THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR2019

Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring

Task 4 - Post Event Investigation Process

Craig Arnold, Will Perren

Report details

<table>
<tr><td>Report prepared for:</td><td colspan="3">Department for Transport</td></tr>
<tr><td>Project/customer reference:</td><td colspan="3">TETI0042</td></tr>
<tr><td>Copyright:</td><td colspan="3">© TRL Limited</td></tr>
<tr><td>Report date:</td><td colspan="3">30/06/2022</td></tr>
<tr><td>Report status/version:</td><td colspan="3">1.0</td></tr>
<tr><td colspan="4">Quality approval:</td></tr>
<tr><td>Gareth Slocombe
(Project Manager)</td><td>G. Slocombe</td><td>David Hynd
(Technical Reviewer)</td><td>D. Hynd</td></tr>
</table>

Disclaimer

This report has been produced by TRL Limited (TRL) under a contract with the Department for Transport. Any views expressed in this report are not necessarily those of the Department for Transport.

The information contained herein is the property of TRL Limited and does not necessarily reflect the views or policies of the customer for whom this report was prepared. Whilst every effort has been made to ensure that the matter presented in this report is relevant, accurate and up-to-date, TRL Limited cannot accept any liability for any error or omission, or reliance on part or all of the content in another context.

Executive Summary

Future deployment of Automated Vehicles (AV) on our roads brings with it the challenge of managing incidents that arise out of their deployment. This report outlines a framework for post-incident response and investigation which aims to ensure the safe deployment of AV and improve public confidence in these systems. Currently, in most cases, police forces handle the attendance at, and investigation of, road traffic collisions, but given the range of data available from AVs, there is an opportunity to learn from not only collisions, but near-misses and other safety critical events. This report outlines the mechanism for reporting such incidents, along with the type of information that would be required in any subsequent investigation.

Whilst the police currently investigate matters involving motor vehicles, investigating AV related collisions is expected to be the jurisdiction of the proposed In-Use Regulator who will handle investigations into ensuring regulatory compliance. However, police involvement in investigation is still necessary to allow them to exercise their duties to investigate and prosecute criminal offences committed by any humans involved. A mechanism for police and In-Use Regulator collaboration has been proposed. Following their investigation, the In-Use Regulator could apply a range of corrective actions and civil sanctions, reserving the option to prosecute for all but the most serious of cases.

An Independent Investigation Authority (IIA) is proposed to conduct AV investigations for generating learnings and recommendations for improved safety. Adopting a similar approach to that of the Air Accidents, and Marine & Rail Accident Investigation Branches, the IIA would, focus on understanding the causal and contributory factors that apply in relevant AV incidents. The recently announced Road Safety Investigation Branch (RSIB) is expected to be able to fulfil this role for AV post-investigation process although regardless some form of IIA would be required.

In order to better generate safety learnings, it is recommended that the IIA directly investigate all AV collisions level 3+, at least initially. Over time as more AV deployments occur and there is more data available, the IIA should focus more effort on thematic analysis. The IIA should then have powers to collect evidence from on-site, off-site and through conducting interviews. These powers reflect what is proposed for the RSIB; however it is recognised the primary focus of the RSIB is thematic analyses.

The investigations would comprise a multidisciplinary team and would draw on skills used by collision investigators and utilise new skills specific to understanding the data available from automated vehicles. These investigations would focus on improving AV operations and sharing learning and best practice.

We expect that through this framework, road safety improvements can be identified and actioned whilst enabling safe AV deployments. We expect a robust and transparent framework for post-incident response and investigation to reassure the public and increase public trust in the deployment of AVs on GB roads.

Table of Contents

List of Tables and Figures

Tables

Figures

List of Abbreviations

AAIB:	Air Accidents Investigation Branch
ACM (ACU):	Airbag Control Module (Unit)
ADAS:	Advanced Driver Assistance Systems
ADR:	Accident Data Recorder
ADS:	Automated Driving System
AEB:	Autonomous Emergency Braking
ANPR:	Automatic Number Plate Recognition
AV:	Automated Vehicle
AVI:	Automatic Vehicle Identification
CAV:	Connected or Autonomous Vehicle
CCAV:	Centre for Connected and Autonomous Vehicles (DfT)
CCTV:	Closed-circuit television
CDR:	Crash Data Retrieval
DVSA:	Driver & Vehicle Standards Agency
EDR:	Event data Recorder
FCI:	Forensic Collision Investigator
FCIN:	Forensic Collision Investigation Network
FCW:	Forward Collision Warning
FLO:	Family Liaison Officers
FNOL:	First notification of loss
GPS:	Global Positioning System
HARPS:	Highly Automated Road Passenger Services
IIA:	Independent Investigating Authority
IMS:	Infrared motion sensor
IoT:	Internet of Things
LiDAR:	Light Detection and Ranging
LSAV:	Low-speed autonomous vehicle (<20 miles per hour)
NIP:	Notice of Intended Prosecution
NTSB:	National Transportation Safety Board
NUIC:	Non-User In Charge
OBD2:	On-board Diagnostics (2nd generation)

