to reduce risk	**Medium** Additional control measures needed to reduce risk	**High** Activity not permitted	**High** Activity not permitted
	May happen An event that could happen once every 5-10 weeks	**Low** Control measure maintained and reviewed as necessary	**Medium** Additional control measures needed to reduce risk	**Medium** Additional control measures needed to reduce risk	**High** Activity not permitted
	Unlikely An event that could happen less than once per 10 weeks	**Low** Control measure maintained and reviewed as necessary	**Low** Control measure maintained and reviewed as necessary	**Medium** Additional control measures needed to reduce risk	**High** Activity not permitted
	Very unlikely An event that is highly improbable or is not known to occur	**Low** Control measure maintained and reviewed as necessary	**Low** Control measure maintained and reviewed as necessary	**Low** Control measure maintained and reviewed as necessary	**Medium** Additional control measures needed to reduce risk

2.4.2 Risk scoring

In order to assign each operational activity with a risk value, a scoring workshop was undertaken. Attendees for the workshop included experts in: risk management, road worker safety, traffic officer risk management, and statistical analysis. The information on the number of reported incidents and the severity of reported injuries was used to inform the scoring of each individual operational activity. Results of this scoring can be seen in Table 2.

Table 2: Risk scoring of operational activities

Operational activity	Probability of occurrence	Consequence severity	Risk value
Impact protection	Unlikely	Minor harm	Low
Incident support and recovery	May happen	Minor harm	Low
Mobile lane closure	Unlikely	Minor harm	Low
Short term closure	Unlikely	Minor harm	Low
Temporary traffic management	Likely	Moderate harm	Medium
Other	Unlikely	Moderate harm	Low

Due to the relatively low number of reported incidents and limited number of reported injuries, five of the identified operational activities were assessed as having ‘low’ risk values. For these operational activities, existing control measures should be maintained and reviewed frequently (as outlined in GG 104) to ensure their effectiveness.

A single operation, the use of an IPV for temporary traffic management operations, was identified as having a medium risk value. As a result, additional control measures would need to be identified and implemented to ensure risks posed from such operations can be reduced.

3 Stakeholder engagement

3.1 Method

In order to engage with industry stakeholders, a series of telephone or face to face interviews were arranged. This section outlines: how the stakeholders were selected, the topic areas used for the interviews, and summarises the findings of the interviews into common themes.

3.1.1 Participants

A range of participants were identified from TRL’s network of contacts for participation in this investigation. Individuals were selected based on their roles within Tier 1 and Tier 2 service providers along with representatives from vehicle manufacturers and suppliers of LMCCs.

These service providers hold the collective responsibility for the maintenance and construction activities on the SRN including the provision of temporary traffic management operation activities, identified in Section 2.4.2 as having the highest risk value of reported IPV operations the past three years.

In total, six separate discussions were conducted with 9 individuals who represented a range of technical, managerial and training roles across the industry. Following initial contact, participants were provided with a briefing note, which can be seen in Appendix A, and informed consent was sought verbally for their involvement in the investigation. Details of the topic guide used for these discussions can be seen below.

3.1.2 Discussion

Each discussion followed the topic areas outlined below; the order and area of focus for each discussion was adjusted according to the expertise and knowledge base of individuals involved. This approach would allow for the collection of deeper insights into each of the three main areas. The topic areas were:

- Incidents occurring on the SRN, including details of:
    - the activities taking place at the time of these incidents
    - the equipment and vehicle types involved
    - the results of any investigations undertaken as a result of these incidents
    - any likely causes
    - how these incidents have been typically reported
    - which of these activities involving incidents are considered high risk by the industry
- The automation of high risk activities, including details of:
    - existing activities that could be suitable for automation
    - any automation solutions currently available
    - any plans for automation
    - any concerns around the automation of activities
- Other thoughts.

The conclusion of each discussion included ‘next steps’ and the verbal agreement on any key noted discussion points. Summaries of these discussions can be seen in the subsequent section.

3.2 Summary of discussions

The following sections present the key findings from the discussions with industry stakeholders. The three main areas of focus for the engagement were:

- To gain further insight into the number and types of incidents involving IPV collisions on the SRN
- The identification of high risk activities undertaken using IPVs on the SRN
- The identification of views regarding the automation of these activities.

3.2.1 Standard Operating Procedures

In order to understand the use of IPVs in the protection of temporary traffic management activities, in particular the location of these IPVs relative to operatives and works vehicles, participants were given the opportunity to detail their standard operating procedures (where appropriate).

Overall, broad agreement was expressed on how IPVs are used on the SRN in the protection of temporary traffic management operations, with the positioning of the IPV during the installation and removal for temporary traffic management dependent on the lateral location of the works activities (nearside or offside of the carriageway) and the presence (or lack of) hard shoulder.

For example if a nearside single lane closure is being installed or removed on a carriageway with a hard shoulder, the activity of placing the cone taper will typically be undertaken from the hard shoulder without the use of an IPV upstream of the work force. Some providers' procedures do include the use of an IPV for the protection of the workforce in these instances, but this operation is not consistent across all of the providers.

