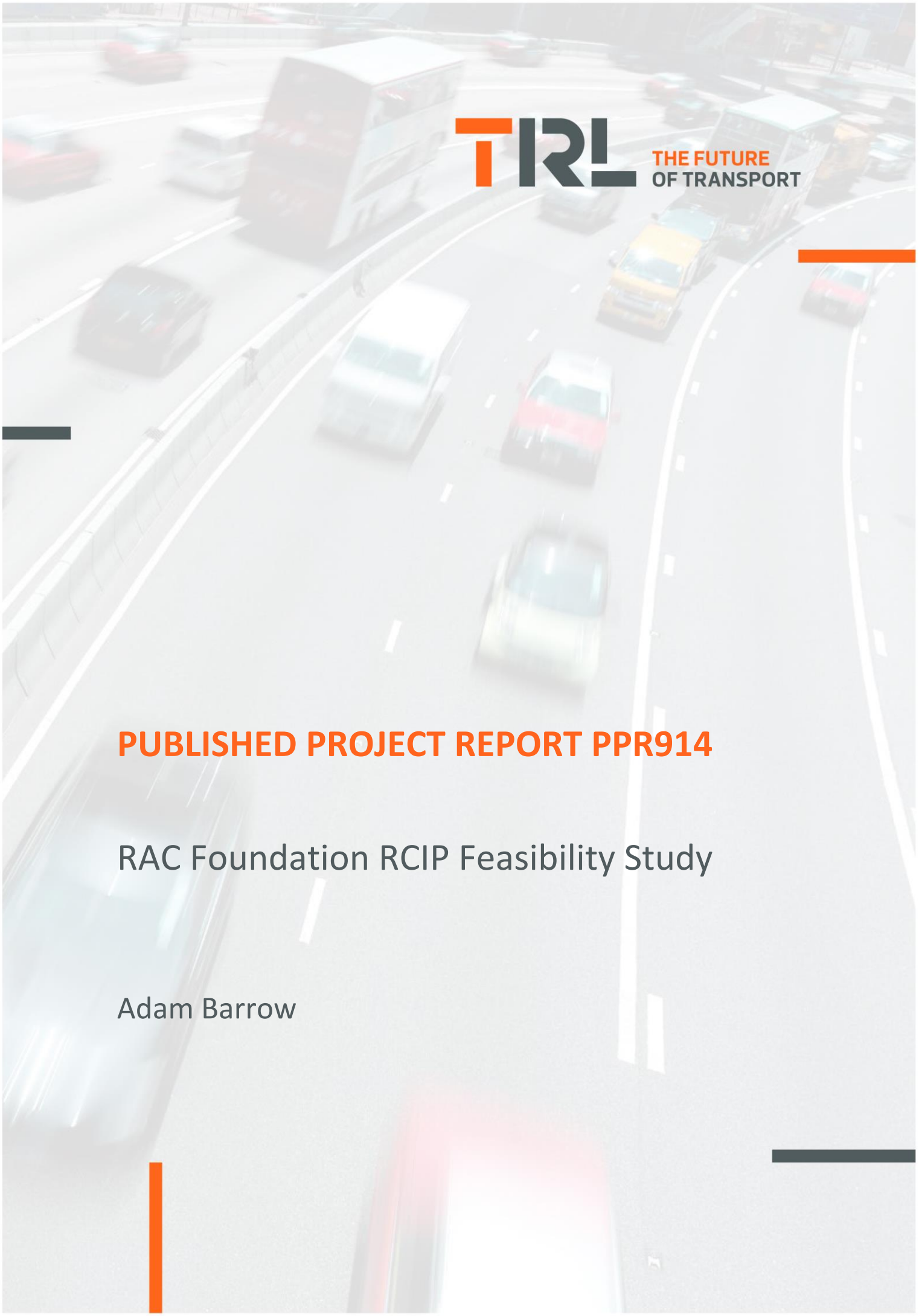

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RAC Foundation RCIP Feasibility Study

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Table of Contents

Executive Summary

The RAC Foundation has selected the AcciMap method to use in a small scale trial performed by analysts embedded in three police forces for their Road Collision Investigation Project (RCIP). Analysts will have access to Police collision investigation files as the primary information source to populate the AcciMaps with the possibility of performing further investigations when the source data does not evidence all parts of the AcciMap. The AcciMap method provides a holistic approach to identifying the systems failures that cause collisions. From this evidence base, recommendations to improve road safety can be made.

AcciMaps are an established method for identifying systems failures but have had limited use in road traffic collision investigation. The aim of this project is to assess the validity of the AcciMap approach by evaluating its compatibility with existing in-depth collision investigation programmes. The Highways England Fatality (HEF) Research programme also uses Police collision investigation files to provide evidence-based countermeasures using a systems-based approach to identifying causation factors based on Reason's 'Swiss-Cheese' model of systems failures. A comparison of the existing HEF methodology and the proposed AcciMap trial was completed to inform the development of the AcciMap framework and provide guidance on how to successfully implement it in the RCIP trial.

The comparison showed there is good evidence for using the AcciMap method to identify systems failures and provide recommendations that can improve the outcome of individual collisions. There are challenges and limitations with the method that should be considered thoroughly before implementation in a feasibility trial to ensure that the recommendations provide useful safety findings that are evidence-based. For example, the AcciMap could be developed to include post-collision factors, thereby aligning the recommendations more closely to the safe-systems approach that is widely adopted by stakeholders.

Critically, the identification of a factor that influences a collision does not inherently denote the presence of a causal link to other parts of the AcciMap. These relationships will need to be investigated by the RCIP analysts in detail by understanding and interpreting the available source data.