ODD:	Operational Design Domain
OEM:	Original Equipment Manufacturer
PET:	Post Encroachment Time
RCM:	Restraint Control Module (See ACM)
SIO:	Senior Investigating Officer
SSM:	Surrogate Safety Measures
TTC:	Time To Collision
UBI:	Usage Based Insurance
UKAS:	United Kingdom Accreditation Service
UNECE:	United Nations Economic Commission for Europe
VCA:	Vehicle Certification Agency
VMAD:	Validation Method for Automated Driving
VMS:	Variable Message Signs
WIM:	Wight In Motion
WHO:	World Health Organization

1 Introduction

Automated Vehicles (AVs) including Low Speed Automated Vehicles (LSAVs) are likely to present significant challenges for those agencies involved in the response to, and investigation of, incidents involving these vehicles. The most obvious example of such incidents would be a road traffic collision, but other incidents may be more nuanced. These vehicles contain advanced technologies, many of which focus on improving safety. However, safety is not guaranteed, and it is unhelpful to assume these systems will be faultless. As with any complex system, inevitably, there will be issues which need addressing. When such complex systems involve vehicles, we could expect incidents which results in risk to the occupants or public. In more serious cases, these incidents could lead to injury or damage. In less serious cases, minor breaches of road traffic legislation could occur. Both would require investigation given the relationship between traffic infractions and road collisions (Chen, Cooper & Pinili, 1995). The categorisation and management of any incident involving an AV requires careful thought, because the range of potential incidents is at least as wide as non-ADS vehicles, but with added layers of complexity owing to the lack of a driver.

The effectiveness of any post-incident response to incidents involving automated vehicles is an important aspect if we are to develop and maintain public confidence in the real-world application of automated vehicle systems. It is necessary to consider and develop a reliable system for incident detection and notification, as well as identifying those challenges which arise from the deployment of automated and highly automated vehicles on the roads of Great Britain. The challenges faced are multi-faceted and range from the administrative, relating to incident reporting and management, to the technical, relating to the interpretation and analysis of data that are recovered from the vehicle following any post-incident investigation. It is also necessary to determine how the reporting of such incidents would occur, and the requirements for any report.

The potential extent or frequency of incidents involving these vehicles is unknown, but we expect they would occur with less frequency than in non-ADS vehicles. A further challenge involves the fundamental way in which these vehicles operate. In non-ADS (driven by a human) vehicles, safety assurance occurs through type-approval, driver licencing, insurance and enforcement activities. Having been subject of type approval, the way the vehicle operates rarely changes, leaving regulatory and enforcement agencies to deal with driving standards and documentary breaches (e.g., insurance, taxation, and MOT). Conversely, in AVs all the same aspects apply, but software updates have the potential to change the way these vehicles act and react in certain situations. Regular software updates are an opportunity for improvement by altering the way a vehicle operates in light of other incidents or near-misses, but this also poses a risk. To develop software updates effectively, manufacturers will require a sufficient understanding of how, and why, incidents occurred. Any learning from these incidents will need to be shared between stakeholders who will benefit from those learnings including other manufacturers, operators, regulators and the wider transport industry. Whilst we would expect any new software update to improve road safety, there remains the possibility that it would have the opposite effect. The ability to conduct in-use safety monitoring would seek to mitigate those risks by ensuring continual oversight of AV technology.

A further challenge relates to the commercial sensitivity of the innovative technologies these vehicles contain. The effectiveness of any post-incident response or investigation will inevitably fall on the ability of frontline responders and post-incident investigators to obtain, interrogate, and interpret the data arising from these technologies. Engagement with these parties by investigation teams will be key in ensuring an effective and transparent investigation. The investigation of these incidents will not solely involve advanced technologies, and the skills required to investigate non-ADS vehicle incidents will need to be retained. For example, it may be necessary to investigate mechanical defects and consider the physical environment in which the vehicle was operating at the time of an incident. Similarly, it may become necessary to understand the role of pedestrians, or other non-ADS vehicles, and the role they played in any incident. There is a statistically significant relationship between infractions and road collisions (RAND, 2019) but we do not know if this relationship will exist with AV. Nevertheless, such infractions will require investigation. The interaction between AV and non-ADS vehicles will probably become the focus of any investigation where both are involved.

Given the levels of automation forming the basis of this framework, it is likely that different investigations are needed to fulfil different purposes. An in-use regulator led investigation will be focused on determining compliance with safety requirements set out and will seek to ensure accountability through application of sanctions on the manufacturer and operator, as appropriate. Independent investigations will be concerned with the examination of potential systemic failures of the vehicle or developer as opposed to the attribution of blame or liability to individuals. We can draw comparisons to the investigation of aviation, rail, and marine incidents, which focus on learning from the failure of systems and processes to improve overall safety. Investigations involving vehicles operating at higher levels of automation, such as those being considered for this report, may suit a similar investigative framework. Failing to implement an effective post-incident response will miss opportunities to identify the causal and contributory factors that apply to AV incidents, thus preventing the opportunity to identify and implement corrective measures quickly.