All other closures, including those for offside closures or on roads with no hard shoulders, were installed with an IPV positioned upstream of the taper location during installation.

Both methods align with guidance published by the Traffic Management Contractors Association (TMCA), with new guidance to be released in 2019. These variations in operational procedures mean that the exposure of IPVs to the risk of collisions with road users varies from provider to provider.

One participant expressed concern that some methods of working might contribute to the number of incidents, and that operatives might become complacent and not work to set procedures.

3.2.2 Supplier incident reporting

Having identified the potential for under reporting during investigations into both AIRSWeb and NILO data sets, discussions were directed towards the industry's understanding and implementation of incident reporting and AIRSWeb.

All participants outlined that every incident, including near misses, should be logged on AIRSWeb. Both Tier 1 and Tier 2 participants indicated that their organisations also operated internal reporting systems for incidents and near misses. These systems, which utilise the electronic logging of incidents, could be a future source of incident data for similar investigations in the future.

However concerns were raised that incidents involving sub-contractors may not be logged in similar systems or reported onto AIRSWeb. A participant gave the example of an IPV, used in an incident support and recovery operations role during major scheme works, being involved in a collision and that collision not being logged on AIRSWeb.

Although the levels of known under reporting in AIRSWeb cannot be solely attributed to these inconsistencies, very few incidents were recorded as occurring when IPVs were used to provide protection for incident support and recovery.

Participants suggested potential subsequent investigations could include contributory factors such as engineering aspects and potential near misses, if reported.

The manufacturer involved in these discussions noted that they are rarely aware of the circumstances of an incident that resulted in vehicles requiring repair or replacement. Typically, vehicle repairs are required as a result of low-speed driving incidents. With LMCCs being modular, replacement of damaged modules is a relatively simple repair. Full replacement of LMCCs would likely be required after any collision on high speed roads, like those on the SRN.

3.2.3 Highest risk activities

As investigations into AIRSWeb and NILO had only managed to provide limited insight into potential high risk operational activities, participants were asked for their views on which specific works activities were considered to have particularly high risk values.

Initial discussions focused on elements of traffic management such as:

- The installation and removal of a taper with the IPV upstream of the workforce providing protection, then having to manoeuvre around the taper to enter the closed lane
- The installation of all elements of temporary traffic management on carriageways where there is no hard shoulder
- The installation of 'splitter details' (the point at which changeovers and lane merges separates from the main carriageway).

Participants then went on to comment on other activities where an IPV was not always deployed, these included:

- Impact protection operations during hard shoulder working e.g. litter picking
- Mobile lane closure operations such as streetlight inspections etc.
- Incident and recovery operations within major schemes
- Short term works activities e.g. pothole repairs etc.

It was suggested that the number of incidents might increase during particular times of the year due to an increase in on-road activities such as surface repairs, grass cutting, weed spraying etc. Other factors such as seasonal reduced visibility and duration of day light may also be factors.

3.2.4 Awareness of automation

All participants were aware of some level of automation innovation within the industry, whether as stakeholders in development or from general awareness from trade publications and events. Each specific example focused on automation either as a specific works activity to reduce the time needed to undertake the activity, or as an element of the traffic management operation to reduce the time to install/remove the traffic management or remove the requirement for the work force to be present.

The areas of automation mentioned in the discussion included:

- Cone laying machines
- Automated IPVs
- Demountable crash cushion 'skid'
- Remotely-controlled cone deployment
- Litter picking
- Debris collection
- Pothole filling
- Surface patch repairs
- Marker stud placement
- Barrier post removal

- Barrier installation system.

One participant suggested that all activities should be reviewed and any activity that could be completed within 60 seconds should be automated. Another participant commented that their company views automation as an obligation. The company is considering automation of the entire temporary traffic management installation sequence. They consider that technology is now capable of delivering this, but do not have a timescale to achieve it.

A manufacturer noted that they are currently developing equipment to semi-automate two high risk activities of temporary barrier installation: working at height (on a vehicle) and drilling into the road surface (for anchoring the barriers).

3.2.5 Automation alternatives

Several participants are already involved in the development of automation, whether by commissioning research and development of innovative equipment, sourcing existing equipment, or designing and manufacturing prototypes. One manufacturer commented that they are having conversations with clients on innovation, but nothing yet on automation.

One manufacturer is developing a trailer crash cushion which meets the same standards as a LMCC. Potentially, this could allow a crash cushion to be fitted to vehicles undertaking works activities where an IPV is not currently or routinely used, or remove the need for an IPV to accompany the works vehicle, so that only a single driver is placed at risk.

3.2.6 Concerns about automation

The industry as a whole is aware of the anticipated benefits to be gained from the automation of works activities in areas such as safety and manual handling, however operatives have expressed scepticism. This is often due to high profile reporting of incidents in the media, many involving existing automation in road user vehicles.