The evidence required to support every part of an AcciMap may not always be available or the evidence may not conclusively support a causal link identified by the RCIP analysts. In these situations, a balance must be made between enabling expert judgement to create links that are not specifically evidenced and restricting the AcciMap to factors that can be clearly evidenced. This will ensure the method still provides useful safety recommendations without introducing potentially erroneous biases and without overly limiting the outputs of the trial.

The AcciMap method can be susceptible to confirmation biases that will be reinforced by the presence of the same factors and relationships that appear in multiple collisions, but are not necessarily causative in a specific collision. Therefore, it is important that the RCIP analysts are sufficiently trained and supported by expert panels to identify these situations and have sufficient expertise to make accurate judgements on the collision's causation. Furthermore, unknowns and uncertainties in the AcciMap must be clearly stated so it is clear which recommendations are truly evidence-based and which involve expert judgement.

1 Introduction

1.1 Background

The RAC Foundation has set out to trial a new method of collision investigation based on a systems approach to identifying the collision's causal factors as part of the Road Collision Investigation Project (RCIP). The output from these investigations will provide the evidence-base for recommendations to address the systems failures and improve road safety. The AcciMap was selected as the systems-based investigation method to be used in the RCIP following a review of eight similar methods conducted by Professor Stanton (Stanton, 2019) on behalf of the RAC Foundation.

The purpose of the RAC Foundation's trial is to establish if the AcciMap method is a suitable analytical framework that could be used in a national Road Collision Investigation Branch to infer more effective safety learning from collisions. The trial will be conducted by RCIP analysts embedded in three Police forces who will investigate a sample of fatal collisions using the AcciMap method.

AcciMaps are an established method for identifying systems failures but have had limited application to road traffic collisions. The review of systems-based investigation methods (Stanton, 2019) has explored and documented the known advantages and disadvantages of the AcciMap method in relation to investigating road traffic collisions. Principally, the main advantage to using AcciMaps is the holistic approach to identifying systems failures which result in recommendations that target all 'levels' and the actors within those levels. The primary challenge for implementing AcciMaps in the trial is the lack of defined taxonomies within and across the different levels. Therefore, the identification of causal factors and their inter-relationships can be dependent on the subjective assessment of the analyst. This means steps should be taken to maintain the robustness and reliability of the AcciMap outputs to prevent the introduction of biases that negatively impact the validity of any recommendations.

A number of in-depth collision investigation programmes exist in the UK that provide evidence-based recommendations to improve road safety. Principally, the Highways England Fatality (HEF) research programme stems from the UK's Road Accident In-Depth Studies (RAIDS) and uses Police fatal collision investigation files as source data to provide evidence-based recommendations. The countermeasures considered in HEF and RAIDS are also based on a systems-based approach to identifying causation factors based on Reason's 'Swiss-Cheese' model of system failure (Barrow *et al.*, 2019) (McCarthy and Barrow, 2015).

The 'Swiss-Cheese' model categorises factors into different planes. In the model's application in HEF these planes mirror the safe-systems themes of people, vehicles and roads (as shown in Figure 1), but the model can be organised in a variety of ways. The model demonstrates that specific factors can occur anywhere in the model but it is only when these factors 'align' that a collision occurs. For example, it is possible to drive at extremely excessive speeds and not have a collision. In this situation the factor of speeding would be represented as a 'hole' in the people plane and would be a large hole as extreme speed is highly hazardous. However, when that factor is combined with other factors (e.g. low tyre tread and/or a puddle) the factors align and result in a collision.

This method of conceptualising the collision allows a systems-based approach to identifying causation factors and, therefore, countermeasures that could prevent the collision from occurring or mitigate the severity of any injuries. Figure 1 shows the planes of causation factors that align to result in a collision and how the application of countermeasures (blue planes) can alter the causation factors to prevent the collision from occurring.

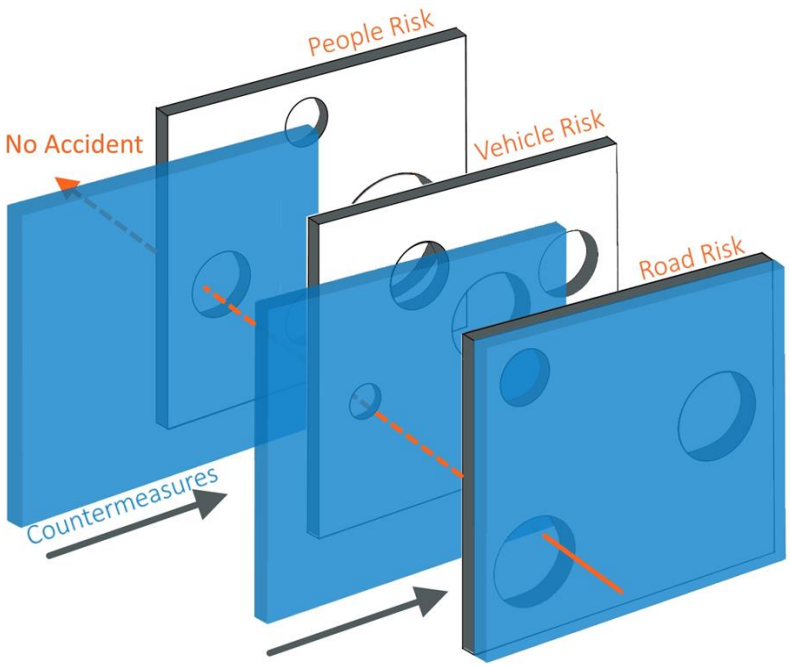

Figure 1: 'Swiss-Cheese' model of collision risks and countermeasures as applied in the Highways England Fatality Research programme (Adapted from (Reason, 1990))