2 Scope and purpose

This report aims to consider a framework for the post-incident response and investigation of automated vehicle incidents. The basis for the report is the deployment of AVs at limited scale.

In this report, we limit the use-case to an AV which is a vehicle equipped with an SAE Level 4 ADS that operates on roads with a speed limit of 30 mph or less and operates at a maximum speed of 20 mph without an operator in the vehicle. The principles and recommendations outlined in this report are nonetheless applicable to automated vehicles in general and will likely serve as a basis for future phases of the scheme including wider automation use cases.

The report focuses on the processes and framework that would be required to effectively respond to, and investigate, AV incidents. This would likely involve incident reports received from the public, police, or other stakeholders.

Post-incident response will involve multiple stakeholders, many of whom will need to conduct different investigations targeting a specific question. The different investigations discussed are:

- **Police led investigation** – Police Forces will investigate collisions they attend, any traffic infractions identified through typical means (police officers, speed cameras, etc.) and any reports made to them by a member of the public. The purpose of police investigations traditionally is to identify if any offences occur and whether action should be taken. For collisions between AVs and conventional vehicles, the police will need to maintain jurisdiction over conventional elements where driving offences by a human could still occur.
- **In-Use Regulator led investigation** – The In-Use Regulator will have responsibilities to monitor the safety of authorised AVs and investigate infractions[1] involving AVs and have powers to enforce its decisions and apply regulatory sanctions. Investigations will be focused on determining whether there was non-compliance with safety and performance claims which formed the basis of approval. While this is regulator led, the actual investigation of the causal factors and context of the event will likely be conducted by the manufacturer (supported by the operator).
- **Independent Investigating Authority led investigation** – The Law Commission propose an Independent Investigating Authority (IIA) be set up to investigate the most serious, high-profile or complex collisions (and potentially other incidents). This body would focus on conducting blame free investigations for the purposes of generating learnings that can be shared to improve the safety of AVs.

It is clear that one, two or all three of these entities could be involved in an incident and their investigations may take place in parallel. For the scheme to operate effectively with limited duplication of effort and minimal burden on all parties, that the interface between and the roles, responsibilities and remit of these investigating bodies be established. Work done previously (Balcombe and Perren, 2022) outlines the requirements for the in-use

[1] 'Infraction' is a term developed by the Law Commission to refer specifically to AVs. It refers to any driving behaviours which would attract prosecution or a civil penalty if brought about by a human driver.

regulator to investigate and respond to events. The scope of this work considers events where multiple investigations and involvement from different stakeholders is required. Invariably this will include severe collision events but will also include any events escalated for independent investigation or any events involving potential offences by non-ADS drivers.

3 Background

There are a range of organisations working within the transport industry who manage the response to, and investigation of, incidents involving the aeronautical, marine, and rail sectors. In addition, there are regulatory and investigative bodies who deal with automotive incidents. These organisations provide a useful insight from which to draw learning to support the investigation of AV incidents.

Organisations such as the Air Accidents Investigations Branch (AAIB), Marine Accident Investigation Branch (MAIB) and Rail Accident Investigation Branch (RAIB) all adopt a learning-focussed approach to their investigations. Further information on these organisations as well as other investigating bodies are given in Appendix A.

Whilst oversimplifying their operating method, one can consider these organisations as adopting a four-stage approach to incidents within their remit. Initially, incidents are reported, after which they make an assessment regarding whether further investigation would be necessary. If so, they appointed a team to investigate. Following the investigation, the aim is to refine practice to reduce the likelihood of recurrence. A simplified process is shown below. The report stage deals with how and when incidents could be reported. The respond stage deals with how the response to the incident, how a response could be managed and who handles the management of it. The react stage considers when and how investigations could be conducted and includes who manages the investigation. In the final stage, operations are refined based on the learning achieved through the investigation stage. Each of the stages are dealt with in greater detail later in this report.

Figure 1: Simplified process

Each of these organisations features multi-disciplinary teams and industry experts to develop an investigative strategy based on the circumstances of the incident. Not all incidents will be investigated, but the organisation will manage this decision-making process on a case-by-case basis, underpinned by a strong incident response framework.

The organisations have a legal power to investigate and make safety recommendations. Final reports may or may not be subject to consultation, but relevant safety messages are circulated to stakeholders and other relevant parties, aimed at learning from the incident rather than focussing on criminal culpability. It is our proposal that the Department adopts a similar approach for investigating AV incidents. Once established, the Road Collision Investigation Branch could assume the role as an IIA, supported by the police, who are likely to manage the initial incident response.