If future expectations or working requirements detail the use of automation across the industry, concerns over the potential costs of new automation technologies, particularly for smaller companies and suppliers, were raised. When this is coupled with the delays typically seen in the initial development and market introduction of automation solutions, overall it was suggested that greater industry involvement in the automation of works activities may see greater returns to investment.

Manufacturers raised concerns over the maintenance of LMCCs. It is possible that not all cushions currently in operation meet new standards for use at higher speed limits. There is no formal requirement to have old systems inspected for structural integrity so it was suggested a statutory requirement, similar to other equipment regulation, should be introduced.

3.2.7 Other thoughts

Several other topic areas came up during each discussion, many of which cover other aspects of temporary traffic management operations and which may not directly align with investigations into high risk activities and subsequent automation. A summary of these points has been included in Appendix B.

4 High risk activities which could benefit from automation

4.1 Risk analysis

As outlined within the previous sections of this report, the following activities which are undertaken under temporary traffic management operations have been determined to be of high risk:

- The installation of temporary traffic management within the carriageway, such as offside tapers
- The installation of temporary traffic management on carriageways with no hard shoulder, including placement of advanced signing and both near side and off side tapers
- The installation of 'splitter details' within road works.

Not all of these activities will be suitable for automation; in order to identify which could benefit, a review of existing and potential solutions was undertaken. This review is outlined in the following section.

4.2 Review of literature

The purpose of this review was to understand how and where Highways England should best focus its efforts to reduce road worker injuries through automating key high risk processes. This would require an understanding of all available solutions along with their expected benefits in terms of a reduction in injury risk for road workers.

Table 3: Initial search terms

Target Group	Intervention/action	Outcomes
Road worker	**Automated processes**	**Injury severity**
Roadworker *Road-worker* *Roadworks operative* *Works vehicle operative* *Works vehicle driver* *IPV driver* *Construction worker* *Site worker*	*Automated* *Automation* *Self-driving vehicles* *Robotics* *Activity* *Work activity* *Incident support* *Incident protection* *Vehicle protection* *Vehicle recovery* *Road works* *Roadworks*	*Injury* *Personal injury* *Hospital admission* *KSI* *Killed or seriously injured*

The following criteria were applied to the initial search, prior to sifting:

- Restrict results by language (English)
- No restriction on country of origin

- No restriction on research type, include systematic reviews, case studies, research news, conference papers, journal papers, peer-reviewed or non-peer-reviewed material etc.

This initial review produced limited results, with the majority of solutions (outlined in Appendix C) being either already in use on the SRN or currently under investigation by Highways England. Further terms were then added and the focus of the review shifted.

These further terms arose from work undertaken within the stakeholder engagement interviews are outlined in Table 4 below.

Table 4: Further search terms

Target Group	Intervention/action	Outcomes
Road worker	**Automated processes**	**Injury severity**
	Temporary traffic management *Cone laying machines* *Automated IPVs* *Demountable crash cushion 'skid'* *Remotely-controlled cone deployment* *Litter picking* *Pothole filling* *Marker stud placement* *Barrier post removal* *Barrier installation system* *Road rake* *Robocone* *Post puller*	

4.2.1 Limitations of review

Earlier investigations of incident data (outlined in Section 2) were unable to identify specific works activities being undertaken at the time of reported incidents. Instead, these investigations only provided information on the operational activity being undertaken, e.g. temporary traffic management, mobile lane closure etc. As a result, specific search terms focusing on works activities and their automation could not be identified and included in this literature review.

The inclusion of further search terms developed from stakeholder engagement has the potential for biasing the results of the review. For this reason caution should be taken when interpreting the findings for this further review (outlined in Appendix C).

4.2.2 Review findings

This review has identified several technology solutions suitable for use in: the installation and removal of temporary traffic management, the impact protection element of operations, and works activities undertaken within operations.

The suitable solutions, whether in development or market ready form, include:

- Automated tapers
- Remote operated traffic management variable message system
- Roller blind signs
- Automated cone laying machines
- Autonomous IPVs
- Demountable LMCCs
- Object retrieval systems
- Sign cleaning systems
- Barrier repairs and installation systems
- Pothole repair systems
- Road stud placement and removal systems

These solutions are currently being mapped by Highways England as part of several separate investigations.

5 Conclusions from initial investigations

5.1 Activities suitable for automation

As outlined in Section 1.3, the intended purpose for these initial investigations has been to review incident data and engage with stakeholders to identify high risk activities which could benefit from automation.

The results of risk analysis, detailed in Section 4.1, identified three specific operations which could benefit from automation: installation and removal of traffic management within the carriageway; installation and removal of traffic management on carriageways with no hard shoulder; and the installation of 'splitter details' within road works.

Potential suitable automation solutions were then identified within Appendix C with solutions focusing on systems which could remove the requirement for operatives to be present in the carriageway when undertaking the various activities required in the installation and removal of temporary traffic management.

Systems such as automated tapers and remote operated variable message signs at fixed taper locations would remove the requirement for the presence of operatives when implementing temporary traffic management operations. This would remove the requirement for an IPV to be present to provide protection; thus, reducing the probability of collisions taking place. These systems would help reduce the risks posed from the first two high risk operations, installation and removal of traffic management within the carriageway, installation and removal of traffic management on carriageways with no hard shoulder.