The 'Swiss-Cheese' model also enables persistent systems-failures to be identified, even if they do not result in a collision in a particular instance. These would be represented as permanent holes in the relevant plane of the model that frequently align in some cases to result in a collision. For example, a persistent hazard was found in a recent analysis of the HEF database which identified 10 fatal collisions that were directly caused by defective tyres. However, in the total sample of collisions 49 vehicles were identified as having defective tyres. This means that defective tyres are a persistent hazard in the HEF sample, where approximately one in five vehicles with tyre defects directly caused a fatal collision (Barrow *et al.*, 2019). Countermeasures to address the systems-failures that lead to the tyre defects can now be derived to prevent the same failure mechanism in the future.

The AcciMap utilises a very similar systems-based approach to the 'Swiss-Cheese' model. Importantly, both HEF and RAIDS use standardised data structures that are captured in databases and enable a range of analyses; from statistical analysis of the whole dataset to individual case-by-case analysis. Statistical analysis of AcciMaps is very difficult because of the lack of taxonomies throughout the framework. Therefore, analysis of the data structure from existing in-depth collision research programmes will inform on what taxonomies should be introduced to the AcciMap framework in the trial.

1.2 Project Purpose

The purpose of this project is to assess the validity of the AcciMap framework in relation to in-depth collision investigations by using TRL's expertise in in-depth collision research, in particular, the HEF programme.

There are clear similarities between the RCIP trial and the HEF programme. HEF uses Police collision investigation files as the source information for the investigations. While the RCIP trial will also use these as the primary information source, the RCIP analysts will also have the ability to seek other information sources that will provide more evidence. In turn, this should lead to further evidence-based recommendations to improve road safety. Furthermore, the HEF programme has a defined data structure which may provide insights into the potential taxonomies that should be incorporated into the AcciMap method to improve reliability.

2 Method for Assessment

TRL performed a comparison of the AcciMap framework with the existing data structure of the HEF programme to assess the AcciMap method's validity for in-depth collision investigation. This was combined with a review of both methods by a panel of TRL's vehicle safety, road safety and human factors safety experts to provide recommendations on how the AcciMap should be completed by the RCIP's analysts as part of trial.

The comparison of HEF and AcciMap was divided into three stages which are shown in Figure 2.

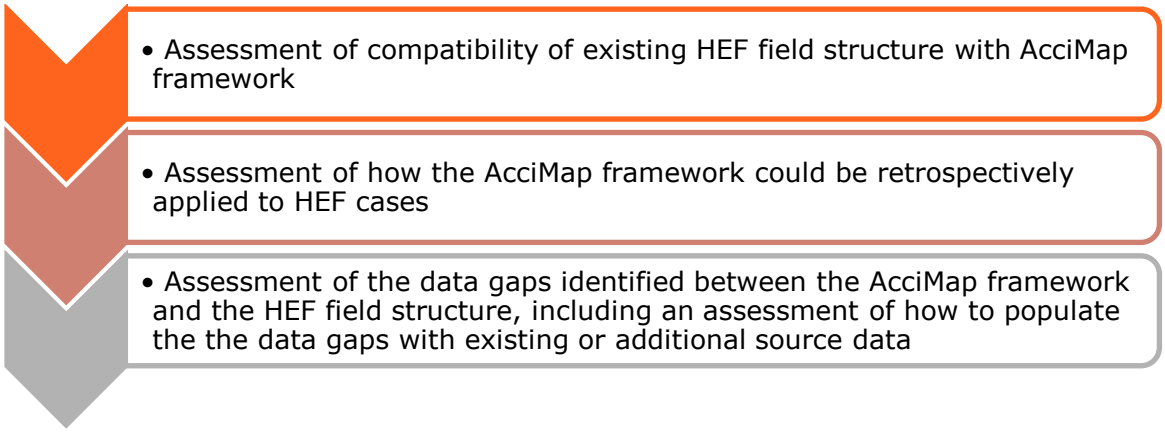

Figure 2: AcciMap feasibility assessment methodology steps

Firstly, the compatibility of AcciMap with the existing HEF data structure was assessed to determine how much overlap there is in the information captured by the two methods. This was followed by an assessment of how much of the AcciMap framework can realistically be evidenced by existing in-depth collision datasets and their source data (i.e. Police collision investigation files). The outputs were used to determine how easily the AcciMap method could be retrospectively applied to existing HEF cases and the degree to which further investigation will be required by the RCIP analysts if they were to retrospectively apply an AcciMap to a HEF collision.

Finally, an assessment of the data gaps between HEF, the source data and the AcciMap framework was done to identify what additional information is likely to be required to fully populate an AcciMap. The TRL expert panel also provided insight into how the analysts should interpret the missing information to complete the AcciMap robustly.

3 Findings

3.1 HEF field structure and AcciMap framework compatibility

Table 1 shows the distribution of HEF fields mapped to the AcciMap framework levels based on how the information contained in the HEF fields would be captured in an AcciMap. The HEF database has a hierarchal structure (e.g. all of the fields located within the 'Vehicle' level will be repeated for each vehicle in the collision). At this point in the assessment only the 'flat' HEF field structure is considered, with no hierarchy. This means that each field may appear in more than one AcciMap level depending on the information in the particular field. For example, the nine fields capturing information on each countermeasure can appear at any level and can appear in multiple levels, depending on what the specific countermeasure is:

- A countermeasure adding a vehicle technology might appear in the 'Equipment and Environment' or 'Operational Management' AcciMap levels;
- A countermeasure addressing the design of vehicle restraint systems might appear in the 'Regulatory bodies' or 'Equipment and Environment' AcciMap level.