3.1 Road Safety Investigation Branch (RSIB)

In autumn 2018, the UK government funded the Road Collision Investigation Project (RCIP) which was designed to examine the causes of collisions and assess whether there is a business case for the creation of an independent body for investigating road collisions. In October 2021, a consultation was launched regarding the proposal to establish such a body in Great Britain.

The remit of the proposed body was to collect evidence from road traffic collisions (including from on-site, from reports and through interviews), investigate them (in coordination with the police conducting parallel investigations), conduct statistical (thematic) analyses on the causes of collisions and make independent safety recommendations for remedial action (DfT, 2021)[2]. Primarily the body would be focused on thematic analyses with little to no involvement in on-site investigations, although the powers to do so exist as stated above. In June 2022, The UK government announced that following overwhelming support, they would be setting up The Road Safety Investigation Branch (RSIB) (UK Government, 2022).

The Law Commission suggest that an Independent Investigatory function is a prerequisite for AV deployment in GB (Law Commission and Scottish Law Commission, 2022). It was also proposed that the RSIB could serve this function for the AV safety assurance scheme as proposed by the Law Commissions (DfT, 2021). However, for the purposes of this report it is useful to explore the remit, powers and responsibilities of an investigatory function specifically for AVs without prejudice or limitation to what is proposed to the RSIB. In this way the effectiveness of the RSIB can be appraised in this context and any gaps and differing requirements solely for the investigation of AVs can be identified.

Herein, the IIAy functions for AV deployment are assumed to be conducted by the Independent Investigatory Authority (IIA), an abstract entity devised solely for this report to avoid conflation with the RSIB.

4 Current investigative approaches

Currently, there is a focus on the attribution of blame and determining criminal liability during the (police) investigation of road collisions. This role is invariably undertaken by Forensic Collision Investigators (FCI) who support the wider police investigation. The role of FCI is to act as an independent and impartial expert witness to assist the Court in matters outside of their expertise. In practice however, police FCI invariably take a position within the

[2]Among other proposed responsibilities, see: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1030169/deepening-our-understanding-of-road-traffic-collisions-and-how-best-to-address-them-consultation-on-establishing-a-road-collision-investigation-branch.pdf

prosecution case, with Defence experts (appointed by opposing Counsel or their representatives) forming part of the case for the Defence.

There are also well-established civil processes for managing tort claims arising out of negligent driving by collision investigators who support the legal industry. These involve private sector organisations (such as TRL) who have Consultants with similar qualifications utilising similar methods to reconstruct collisions. These are also the same investigators who would provide expert evidence for the Defence.

The investigation into collisions depends on the level of severity. The involved parties may deal with minor collisions, including those involving only damage, thus these attract no police attention. Whilst it is common for involved parties to contact the police to report such collisions, there may be no tangible police investigation. Similarly, less serious collisions may never be subject of civil litigation, and as such a collision investigator may not ever review the case. Often motor insurers are the only organisations who conduct any tangible investigation into such collisions and are often aimed at establishing whether a claim is valid or fraudulent.

Section 170 of the Road Traffic Act 1988 (see Appendix B) sets out the requirement to stop and report collisions, but collisions involving injury generally attract some level of investigation from the police. In cases involving a fatality, the police classify cases based on the circumstances (College of Policing, 2020). The classification of the incident helps assign an appropriate RP (roads policing) lead investigator;

- *Category A+* – Assessed as a likely homicide investigation or where the complexity requires the deployment of a nationally registered Senior Investigating Officer (SIO)
- *Category A* – Confirmed fatality – one or more vehicles have failed to stop, and/or drivers have left the scene, or other factors are present that significantly increase the complexity of the investigation
- *Category B* – Confirmed fatality – all drivers/riders are known or can be immediately identified
- *Category C* – Confirmed fatality – driver/rider only killed, no third party involvement – inquest only
- *Category D* – Confirmed fatality – driver/rider only killed, death due to natural causes. Cases may involve a third party – no inquest necessary

4.1 STATS19

Police report data regarding various aspects of a collision involving injuries for STATS19, a form which is later sent to the Department for Transport. STATS19 is categorised and considers various aspects, including the physical environment, weather, vehicle types, demographic information, and various other factors relevant to the collision. The reporting officer also selects from a pre-defined list of contributory factors. The officer selects and assigns these a probability (very likely or possible).

Whilst STATS19 identifies aspects present at the time of the collision, a key criticism is that the data is based upon the judgement of the officer who initially attended the scene, as opposed to circumstances which come to light following an investigation (PACTS, 2021). The selection of contributory factors is subjective. Sometimes a subsequent investigation reveals a vastly different set of contributory factors from that recorded by the attending officer because of evidence coming to light during the investigation. This generally only occurs following more serious collisions; those with minor or no injuries may not be reviewed again. FCI reports would, however, be a useful source of information to determine the causal and contributory factors in a collision. Anecdotal evidence suggests forces do not scrutinise these reports in sufficient detail as to allow collision trends to be identified. Road Safety professionals, often working as part of Road Safety Partnerships do analyse this information but often this almost always has a local rather than national focus and misses the opportunity to learn from other local authorities. This does, however, remain a useful source of information going forward.