The installation of 'splitter details' within road works currently cannot be automated in such a manner. Such an activity, which requires an IPV to operate in the carriageway, would benefit from systems which provide a reduction in injury severity to IPV operatives. By removing the driver from the IPV, the likelihood and severity of injuries to said driver resulting from collisions would be eliminated.

5.2 Next steps

As outlined in Section 1.2, the remaining two work areas, mapping implementation and scoping a proof-of-concept, were planned to be undertaken and summarised in a separate report.

It was anticipated that the process of taking the previously described optimum solutions (automated taper, remotely operated variable message signs and automated IPV) from their current state to on-road use will be outlined. Particular focus would be paid to documenting the systems' performance requirements, timescale to implementation and perceived benefits.

At the point of writing, Highways England is investigating the real-world development and trials for these three optimum solutions as part of separate research. As such, the focus of this investigation was shifted. These new areas of work would provide details on: the effectiveness of AIRSWeb in identifying collisions involving IPVs, potential improvements that could be made to aid in the identification of collisions involving IPVs, and the future use of such reporting systems.

6 Further investigations

6.1 Additional data on frequency of IPV use

After identifying the number of reported incidents involving collisions with IPVs, further work was undertaken as part of this investigation in order to better understand the frequency rate of collisions by work activity. In order to identify a frequency rate a total number of 'non incident' occurrences of each operational activity would be required.

This information would be collected from supply chain records which would outline the number of operational activities undertaken during the same period of time as the wider investigation. A single major supplier of temporary traffic management agreed to share this information for use in this investigation.

Once the data was received, processed and reviewed it was determined that it would not be possible to calculate the total number of 'non incident' uses of IPVs. The data supplied had been filtered prior to sharing, resulting in only incidents involving collisions with IPVs being included.

6.2 Effectiveness of fields in AIRSWeb and NILO

As described in Section 2.1.2 several issues were identified with the effectiveness of the data captured in AIRSWeb for identifying and investigation collisions involving IPVs. A full list of fields included in AIRSWeb, ranked in order of benefit to the investigation and completeness, is provided in Appendix C.

6.2.1 *Fields used to identify reported collisions involving IPVs*

In order to identify reported collisions involving IPVs in the AIRSWeb database, two free text fields were used. A word search was conducted on these two fields to identify incidents where an IPV was struck, as outlined in Section 2.1.1. The two free text fields were:

- Details of the actual job done
- Describe the facts of what happened

Once reported incidents were identified to involve a collision with an IPV several additional fields were examined to understand more facts about the collision. These fields were:

- Event type (which explained if it was a collision or a near miss)
- Date and Time of Event
- Location (to determine if the collision occurred on the SRN)
- Injury Type (to understand injury severity)

To determine the reported collisions involving an IPV from NILO, the binary field 'IPV Struck' was examined. Once reported incidents were identified, other fields were used to understand more about each collision. These fields were:

- Date and Time of the event
- Motorway/Trunk Road
- Junction
- Direction
- Injury to IPV Crew
- Journalistic Colour

6.2.2 *Free text fields*

As previously mentioned, free text fields held the majority of the usable information for identifying incidents involving collisions with IPVs. For this investigation they were critical. However, the varying levels of comprehensiveness and accuracy of the entries in these fields result in additional activities during investigation.

Several simple steps could be used to improve the usability of these fields for investigation in the future. These include:

- The inclusion of an agreed glossary for common terms, ensuring consistency in terminology used.
- The inclusion of a spell check feature at the point of entry.

6.3 Potential improvements to AIRSWeb

The minimum requirements for any incident reporting system, imposed by the BMS and compliance with ISO certification, are:

- That reporting of all incidents whether they are actual, suspected, threatened or potential is encouraged.
- Incidents are reported in a timely manner and are properly investigated.
- Incidents are handled by appropriately authorised and skilled personnel.

- Appropriate levels of management are involved in the determination of response actions.
- Evidence is gathered, recorded and maintained in a form that will withstand internal and external scrutiny.
- As required, external bodies or data subjects are informed.
- Incidents are dealt with in a timely manner and normal operations restored.
- The impact of an incident is understood and action is taken to prevent further damage, identify improvements in policies, procedures and controls and to prevent recurrence where possible.

AIRSWeb in its current format meets many of these requirements. However, there is room to improve by implementing several good practice approaches promoted by HSE. The following sections outline several areas that should be taken forward for investigation by Highways England.

6.3.1 Additional data required

To improve the quality of future investigations into reported incidents involving IPVs, the following additional data fields should be considered for inclusion into AIRSWeb:

- If the incident involved a collision with an IPV, and if so, indicate whether the LMCC was activated at the time of the collision.
- The operational activity being undertaken during the time of the incident.
- The specific works activity being undertaken during time of the incident.
- If any injuries occurred as a result of the incident, including severity along with an indication of who sustained the injuries.
- The classifications of vehicles involved in the incident (e.g. Car or HGV).