The results of the field mapping are shown in Table 1. The full Highways England hierarchal field structure is shown in Appendix A.

Table 1: Distribution of HEF Fields into the AcciMap framework

HEF Field Structure (flat, organised alphabetically)	**AcciMap framework levels** (Stanton, 2019)								
	'Low' levels		**'Middle' levels**			**'High' levels**			
	Equipment and Environment	Driving Process	Technical / Operational Management	Company Management / Local Government	Regulatory Bodies / Associations	Central Government	National influences	International Influences	Outside of AcciMap Structure
Cases	46	42	5	12	9	2	2	7	3
Causation Factors	7	7	0	0	0	0	0	0	0
Countermeasures	9	9	9	9	9	9	9	9	0
Interactions	0	17	0	0	0	0	0	0	17
Occupants	16	149	9	8	8	2	1	7	38
Paths	269	49	67	72	18	5	0	0	0
Phases	0	45	0	0	0	0	0	0	37
Under-run Guards	0	8	0	0	1	0	0	1	8
Vehicle Damage	9	45	14	11	11	0	0	0	11
Vehicle Summary	61	103	22	1	0	0	0	0	0
Vehicles	99	77	10	6	0	0	0	0	0
Total	**516**	**551**	**136**	**119**	**56**	**18**	**12**	**24**	**114**
Total %	**36%**	**38%**	**9%**	**8%**	**4%**	**1%**	**1%**	**2%**	**8%**

The distribution is shown as a heat map with red cells representing areas of the AcciMap framework where there are no HEF fields that directly map onto them and green areas where there is the greatest distribution. The total count of HEF fields is shown at the bottom with the percentage of the total distributable fields also shown has a heat map.

The majority of HEF fields map directly to the 'lower' levels of the AcciMap (see Table 1). The HEF investigations focus on the impact and the immediate events preceding the collision as the information source is based on the Police fatal collision investigation files which often do not report evidence that can inform the higher levels of the AcciMap.

Where the HEF does map to the higher levels of the AcciMap this often relates to the absence or presence of a feature that is manufactured, regulated or subject to design standards. For example, under-run guards fitted to heavy vehicles, the HEF field captures the presence or absence of the guards and if they broke away during the impact. The absence of a guard could be due to the absence of regulation for that particular type of vehicle. However, if the guard is present but has failed during the impact, this could be due to the design standards being insufficient for that particular collision configuration or poor implementation of the guard (i.e. poor installation or retro-fitting).

While there is clear compatibility between the HEF database and AcciMap there is a fundamental difference in how the information is captured. **HEF fields can be used to capture the presence or absence of causal factors in the AcciMap. However, the HEF programme does not inherently code the relationship links between the factors. This is done by analysing the database by either statistical or expert interpretation. As a result, the HEF fields can be used to position factors on an AcciMap but do not support the links between the factors.**

The HEF database also contains 114 data fields that could not be directly mapped into the AcciMap framework. These fields primarily capture information about the collision and the immediate post-collision events. For example, fields capturing the injury mechanism that led to the casualties being injured or killed. The AcciMap framework can be extended or enhanced to capture the information in these fields; however, it has not yet been used to capture information about the collision itself or the subsequent events. For example:

- Occupant restraint performance
- Vehicle restraint performance
- Biomechanics of the casualties (including age, frailty, obesity, etc.)
- Protective equipment performance (e.g. motorcycle helmet)
- Emergency response and pre-hospital care

In order to give a truly holistic approach to identifying systems failures in collisions and provide recommendations that can prevent casualties it is important to investigate these aspects of the collision. If the AcciMap focuses purely on the pre-collision events it will introduce a bias towards primary safety countermeasures and against secondary and tertiary safety countermeasures and will not support the widely adopted safe-systems approach to road safety. It is possible for the AcciMap to be extended or a new AcciMap framework focused on these parts of the events to be created to inform on the collision and post-collision factors.

3.2 Retrospective application of AcciMap to HEF collisions

To assess how easily a HEF collision could be retrospectively coded into an AcciMap framework, every HEF field was categorised based on the mapping location from the previous section and an assessment of if the field could be mapped either:

- Automatically and require no further input;
- With further processing from a coder before being automatically mapped; or
- With manual entry by an analyst only.

Figure 3 shows the distribution of all HEF fields by those categories.

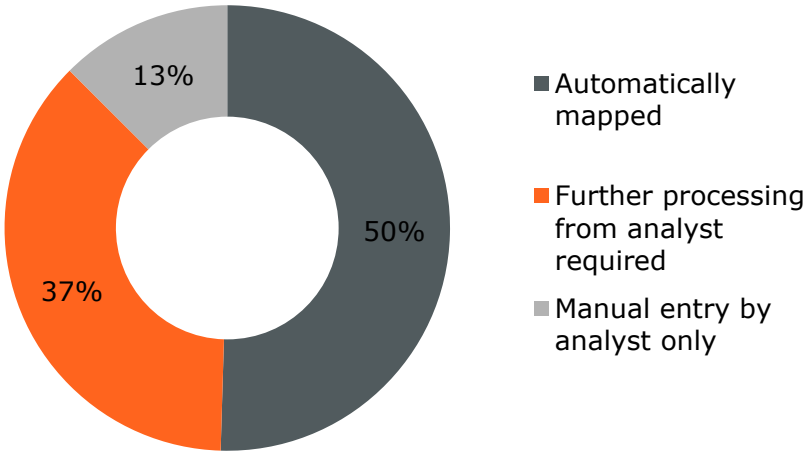

Figure 3: Distribution of HEF fields by the methods with which they can be mapped to an AcciMap framework