4.2 Investigative strategy for police investigations

The investigative strategy employed in collisions varies, often on the seriousness of the collision itself. Less serious collisions may be subject to no tangible investigation at all, but more serious collisions could involve investigators gathering evidence to ascertain if an involved party has committed offences. The range of outcomes varies from awareness courses to prosecution. In very serious cases, such as those involving fatalities, there is often a detailed investigation comprising a full investigative team led by a Lead Investigating Officer (LIO). Family liaison officers (FLO), vehicle examiners, forensic collision investigators (FCI), and investigators would support this team, although members of the team are not always Detectives. In addition, other specialties, such as digital forensics, pathologists, or toxicologists, may assist when necessary.

Most investigations initially focus on the scene and its preservation to secure and recover evidence. Police use the term 'golden-hour' to refer to the period immediately after an incident occurs when evidence is readily available to the police (College of Policing, 2021). It is important to enact a suitable response to secure evidence that will support the investigation. Golden hour considerations include:

- *Victims* – identify, support, and preserve evidence
- *Scenes* – Identify, preserve, and assess
- *Suspects* – Identify, detain, and preserve evidence
- *Witnesses* – Identify, support, and preserve evidence
- *Log* – Record all decisions and rationale
- *Family* – Identify, inform and support (Family Support Officers (FLO) can assist)
- *Physical evidence* – preserve
- *Intelligence* – Identify, prioritise, and exploit
- *Contamination* – Prevent contamination of the victim, scene, and suspects
- *Lines of responsibility* – Identify, inform, brief and coordinate

When managing the initial response to incidents on strategic roads there is often a pressure to reopen the carriageway to prevent prolonged delays. This often means that there needs to be a balance struck between securing the evidence and reopening the road. The ability to provide an efficient and effective response becomes even more necessary in these circumstances. Once police have concluded the initial investigation, they would decide whether further enquires were necessary. Where further enquiries are required, the police can refine the investigative strategy to explore those lines of enquiry.

More detailed investigations also focus on the lead-up to incidents, the incident itself, and the events after an incident has occurred. The World Health Organisation formalised this method (WHO) (2001) based on a framework developed by Haddon (1972). The method involved three time frames, each of which has four dimensions. Haddon's tool was developed as a way of analysing injuries and can analyse any event involving an injury to prevent a recurrence of the event which caused the injury.

The WHO outline an amended version of Haddon's matrix that would apply to understanding road collisions. They outline the aspects below with an exemplar matrix shown in Table 1 which can be used to understand the factors involved.

- Three time periods
  - Pre-event
  - Event
  - Post-event
- Four dimensions
  - Human
  - Vector (vehicle)
  - Physical environment
  - Socioeconomic environment

Table 1: Haddon Matrix

	Human	Vector (vehicle)	Physical environment	Socio-economic environment
Pre-event	Causative and contributory factors			
Event				
Post-Event				

By considering the causative factors in each of these areas, stakeholders can consider interventions that prevent recurrence (or reduce future severity) of the event under investigation. Examples relating to each dimension are provided below, but their circumstances are likely to be varied and specific to that event under investigation. Whilst police explore these aspects as part of their investigation, their role is to determine if an involved party has committed a criminal offence, not solely to improve safety.

4.2.1 Human factors

Any investigation invariably focuses on the human factors involved in any collision. This would focus on the driver's behaviour before, during, and after the collision. This would include elements such as intoxication or distraction in the lead-up to the collision, the wearing of a seatbelt at the time of the collision. Post-event elements could include investigations into medical conditions such as poor eyesight, which police would detect as part of a post-collision eyesight test. During any investigation, police normally interview witnesses and those involved to gain a detailed insight. These interviews can take the form of written statements, audio or video recorded interviews, or interviews under caution (with or without legal representation).

4.2.2 Vehicle

The vehicle will feature heavily in any investigation. Vehicles are generally subject to a full mechanical examination, especially where fatalities are involved. This would seek to establish if there are any aspects of the vehicle which could have caused or contributed to the collision. In terms of pre-event issues, this could include tyres with poor tread, or defective steering. Event related vehicular aspects could include poor occupant or pedestrian protection afforded by the vehicle's design. In terms of post-event aspects, this could include the lack of e-Call system which prevented the emergency services from being automatically notified of the collision.

4.2.3 Physical environment

The physical environment involves consideration of both the road layout and prevailing weather at the time of the collision. In cases involving a FCI, the scene is often subject to a scene survey. More recently, this involves the use of 3D laser scanners to capture the scene evidence and the physical layout of the environment. FCI conduct a detailed scene analysis as part of any reconstruction, which involves consideration of factors which may have caused or contribute to the collision. The road surface and poor weather could form factors which applicable to the pre-event stage of the collision. Lack of roadside safety features such as safety barriers or kerbs could also feature.