6.3.2 Inclusion of causation factors

The use of causation and contributory factors (CFs) to help establish incident causes is widely adopted for the reporting of incidents across various organisations. The intent is for the person reporting to be provided with a number of factors that most commonly contribute to specific incidents in order to establish an initial cause from a subjective viewpoint.

The Department for Transport STATS19 incident reporting form for traffic accidents provides a list of contributory factors for police officers and accident response teams to fill in at the scene. Contributory factors can be useful for an initial classification of an incident but they have a number of disadvantages and limitations which would likely translate to incident reporting requirements across Highways England's supply chain.

Previous research into the use of STATS19 contributory factors by police officers has found that there has been over reporting of some CFs and under-reporting of others (Richards *et al.*, 2010). This is likely due to the lack of familiarity with the factors by police officers. Also some have very broad definitions; some have overlapping definitions; and there is a general lack of training for police officers and a lack of understanding of how the data is used by researchers and investigators.

Another key limitation for the use of CFs for Highways England's supply chain is due to the fact the road workers would be expected to fill out incident reports at the scene, or near misses at the end of their shift. In this case the account of the accident is likely to be purely subjective. Even for a trained accident investigator, it is difficult for anyone involved in the incident to provide purely objective, valid and useful data.

Finally, the promotion of a proper safety and reporting culture is key for ensuring that all incidents and near misses are reported. This means that incident reporting must be simplified and accessible to all those who are responsible for reporting incidents when they occur. The use of CFs is often seen as onerous, which has given rise to misreporting in STATS19. Furthermore, without research and careful selection of relevant CFs, and training on their meaning and proper use, the task of incident reporting is more difficult.

In order to improve Highways England's incident reporting process, it is recommended that causation and contributory factors are not used for the reporting of incidents and near misses across the supply chain. Their limited use in incident investigation, issues with under/over reporting and difficulty to use without proper training mean that the data collected is rarely valid and useful. Furthermore the use of CFs for Highways England only serves to complicate the reporting process further and does not promote good safety and reporting culture.

6.4 Future use of AIRSWeb

An effective investigation requires a methodical, structured approach to information gathering, collation and analysis (HSE, 2013). In order for Highways England to utilise AIRSWeb data in the future, as a source of incident data, improvements need to be made to ensure accurate and reliable data is captured.

6.4.1 Methods for improving reporting by the supply chain

Reporting of incidents involving collisions with IPVs is entered into AIRSWeb by individuals who work within Highways England's supply chain. Understanding what motivates these individuals to report incidents is critical prior to implementing any changes in the future.

Consultation with supply chain representatives should be undertaken to understand the following topics:

- How are people in the supply chain (all levels, especially operators) involved in safety?
- How often are individuals asked for their input on safety issues?
- How often do individuals report unsafe conditions or near misses?
- Is there active, structured involvement in safety circles?
- Whose responsibility is safety regarded to be?
- How accurate are individual's perceptions of hazards and risks in the supply chain?
- How effective is safety training in the supply chain at meeting needs?

Once consultation has been undertaken the following techniques can be considered for implementation to encourage the supply chain to report incidents involving IPV collisions:

- Incentivise reporting
- Remove any actual or perceived penalties for reporting

- Require ‘no event’ feedback for works activities as well as incidents
- Install ‘event’ buttons or sensors into IPVs to record impacts
- Create feedback loops for reported incidents

6.4.2 Communicating good practice

Improving the reporting culture in any organisation takes time, however Highways England can begin this process by communicating what it believes good practice should be to its supply chain. This can be done through a variety of different mechanisms. Research indicates that active employee participation is a positive step towards preventing and controlling hazards (HSE, 2005).

Irrespective of the mechanism used, the goal for any communication effort should be to communicate a specific message to the end user in a way that is clear, accessible, and easy to understand (O'Grady and O'Grady, 2008). Understanding the general learning styles of the intended end user can help inform the approach taken.

Targeted training sessions or briefing material could be used to communicate how the individuals using AIRSWeb in the supply chain can help make improvements to safety.

As well as communicating good practice and implementing improvements to reporting systems Highways England should consider the collection of lead indicators rather than solely incident frequency rates. Assessments of current working practices scored against current agreed best practice could be used as a lead indicator for incidents involving collisions with IPVs.

Measuring the behavioural and situational aspects of safety culture reveals more about what is shaping the culture of an organisation than measuring solely attitudes and perceptions. Assessments are most successful when a variety of data collection methods are employed. Documentation reviews and behavioural observations should be used in conjunction with employee interviews and questionnaires (HSE, 2005).

By using a lead indicator alongside reported incident information, Highways England would be able to understand and monitor high risk activities involving IPVs in a less limited way.