It is possible to retrospectively map a HEF collision into an AcciMap relatively easily as the majority of fields can be positioned within an AcciMap automatically. The remaining half of the HEF fields would require further processing from the analyst with some of the fields requiring interpretation of the information and the analyst to manually translate the data into the AcciMap. **Therefore, it is very unlikely to retrospectively apply an AcciMap to a HEF collision without further investigation.**

An example of a field that may require further processing to position it within the context of an AcciMap is the field that captures the presence of a pedestrian 'desire line' at the collision locus (evidence of a route used routinely by pedestrians that does not use dedicated pedestrian facilities). The presence of a pedestrian desire line does not implicitly mean it is a causative factor in the collision. Furthermore the causative links resulting in the presence of the desire line are dependent on the circumstances of the collision and its locus (e.g. the presence or absence of other pedestrian crossing facilities available). Although the way in which a desire line is translated into the AcciMap is dependent on the circumstances for a specific collision, its presence alone indicates there is a resident failure in the system,

even if it did not directly contribute to that collision. This is likely to be true for other resident systems failures. These resident failures should not be excluded from consideration for recommendations if they were not directly involved in the collision being investigated as they pose a potential hazard for other collisions that may occur.

Additionally, the findings from the previous section showed that even for the fields that can be automatically positioned, extensive further work is required to identify the causal relationships between the factors. **Furthermore, extensive investigation will likely be required by the analysts to find the information to inform the gaps between the HEF structure and the AcciMap framework** (i.e. the red cells in Table 1).

3.3 Data gap analysis

In order for the RCIP analysts to comprehensively complete an AcciMap for a road traffic collision they will need to investigate information sources that can provide insight into all levels of the AcciMap. The data gaps identified in Table 1 represent the parts of the AcciMap that will require further investigation by the RCIP analysts to find new information sources to inform on the causal factors and relationships at those levels.

The information contained in a Police collision investigation report may contain information that populates any part of the AcciMap. However, the structure of the HEF database broadly mirrors the information in a typical Police collision investigation report as this is the sole source of information for the HEF investigations. Therefore, it is reasonable to assume that the Police reports will not always be able to inform on the data gaps and will require the RCIP analysts to seek other information sources.

The purpose of this assessment is not to provide a comprehensive list of information sources for the RCIP analysts to search in order to populate the levels of the AcciMap that not available in the Police collision investigation files. This would be impractical as the list of possible sources will be extensive and their relevance will depend on the individual circumstances of each collision. Instead, the aim of this assessment is to use the findings from the previous sections and the experience of TRL experts to set out a framework for a methodology that the RCIP analysts can follow to identify systems failures in collisions.

The RCIP analysts will need to identify and investigate information sources that enable the following lines of enquiry to inform on the presence and nature of the systems failures. For manufactured elements in the collision (including: protective equipment, vehicles and the road environment) the identification of a system failure can be present in one or multiple levels:

Network performance monitoring: Review how the network within which the particular hazard, failure or factor resides (e.g. the Strategic Road Network or a vehicle fleet) is reported, what information is captured and how that information is assessed and interpreted:

- Is the presence of the hazards, failures or factors being recorded or are they undetected?
- Are they being captured in sufficient detail that they are fully understood correctly and accurately?

- Are they being reported pro-actively or only after a safety incident?
- Do the responsible actors acknowledge when these events are identified and are their reactions appropriate?
- Are these data feeding into the relevant design and standards?

The factors identified will likely fall into the following levels of the AcciMap:

- Central government;
- Regulatory Bodies / Associations;
- Company Management / Local Government; or
- Technical and Operational Management.

Regulation, design and standards: Review the governance of the standards and the appropriateness of the specification for the respective measures (e.g. road surface, vehicle restraint system (barrier), vehicle airbag, vehicle crash structures, helmet crashworthiness, etc.) and their components, and if they are resulting in appropriately safe designs:

- Are the standards governing the specification of the measures suitable for the expected application and real-world performance of the measure?
- Is the life cycle of the standards from testing and validation to the implementation of the measures on the road acceptable or is too long that they are no longer relevant?
- Is the competency of the people assessing and implementing the standards sufficient to identify and accurately report hazards, failures and factors?
- Is the information captured sufficient to correctly and accurately understand any potential hazards, failures and factors?

The factors identified will likely fall into the following levels of the AcciMap:

- International Influences;
- National influences;
- Central government; or
- Regulatory Bodies / Associations.

Manufacture, construction and implementation: Review how the particular measure is implemented in the real world and how the design standards are interpreted and executed:

- Is the measure built correctly to specification but not installed correctly?
- Is the competency of the people implementing the measure sufficient to do so correctly?
- Are there suitable audits and assessments of the measures to ensure that the measures are implemented correctly and failures reported sufficiently?
- Is there a suitable process to deal with manufacturing non-conformity with standards, e.g. product recall or reinstallation?

- Are the measures implemented in a way that will hinder effectiveness or decrease operational life?

The factors identified will likely fall into the following levels of the AcciMap:

- Company Management / Local Government; or
- Technical and Operational Management.