4.3 Finalisation

Following any investigation, the Lead investigating officer (LIO) and/or Crown Prosecution Service (CPS) review the reports obtained from those specialists involved in the investigation. The aim is to ascertain if there is sufficient evidence to support a prosecution or if there is to be no further action. Police do not make finalised reports public.

The Coroner will also oversee cases where there are fatalities. Ordinarily, the Coroner will adjourn any inquest into the death until the conclusion of the criminal investigation. Where there is likely to be no prosecution, for example, where only the deceased is involved, the Coroner will be involved throughout.

4.4 Victim / family support

Throughout the process of road death investigation, a firm focus remains on the families of those involved and the provision of support. Where fatalities are involved, Family Liaison Officers (FLO) take the lead for liaison with the family. There are also road safety charities who support families, such as Brake, RoadPeace, Road Victims Trust, and Aftermath Support. Their role is integral in supporting families both throughout, and after the police investigation has ended. Often these charities provide emotional and practical support to those involved in road collisions and are essential in ensuring people receive support throughout. There is no standardised mechanism for referral to these charities, and often it is reliant upon the FLO providing the details to those affected. The role of charities would benefit from being formalised as a key part of a collision investigation.

4.5 Summary

A significant number of road collisions involves no tangible investigation, with the matter often being managed solely by the drivers involved or their insurance companies. Insurance investigations focus on reducing fraud, rather than providing an insight into the causative or contributory factors at play.

Generally, investigations are conducted as part of criminal or civil proceedings. The police invariably undertake Criminal investigations, or in some select cases the DVSA. The legal or insurance industries manage civil cases in most cases. Whether criminal or civil, Forensic Collision Investigators, acting as independent and impartial expert witnesses, often support these investigations.

These investigators come from a range of backgrounds and work within both the private and public sector. FCIs aim to reconstruct the collision and provide some insight into the causative or contributory factors at play. Their role is not to understand the broader landscape in which the collision occurred, so rarely focus on the socio-economic factors which may be relevant.

In the short term, following AV deployment under the assurance scheme, the ability to generate useful safety learnings from thematic analysis is limited due to the expectantly low number of collisions from which to draw conclusions from. As such, it is recommended that initially all AV collisions are subject to detailed investigation to provide insight into the causative or contributory factors at play and generate learnings for improved safety.

The In-use regulator will be expected to conduct investigations on individual AV collisions however the remit of these, as discussed (see Section 2), is primarily limited to evidence provided by the manufacturer and operator and is primarily focussed on establishing blame or non-compliance so that sanctions can be imposed as necessary. The In-Use Regulator will not have the ability to collect evidence from the scene of a collision and will likely rely on police reports[3].

[3] Though the police reports will likely be limited to evidence necessary to establish whether a driving offence had occurred.

In order to better generate safety learnings, it is recommended that the IIA directly investigate individual all AV collisions level 3+[4], at least initially. Over time as more AV deployments occur and there is more data available, the IIA should focus more effort on thematic analysis. The IIA should then have powers to collect evidence from on-site, off-site and through conducting interviews. These powers reflect what is proposed for the RSIB however it is recognised the primary focus of the RSIB will likely be thematic analyses.

It is recommended that the IIA retain the services of Forensic Collision Investigators as they are skilled and qualified to reconstruct the circumstances of collisions and have experience supporting the wider investigation of a collision. Additionally, the IIA should have access to independent organisations expert in AV data and AV behavioural safety to assist with investigations.

We would recommend that the scope of each investigation is tailored depending on the circumstances, with more serious incidents subject to a larger, more in-depth response and investigation. The investigative branches discussed adopt this approach, and it is one we support.

We would recommend a starting point for Independent AV investigations use already established methodologies for investigation collisions of conventionally driven vehicles. The WHO recommend a framework based on the Haddon Matrix, as discussed in Section 4 and is proven for collisions with conventionally driven vehicles. It is recommended that this approach is used for collisions between AVs and conventional vehicles. Additionally, there have been recent advances in methodologies applicable to AV collisions, which is discussed in Section 6.7. Ultimately however, any methodology should enable evaluation of human, vehicle, socioeconomic and environmental factors such that learnings can be associated with each factor so that it's possible to understand who is best placed to implement and monitor the corrective actions recommended.

Any investigation must also ensure the victim and their family are supported throughout. This requires specialist training and is often provided by the police or road safety charities. Given limited police jurisdiction in some AV collisions, it is recommended that the In-Use Regulator work closely with one or more road safety charities to provide this support to victims of AV collisions and their families, as needed.

The ability to provide an effective and efficient response will be key in balancing the need to secure evidence and gather evidence at the scene of road collisions. This is even more necessary when the collision has occurred on the strategic roads network whereby there is often pressure to reopen the road as soon as possible. It is important to establish clear guidelines regarding how an incident is responded to between the police, In-Use Regulator and IIA, as well as other groups such as National Highways (if applicable)

---

[4] As defined in the road incident taxonomy for this project (Reed, 2022):

- Level 3: Police-reported collision with vehicle / property damage only.
- Level 4: Police-reported collision with possible or slight human injury.
- Level 5: Police-reported collision with serious human injury or fatality.