7 Recommendations

The following recommendations should be considered for implementation by Highways England, based on the findings for this investigation:

- Highways England should continue with the existing real-world development and trials of technologies suitable to automate the previously outlined solutions: installation and removal of traffic management within the carriageway, installation and removal of traffic management on carriageways with no hard shoulder, and the installation of ‘splitter details’ within road works as part of separate research.
- To improve the quality of future investigations into reported incidents involving IPVs, additional data fields should be considered for inclusion into AIRSWeb, these have been outlined in Section 6.3.1.
- Alongside these additional data fields, the inclusion of an agreed glossary of common terms should be introduced for use with free text fields within AIRSWeb. Ensuring consistency in terminology.
- Consultation should be undertaken with the supply chain in order to afford understanding into what motivates the reporting or under reporting of incidents. Using this insight, various suitable techniques to encourage the supply chain to improve incident reporting should be selected and implemented.
- At the same time, in order to improve incident reporting, Highways England should begin the process of communicating what it believes to be good practice in incident reporting to its supply chain.
- The assessment of current working practices within the supply chain, for the implementation and removal of traffic management, should be reviewed and scored against current agreed best practices. These scores would then be used as a lead indicator for incidents involving collisions with IPVs rather than solely relying on reported incidents.

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Appendix A Stakeholder engagement briefing note

Automating key high risk processes

Highways England wish to gain a clear understanding of the benefits that might be achieved from automating high risk processes that put road workers at risk. "High risk processes or activities" are those activities on the Strategic Road Network where IPVs are used to protect customers when work is being undertaken on the carriageway and/or Temporary Traffic Management (TTM) is being installed to close lanes for road works.

We are keen to discuss automation of high risk activities with representatives from the roadworks community, including Tier 1 and Tier 2 service providers and contractors. We would be grateful if you could attend a one hour telephone discussion with TRL staff. It is not expected that there will be any risk to you or disadvantages from taking part.

Notes taken during the session will be compiled and subsequently form part of the final report. Your submission will contribute to later parts of the project where opportunities for automation of high risk activities will be examined. No personal, company or contact details will be included in the report. You are free to withdraw from the session at any time and do not need to give a reason. There is no payment for taking part in the session.

If you have any questions, please contact the team with the details you have already been provided. You may also ask questions at the start of the session.

Thank you for your help,

TRL

If you are willing to take part in this consultation, could you please reply to this email to confirm that you:

- Have read this information
- Have been given the opportunity to ask questions on all aspects of the study and have understood the advice and information given as a result
- Voluntarily agree to take part in the Automating Key High Risk Processes session
- Understand that you are free to withdraw at any time without needing to justify your decision
- Understand that the information you provide will be compiled and may be included in project reports provided to Highways England (where it is relevant to the project)

Appendix B Other thoughts from stakeholders

Several other topic areas came up during each discussion, many of which cover other aspects of temporary traffic management operations not directly aligned with investigations into high risk activities and subsequent automation. These additional areas have been outlined earlier in the report including alternative equipment solutions, new procedures, further calls for road user education of temporary traffic management and signage and maintenance concerns.

It was suggested that equipment such as 'Portable Flat Traffic Delineators' could in some circumstances provide a suitable alternative to the cones currently used. The legality of IPVs being used for incident management was questioned. It is understood that trials are underway or planned to crew response vehicles with both operatives and Highways England Traffic Officers to ensure appropriate powers to direct traffic are assured.

The role of Highways England in the design and implementation of traffic management was raised. A participant indicated the need for Highways England to lead by imposing consistent requirements for all contractors, ensuring no financial dis-benefit for those who innovate or provide higher levels of safety-related equipment. It is assumed that Highways England staff do not have the available resource to seek advice on traffic management issues, when dealing with contract and taking decisions which influence the design of temporary traffic management.

Appendix C Review of literature – Potential solutions

Automating the installation and removal of temporary traffic management

The following solutions provide the opportunity to remove the requirement of manual placement or removal of varying elements of temporary traffic management. Such systems would remove the requirement for the presence of road workers. The removal of operatives from the carriageway during the installation and removal of traffic management would remove the requirement for an IPV to provide protection to the operatives, reducing the risk of collisions between the IPV and road users.

Further safety risk assessments for such solutions would be required, as the LMCC on IPVs provides protection to the road users from the risks posed by collisions with works vehicles. The risk posed to road users from collisions with the solutions described below would need to be considered.

Automated taper

Versilis$_{INC}$ - SwiftGate^{TM} solar powered automated taper module

The SwiftGate^{TM} module has been designed to reduce the risk posed to road workers manually installing lane closures and tapers. SwiftGate^{TM} is a permanent infrastructure installation and would require the use of preplanned fixed taper installations. The system has not yet been used on the SRN, with the latest verson of this system fully operational on Highway A-13 in Montreal, Canada.

The SwiftGate^{TM} module system pivots horizontally from the top of a temporary vehicle restraint system (VRS). The modules can be programmed to operate individually, sequentially, or in groups. The colour and reflective material of the pivoting gate can be customised to suit the application. Flashing LED devices can be installed on the pivoting gate end panels to increase the efffectiveness of the system. The SwiftGate^{TM} system adopts a remote monitoring control which can be operated by either a RF unit, cellular phone or a web-based application.