Operational life: Review the suitability of the measures design, the maintenance and compliance schedules so that the measure remains safe throughout its operational life or is replaced:

- Do the design and standards specify an adequately robust measure with adequate longevity relative to its cost?
- Are there suitably regular inspections of the elements to establish roadworthiness and crashworthiness are maintained over time?
- Is the competency of the personnel conducting the inspections sufficient to identify failures, hazards and factors?
- Is the measure too complex to appraise effectively, including tools and software?
- Have there been any changes to conditions that will negatively influence performance after design, manufacture and implementation?
- Is there a feedback loop to identify network level performance of measures?

The factors identified will likely fall into the following levels of the AcciMap:

- Technical and Operational Management;
- Driving Process; or
- Equipment and Environment.

N.B. these questions are not exhaustive but demonstrate the potential line of enquiry that is required to identify systems failures for manufactured measures in a collision.

The collision causation factors and systems failures relating to the human behaviour and human factors are generally more challenging to identify and interpret than evidence relating to manufactured elements (e.g. vehicles and the road). Furthermore, human behaviour is also more challenging to investigate because it is more transient than vehicle and road factors and susceptible to change in an instant.

In order to populate a comprehensive AcciMap that includes the reasons why the actors took specific actions in the collision, the RCIP analysts need to identify the evidence base that informs what behaviours occurred and the human factors that influenced those behaviours.

The line of enquiry the RCIP analysts pursue should inform on the reasons why that person took a specific action or series of actions (i.e. understanding their cognitive processing). These include understanding the following cognitive processes:

- **Perception**: What sensory inputs did the person detect and why did they detect them in that way?
- **Memory**: What previous experiences influence the actor to take that specific action?
- **Decision making**: Why did the person take that specific action, series of actions or lack of action?
- **Reaction time**: How long did it take the person to react and why did it take that amount of time?

Some of the human factors that can influence these behaviours could include:

- **Fatigue or monotony;**
- **Distraction or inattention;**
- **Alcohol or drugs;**
- **Vehicle, infrastructure or road layout design;**
- **Age, gender or anthropometrics; and**
- **Driving experience.**

The factors identified will likely fall into the following levels of the AcciMap:

- Technical and Operational Management;
- Driving Process; or
- Equipment and Environment.

These human factors have specific mechanisms and ways of influencing different behaviours. Therefore, to investigate this part of the AcciMap comprehensively the RCIP analysts must critically analyse the evidence at the collision scene and the post-collision assessments to identify the factors which may have influenced behaviour. They should be prepared to take the line of enquiry with people close to the actor (where applicable and possible), including:

- The actors themselves;
- Their loved ones and friends (i.e. people who see the actor on a regular basis outside of working hours); and
- Their employers and colleagues (i.e. people who see the actor on a regular basis during working hours).

It is crucial to understand how these factors were present over time and not just if they were present at the time of the collision. In order to investigate this part of the AcciMap comprehensively the RCIP analysts should have an understanding of both behavioural science and human factors.

N.B. these elements of human behaviour and human factors are not exhaustive but demonstrate what a line of enquiry should aim to inform in order to identify human factors and behaviours and the systems failures associated with them.

4 Discussion

This report set out to assess the validity of implementing the AcciMap approach in the RCIP trial by evaluating its compatibility with the existing HEF programme. AcciMaps have had limited application in road traffic collision investigation (Newman and Goode, 2015;Newman *et al.*, 2017;Stanton, 2019), so the assessment of its compatibility with HEF provided useful insights into how the method should be applied in the RCIP and what considerations should be made to ensure robustness and reliability of the outcomes.

Both HEF and the RCIP trial will use Police collision investigation files as the primary information source to identify the root cause of collisions and provide evidence based countermeasures and recommendations. Importantly, both methods infer safety findings beyond the evidence presented in the Police source information. This is possible because the purpose of the Police collision investigation reports is different to those of HEF and RCIP. Useful safety recommendations can still be made with careful and considered expert judgement in the absence of evidence that directly supports the conclusions.

Most of the HEF field structure can be translated into the AcciMap structure. The main areas where there is currently no overlap relate to the data regarding the collision itself and post collision events (including the emergency response). This may result in more recommendations for collision avoidance than other aspects of the safe-systems approach (i.e. secondary and tertiary safety). For example, improvements to the emergency response to a collision and pre-hospital care of casualties will not be identified unless the AcciMap is further developed to focus more on the collision and post-collision events. If, for example, the 'X-axis' of the AcciMap is considered to represent the timeline of the collision then the AcciMap could continue on to include the collision and post-collision events. Similarly, a combination of separate AcciMaps could each focus on the separate stages of the collision and together provide a comprehensive description of the events. As the overall aim of the RCIP is to propose an analytical framework to improve road safety at a national level, the RCIP should consider how to extend or adapt the AcciMap to include all aspects of a collision.

The potential to retrospectively apply the AcciMap method to HEF collisions that have already been coded into the database could provide a way to rapidly increase the dataset of AcciMap collisions. Much of the HEF field structure can be placed automatically into an AcciMap or with minimal additional processing. However, the relationships between the actors and actions are not intrinsically coded, so creating these would require extensive further analysis. This is likely to be collision specific and will differ from one case to another, despite the same data being coded. So this effort would need to be repeated for each HEF collision.

A HEF collision could be used to quickly provide the groundwork to populate much of an AcciMap but would require substantial additional investigation time to complete. This is primarily because of the fundamental differences in how the two methods capture information; rather than a difference in the information (with the exception of the collision and post-collision data discussed above). Where the HEF method populates a database that can be analysed statistically with a large sample of collisions; the AcciMap populates a more holistic report for a single collision.