The lack of human involvement in some automated operations will mean that unless a non-ADS vehicle is involved, there is likely to be limited police involvement. The aspects of the incident involving the automated vehicle would be managed by the in-use regulator, outside of any police investigation.

5 Collision investigation data

There are a range of data that apply to the investigation of road collisions, and for collision reconstruction. This section of the report focuses on digital data that is obtained as part of collisions as opposed to material generated from physical evidence at the scene, or witnesses. Sources usually available to investigators and how it can support investigation is discussed in Section 5.1. Section 5.2 describes the data required for a key element of investigation, reconstruction. An exemplar case study is then discussed which shows how this data is used practically in an investigation

5.1 Sources of data[5]

This section deals with the most common types of information used by collision investigators to reconstruct road collisions but does not deal with the physical evidence. The most common sources of data are:

- Incident scene data including infrastructure
- Vehicle data
- Driver/ operator data

The Police can often obtain most data required from the vehicle(s) for their investigations (see Section 5.1.2); however, obtaining CCTV data is more complex and often requires the police to conduct trawls of an area to identify cameras. As discussed in the following sub-sections, these are complex datasets that require training and expertise to analyse.

5.1.1 Incident scene data

During an investigation, the police will often compile vast amounts of investigative material. The full range of material is wide and varied. This does not only involve documentary evidence, such as witness statements, but can also include digital data. For example, the response to serious collisions often involves the deployment of an FCI, who carries out scene surveys at the collision locus. Scene surveys allow for accurate measurements to be taken and for the FCI to represent the scene graphically. There are three primary methods of scene survey:

- *3D laser scan* – this involves the deployment of a 3D laser scanner to capture the layout of the collision locus. This produces a 3D point-cloud (similar to a 3D model) of the scene and allows for detailed observations and measurements to be taken later.

[5] Throughout this section investigations are described as being undertaken by police. This is to ensure clarity, but there are well established private sector companies who have similar skills, but who tend to investigate cases for criminal defence, civil, or insurance purposes.

These scanners are useful in processing a collision scene quickly and accurately. The police use various brands of laser scanner throughout the country, most of which utilise proprietary software to view and interpret the data. It is possible to conduct conversions to more accessible file formats, such as DWG or E57. Anybody can view these versions using free open-source software which improves accessibility. The method of laser scanning is beyond the scope of this report, but an exemplar 3D laser scan can be seen in Figure 2.

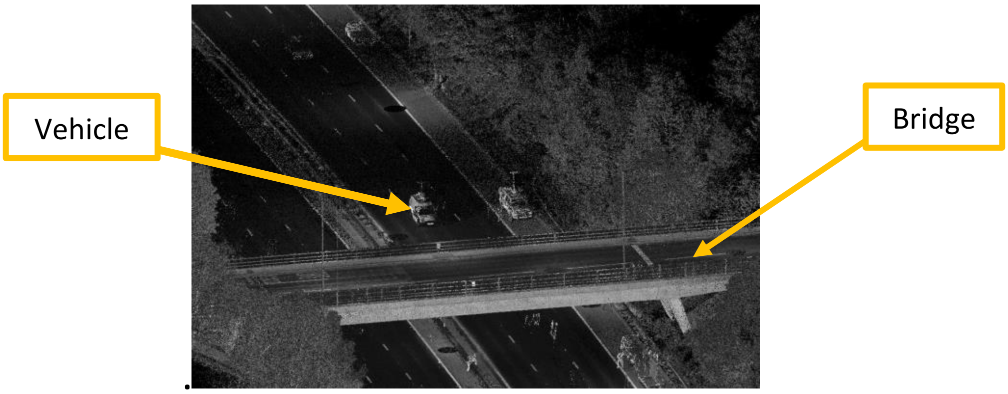


Figure 2: Exemplar laser scan

- *Total station theodolite* – this involves a points survey of the scene and is a more traditional method of scene survey. It involves the investigator identifying each point whilst processing the collision scene. Measurements are relative to the position of the total station device in relation to the position of a survey pole, which is carried around the scene by the investigator. The total station stores the angle and distance between the device and survey pole, along with the description of the point identified by the investigator. Following this, the production of a 2D plan is possible. This enables accurate measurements and a graphical representation of the scene to be obtained. An anonymised scale plan can be seen in Appendix C.
- *GPS* – a GPS survey is similar to a total station survey, but it obtains the position using the global positioning system of satellites. The plan would appear no different to that produced by a total station. It is useful when larger distances are involved because, unlike a total station, it does not require a direct line of sight for a measurement to be obtained by the device. Both total station and GPS utilise proprietary software for plan production. However, once produced, the investigator can share the data in common file formats, such as PDF.