Remote operated temporary traffic management variable message system

Nissen^{TM} - VarioSign Standard 12B and Narrow 9(5) systems

The installation of advanced signing in the lane change zone of temporary traffic management poses a direct risk to road workers working on either the hard shoulder or in the carriageway. The Nissen remotely operated temporary traffic management system (ROTTMS) VMS VarioSign can be used to display pictorial lane closure information (i.e. either single or multiple lane closures) together with a supporting text legend (i.e. distances of 220 yards, 400 yards, 600 yards, 800 yards or 1 mile from a closure) used to provide advanced signing for traffic management. The legends used on such systems are compliant with the Traffic Signs Regulations and General Directions (DfT, 2016).

Like the automated taper ROTTMS requires the use of fixed taper locations, however the system can be mounted on temporary units which do not require permanent installation.

Rollerblind signs

TM Safety Signs Ltd – BLIND Sign

TM Safety Sign Ltd's BLIND Sign is a remote controlled roller blind. The blind fits over a standard fixed plate sign to allowing immediate remote control of any authorised sign legend. The BLIND sign can be used with 'A' frames or permanent street sign fittings. TM Safety Sign Ltd's BLIND sign is highway approved (Highways England, 2005).

Like previous solutions, roller blind technology requires the use of fixed taper locations as the signage would need to be preinstalled and used multiple times to provide benefits. Similar systems have been in use on both permanent infrastructure and temporary sign frames across the SRN.

Automated cone laying machines

The manual deployment of cones from a works vehicle is labour intensive and presents a degree of risk to the road workers deploying the cones, both in terms of injuries and muscular skeletal disorders arising from manual handling of the cones and from passing traffic, potentially travelling at speeds of 70 mph.

The publication of IAN 188/16 (DfT/Highways England, 2016) has simplified the cone laying requirements for longitudinal traffic cones during relaxation works. Several systems are being developed. Historically, some prototype cone laying machines were developed and tested to assess their design and each machine's capability.

The benefits to such systems include: a reduction in manual handling, removal of unrestrained operatives on works vehicles, potential reducing in installation times. Although providing these benefits, such systems would not address the specific risks posed from the three high risk activities outlined in Section 4.1 to the IPV driver.

Automating the impact protection element of operations

The following solutions provide the opportunity remove the requirement for an operative to be present in the IPV when in operational use. Such systems would reduce the likelihood and severity of injuries sustained by the IPV driver in the instance of a road user collision.

Autonomous IPVs

Colas Automated IPV

Through the use of 'Leader and Follower' technology, Colas have been developing an autonomous IPV enabling the unmanned use of an IPV in traffic management operations. Information on speed and heading is transmitted from a 'lead' vehicle to the 'follower' allowing that vehicle to keep to the established path and speed set by the 'lead' vehicle. The equipment used has been developed in the USA and has been adapted for large vehicles, such as trucks.

Demountable LMCCs

Amey Crash Control System

The system is intended to be rapidly deployed from the works vehicles without operatives having to leave their secure positions within the cab. The system would be placed upstream of traffic management operations and provide impact protection through the use of a crash cushion, similar to those utilised in LMCCs.

Automating works activities undertaken within operations

During both the stakeholder discussions outlined previously and the review of literature, several other automation solutions were identified. These have been documented below. These solutions provided the ability to automate specific works activities, reducing the exposure of operatives to risk of work on or around high speed carriageways.

Although providing some benefits, such systems would only provide limited opportunity to address the risks posed from the three high risk activities outlined in Section 4.1.

Sweeping/cleaning the road surface (including the verge and hard shoulder)

Object retrieval systems

Findings from previous research in worksite safety management (Ashim Kumar *et al.*, 2017) identified best practices and set recommendations to improve safety through the use of object retrieval systems. These systems were identified as a way of sweeping the road surface to collect hazardous objects, at speeds of up to 60 km/h (37.5 mph), and could collect objects as large as a car wheel from the carriageway. The use of such a device would prevent the need for road closures and road workers to remove such large objects from the carriageway.

Overton (UK) Limited - Barber Road Rake 200

The Barber Road Rake 200 is a vehicle towed system that allows for the removal of large objects of litter and debris from motorways, trunk roads and hard shoulders. The system requires the use of a 7.5 ton truck and can be operated via a control box inside the vehicle cab.

Advanced Highway Maintenance & Construction Technology Research Centre (AHMCT) - Automated Roadway Debris Vacuum (ARDVAC)

The ARDVAC is a self-contained vacuum system which allows for the removal of debris from carriageways edges and road side fences or vegetation. Operated from an in vehicle cab with a four foot wide scan path for debris, the system has been designed to be an add-on feature to existing commercially available dedicated cleaning vehicles.

Work undertaken on behalf of the California Department of Transportation (Caltrans) identified and quantified the benefits of a prototype ARDVAC system, which had been developed by AHMCT. The use of such a system was identified as having major safety benefits for road workers through the reduction in exposure due to efficiencies in time and in cab operation.