The holistic approach of the AcciMap has a broader focus than the HEF field structure and directly incorporates stakeholders and influencers (e.g. Highways England and Department for Transport). The majority of the HEF field structure populates the 'lower' levels of the AcciMap directly because the Police collision investigation files are the sole information source for HEF. Some aspects of the HEF database can appear at all levels (e.g. the countermeasure codes), but usually do not map automatically and require manual interpretation. The data gaps between the AcciMap framework and HEF field structure would require further investigation by the RCIP analysts to find and interpret the relevant source information. It is possible that information to inform the data gaps may be found in a particular Police report. However, in general, the HEF field structure mirrors the information found in the Police collision investigation files so this is unlikely to occur routinely.

The range of information sources needed to populate the data gaps, which are primarily in the 'middle' and 'higher' levels of the AcciMap (see Table 1), is vast and will depend on the circumstances of the specific collision. These sources could provide information on the possible factors that may or may not have occurred in the collision but will not intrinsically identify causal factors or links. The RCIP has the advantage of enabling the analysts to seek additional information beyond what is contained in the Police collision investigation files which they can explore to determine any additional causal links.

This report has set out a general framework for identifying systems failures in elements of the collision that are manufactured (including protective equipment, vehicles and the road environment) that will increase the likelihood of RCIP analysts correctly identifying the resident systems failures and completing the AcciMap accurately. Similarly, a general framework for the line of enquiry to identify failures relating to the people involved in the collisions should start by trying to understand the human behaviour as shown in Section 3.3. However, the human factors and behaviour in any collision investigation are usually the most difficult to identify and quantify by virtue of the evidence they leave.

Where the RCIP analysts are required to investigate beyond what is evidenced in the source information, an element of expert judgement will likely be required to identify the causal factors and relationships required in the AcciMap. This is most likely to occur in the 'middle' and 'higher' levels of the AcciMap, where evidence may be sparser and will require greater levels of expertise to interpret accurately. In order to avoid introducing biases in to the AcciMap and the subsequent recommendations the RCIP should employ expert panels to review the available evidence and provide a consensus on the identification and coding of the causation factors and relationships.

For an example of how an individual analyst may draw erroneous conclusions from a paucity of evidence, consider a collision where a vehicle has left the carriageway, impacted a roadside barrier and breached the barrier to contact a hazard behind. There may be multiple causal links as to why the barrier was unable to contain that vehicle. It would be reasonable to hypothesize that the barrier was insufficiently designed because the collision configuration exceeded the design capacity for that particular barrier (e.g. the collision speed the barrier is designed for is lower than the speed limit for the road). In which case there would be a causal link to the actors responsible for the design and standards. However, if the breach occurred because of poor implementation or manufacture of the barrier then this link is in fact not representative of the systems failure for that collision. The

likelihood of the RCIP analyst repeating that mistake for every collision in which a vehicle breaches a barrier (i.e. assuming that the barrier was not designed correctly) is an example of how this confirmation bias can be propagated when there is insufficient evidence to correctly identify the systems failure. These situations should be reviewed by an expert panel to minimise the likelihood of this occurring and come to a consensus on how the uncertainty should be coded in that particular AcciMap.

Support through expert panel reviews will also help to prevent the perpetuation of the same biases in different collisions. It is likely that the same areas of an AcciMap will lack supporting evidence from one collision to the next. As the analysts continue to complete AcciMaps without supporting evidence there is potential to reinforce the confirmation bias from collision to collision.

One aspect the analysts and expert panels will need to address is how to capture uncertainty and unknowns in the AcciMaps. This will help to distinguish between evidence-based recommendations and recommendations that may be drawing on more subjective assessments. For example, if the information on the human factors influencing the collision is not available it must be clearly stated that these are unknown. This is important to understand the limitations of that particular AcciMap and to minimise the likelihood of confirmation biases in the causal relationships and, therefore, the recommendations. Additionally, identifying which levels of the AcciMap are often unknown will provide an evidence-base for recommendations to capture that information in the future.

A comprehensive investigation that identifies all of the pertinent factors in an AcciMap may not always be possible if there is insufficient evidence available in the source information. Understanding when the point of diminishing returns with respect to the time and effort spent completing an AcciMap versus the usefulness of the findings for each collision will maximise the effectiveness of the analysts' time. When the AcciMap is not completed comprehensively the recommendations may not be as specific or as accurate as a complete AcciMap. However, there may still be useful safety findings and recommendations that can be drawn.

The RCIP analysts should be prepared to identify and research myriad information sources beyond the Police collision investigation files to inform all levels of an AcciMap comprehensively. This is required to provide a truly holistic understanding of the systems failures and the subsequent recommendations to prevent road traffic casualties. This will include information sources that govern and regulate road, infrastructure and vehicles. The analysts will also need to pursue lines of enquiry with the friends, family and employers of the road users involved to gather information that informs on the human factors and behaviour. Meaningful recommendations can still be made from investigations where there is insufficient evidence to comprehensively complete the AcciMap when it is understood where the limitations (e.g. uncertainty or unknowns) in that AcciMap are coded.

The AcciMap method can provide a holistic approach to identifying road safety systems failures for an individual collision. However, the analysis of multiple AcciMaps is very limited particularly compared to in-depth collision programmes that use a standardised data structure (e.g. the HEF database). Therefore, the implementation of an AcciMap methodology should be coupled with a robust case selection method that selects indicative cases with an abundance of information available to maximise the value of the

recommendations. A further feasibility study considering if an AcciMap method could be scaled up to a national level should be made following the RCIP trial.