MULAG – Verge cleaning devices

MULAG produce a range of equipment and attachments for verge maintenance activities. The range includes; a verge cleaning attachment (BRG1000), a weed brush (WKB 750), a roadside brush (RB 650) and a verge shovel. Each device is attached to a dedicated MULAG power arm, that arm is then mounted on a truck. These systems have been on sale and in operation in Europe for several years.

McMurtry Ltd - Remote-controlled autonomous slope mowers

McMurty Limited has developed a remotely controlled fully autonomous rotary-deck slope mower which can be used for the maintenance of motorway verges. The system has two variants; one with a cut width of 610mm and a second with a cut width of 1015mm. Both systems require line of sight and have an operational range of 100m.

Sign cleaning

MULAG - Sign and reflector post washing equipment

MULAG have also developed other attachments for their power arm. These attachments facilitate the economical cleaning of traffic signs and reflector posts. The cleaning attachment has a 1.6m wide brush area, suitable for cleaning large traffic signs. As with the verge cleaning attachments, these sign cleaning attachments have been in use in Europe for several years but have not yet been implemented on the SRN.

Barrier repairs and installation

Postpullers (UK) Ltd – Barrier Master

Barrier Master is an automatic system for the removal of safety barrier posts. The system is operated from inside the driver's cab of a works vehicle by a single operator. Available in three different models, the systems are suitable for use with both 3 and 8 tonne excavators and also lorry mounted cranes. Such systems remove the requirement for separate cranes to be present on the carriageway. Removal operations include the removal of perimeter and security fencing, barrier posts, lamp posts and bollards.

Orteco – Barrier installation machine

Orteco has developed a barrier installation machine, designed to move a barrier guardrail (one at a time) and depositing them on two positioning arms. These positioning arms move the guardrail towards the vertically mounted piles with precise movements to allow the operators to insert the securing bolts and tighten them without the need to physically lift the guardrail.

The barrier installation machine is remote controlled, which gives the operator optimum visibility of the installation procedure.

Orteco – Pile drivers for safety barrier installations

The pile driver-crawler mounted system has been developed to allow the installation of road safety barriers. According to the manufacturer, due to its stability, the machine is able to drive the safety barrier posts with a high level of precision. A single operator moves the crawler machine and drives the posts. The pile driver can also be mounted on the back of a truck. The system is used in conjunction with Orteco guardrail machine to reduce the manual handling requirements for barrier installation.

Pothole repairs

Skanska - Pothole Repair ‘Dragon Patcher’

First introduced in 2015, Skanska’s Pothole Dragon Patcher can be operated by a single operative situated within the vehicle’s cab. The manufacturer claims that the Dragon Patcher provides safety, cost and efficiency benefits when compared to traditional methods of pothole repairs. In addition to repairing potholes, the Dragon Patcher can treat minor cracks and crazing, which could develop into potholes.

Road stud placement and removal

WJ road stud installation systems

Comprising of two separate UK available systems, the WJ Guardian and WJ Contramark systems facilitate the semi-automatic and fully automated installation of road studs whilst protecting operatives within an integrated safety cell mounted on a 18-tonne truck.

Appendix D AIRSWeb fields

Field	Use in investigation	Completeness
Details of actual job being done at the time	Free text field to understand what activity was being undertaken	88%
Describe the facts of what happened	Free text field which explains the incident in detail	100%
Event Type	To understand if it was a near miss or accident	100%
Date/Time Event	For the date and time of the event	100%
Location	To determine if incident was on or off the SRN	55%
Injury Type	Used sparingly to understand the injury type and severity	3%
Investigation Findings	Free text field. A search was done on this field of the search terms to garner more information	98%
Event Subtype	Not used	99%
Date/Time Reported	Not used	100%
Time into Shift	Not used	100%
Site/Project1	Not used	100%
Shift Start Date	Not used	6%
Shift Start Time	Not used	100%
Sub Location	Not used	0%
Specific Location (include RCC Log no if relevant)	Not used	69%
Coordinates	Not used	6%
Immediate Actions Taken	Not used	42%
Was treated in medical facility?	Not used	3%
Was employee hospitalised overnight as an inpatient?	Not used	3%
Part of Body Affected	Not used	3%

Illness Type	Not used	0%
Kind of Event	Free text field. Used to understand what kind of event was being undertaken	68%
Causation(s)	Not used	67%
Event Subtype1	Not used	99%
Actual Restricted Workdays	Not used	0%
Actual Restricted Workdays (Total)	Not used	100%
Return To Work Date	Not used	2%

Automating high risk road works processes - quantifying the benefits

The automation of works activities and operations has become increasingly prevalent. To identify the potential benefits of automation of high risk road works processes and attempt to quantify benefits, a set of investigations were undertaken. These included: investigation of reported incident data, stakeholder consultation, and a comprehensive review of published literature. Several high risk activities suitable for automation were identified. Recommendations are made relating to the development of innovations, incident reporting and data gathering, and the assessment of working practices.

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