5 Conclusions

TRL has assessed the AcciMap method within the context of collision investigation by drawing on TRL's expertise and experience as a world leader for the collection and analysis of in-depth collision data. There is good evidence from this assessment that the AcciMap method can identify systems failures in individual collisions and provide recommendations to improve road safety. The AcciMap captures causal factors and relationships in a more holistic way than existing in-depth collision programmes. However, there are challenges and limitations with the proposed method that should be considered thoroughly before implementation in a feasibility trial to ensure that the recommendations provide useful safety findings that are evidence-based and robust.

The AcciMaps applied to collision research have not yet extended to collision and post-collision factors which will bias against secondary and tertiary safety recommendations. Development of the AcciMap to include this evidence will align the recommendations more closely to the safe-systems approach that is widely adopted by stakeholders.

Critically, for the successful application of the AcciMap in collision investigation, the identification of a factor that influences a collision does not inherently denote the presence of a causal link to other parts of the AcciMap. These relationships will need to be investigated by the RCIP analysts in detail by understanding and interpreting the available source data in the ways described in Section 3.

The evidence required to support every level of an AcciMap may not always be available or the evidence may not conclusively support a causal link identified by the RCIP analysts. In these situations a balance must be made between enabling expert judgement to create links that are not specifically evidenced and restricting the AcciMap to factors that can only be clearly evidenced. This will ensure the method still provides useful safety recommendations without introducing potentially erroneous biases and without overly limiting the outcomes of the trial.

The AcciMap method can be susceptible to confirmation biases that will be reinforced by the presence of the same factors and relationships that appear in multiple collisions but are not necessarily causative in a specific collision. Therefore, it is important that the RCIP analysts are sufficiently trained to identify these situations and have sufficient expertise to make accurate judgements on the collision's causation. Ensuring the analysts are supported by expert panels to review cases with ambiguous or sparse evidence is important to maintain consistency and the robustness of the AcciMap findings. Furthermore, unknowns and uncertainties in the AcciMap must be clearly stated so it is clear which recommendations are truly evidence-based and which involve expert judgement.

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Appendix A Highways England Database Field Structure

Figure 4 shows the field structure of the Highways England Fatality database. Each section, and the fields that reside within each section, can be duplicated depending on the number of those items within a specific case. For example, the fields within the 'Vehicles' capture information about a single vehicle and will be duplicated for every vehicle within a case. For each vehicle, all of the sub-sections will also be duplicated depending on the number of those items.

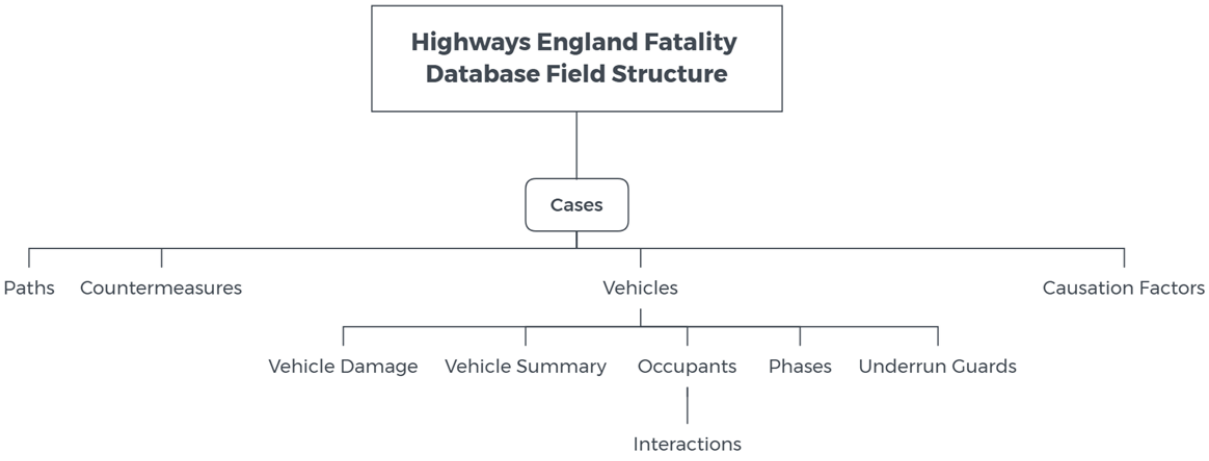

Figure 4: Field hierarchal structure of the Highways England Database

RAC Foundation RCIP Feasibility Study

The RAC Foundation has selected the AcciMap method to use in a small scale trial performed by analysts embedded in three police forces for their Road Collision Investigation Project (RCIP). Analysts will have access to Police collision investigation files as the primary information source to populate the AcciMaps with the possibility of performing further investigations when the source data does not evidence all parts of the AcciMap. The AcciMap method provides a holistic approach to identifying the systems failures that cause collisions. From this evidence base, recommendations to improve road safety can be made.

The aim of this project is to assess the validity of the AcciMap approach by evaluating its compatibility with existing in-depth collision investigation programmes. A comparison of the existing Highways England Fatality Research programme methodology and the proposed AcciMap trial was completed to inform the development of the AcciMap framework and provide guidance on how to successfully implement it in the RCIP trial.

The comparison showed there is good evidence for using the AcciMap method to identify systems failures and provide recommendations that can improve the outcome of individual collisions. There are challenges and limitations with the method that should be considered thoroughly before implementation in a feasibility trial to ensure that the recommendations provide useful safety findings that are evidence-based.

Other titles from this subject area

PPR913	Highways England Fatality Research Report. Barrow A, Hylands, N, O'Connell S. 2019
PPR910	RAIDS Year 3 Final Report – Summary Report. Barrow A, Hylands N, Khatry R. 2019
PPR909	RAIDS Year 3 Final Report – Full Technical Report. Barrow A, Hylands N, Khatry R. 2019

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