Besides a scene survey, the collision scene or the vehicle(s) involved are likely to be photographed. This can include both drone, and terrestrial photography. Photogrammetry may also document and measure the damage profile of a vehicle. Photogrammetry is a method whereby software combines multiple images to enable measurements to be taken. The resultant point cloud (similar to that produced using a 3D laser scanner) can visually represent the object photographed.

Light Detection and Ranging (LiDAR) may also be used for this purpose, although this is less commonly used in the United Kingdom. LiDAR sensors emit pulses of light waves into the surrounding environment whereas laser scanners produce a constant beam. The pulses bounce off objects and return to the sensor. The time taken for this to occur is used to obtain the distances involved. As with photogrammetry and 3D laser scanning, LiDAR produces a 3D point cloud in much the same way as a 3D laser scanner.

Police can use these types of data in isolation or combined with other methods as part of a police investigation into a serious collision. Obtaining these data is reliant upon police attendance at the scene. An investigator could return to the scene of an incident and do this retrospectively, but there is a risk that evidence could be lost.

5.1.1.1 Infrastructure data

In addition to physical scene evidence, there is a wide range of infrastructure data which police can use as part of a collision investigation. Increasing numbers of sensors are being added to the roads, whether it is on the motorways using Motorway Incident Detection and Automatic Signalling (MIDAS) sensors or inductive loops on smaller roads to determine traffic flow. The range of information potentially available is wide. As smart infrastructure is rolled out, the range of data available will grow, perhaps significantly.

Some common types of infrastructure data are discussed below[6], although police do not generally use all as part of a collision investigation.

- *Traffic signal data* – this can include timings of traffic lights to help determine what lighting combination was being displayed at/before a collision. It also helps determine any faults with the signals.
- *Automatic vehicle identification (AVI)* – There are generally two categories of AVI. We could consider automatic toll tags as one method. A sensor detects a tag and associates that with the vehicle containing the tag. The second type is Automatic Number Plate Recognition (ANPR) systems. These use cameras to read the vehicle's registration plate and can cross reference against 'hot lists' to determine vehicles of interest. ANPR is more widely used in collision investigations, as it can determine the time at which vehicles passed a certain point. ANPR also provides overview images which can show how a vehicle appeared in the moments before a collision. ANPR can also identify potential witnesses.
- *Speed detection* – These comprise various systems used to determine a vehicle's speed. Commonly referred to as 'speed cameras', they enable the speed of a vehicle to be determined. These can be an average speed over a longer distance, or a speed from a fixed roadside camera, such as a Gatso. These systems can be useful in post-collision investigation as they enable the speed (whether or not over the speed limit) to be established at known points.
- *Traffic detectors* – these sensors assist with obtaining traffic flow information and can detect incidents. Whilst not used commonly in traditional collision investigation, the volume of traffic could become an aspect of the investigation in some circumstances.

[6] Commonly used data is highlighted in red.

- *Weigh in motion (WIM)* – Weigh-in-motion sensors measure and record a vehicle's weight whilst it is moving. Police rarely use this in the UK. It is possible to weigh a vehicle after the collision, provided the vehicle's condition allows. This would be a much more accurate method of determining vehicle weight if the FCIs deem it a factor in the collision.
- *Journey time monitoring* – these systems can determine the time taken for vehicles to travel between two locations. They are commonly used to monitor route efficiency and provide information such as to gantry-mounted variable message signs (VMS). Whilst this often includes anonymous information, the message displayed on a VMS can be useful in collision investigation. It may be useful to determine whether a driver took the advice provided to them by the VMS or ignored it.
- *Environmental sensors* – these sensors can establish prevailing weather and relay that information to VMS in order to alert drivers. Whilst rarely used by collision investigators, this could, in the right circumstances, be useful to the reconstruction of a collision.

These data are not necessarily dependent upon the police attending the scene of the collision as often infrastructure owners keep these data. The retention period varies greatly, but in some cases, data can be retained indefinitely. Obtaining these data rely on the infrastructure owners being approached and a request being made to determine the information being sought. Again, obtained these data relies on knowledge that systems exist near the collision locus.

5.1.1.2 Closed-circuit television (CCTV)

Collision investigators regularly obtain CCTV footage from a range of sources. Historically, footage was available from local authority-controlled CCTV cameras, similar to that seen in cities across the UK. More recently, affordable systems and the rise of internet-of-things (IoT) technology have seen cameras installed in a range of devices from doorbells to car mirrors. Windscreen mounted 'dashcam' are also rising in prevalence with a 2019 survey of over 20,000 drivers revealing 24% owned a dashcam (AA, 2019). Police can analyse footage from cameras to obtain information relating to the collision or incident under investigation. This includes;

- The actions of the parties involved,
- The layout or position of objects/vehicles involved in a collision,
- Speed analysis to determine the speed of vehicles or pedal cycles,
- Walking speed analysis to determine the speed of pedestrians,
- Timing/timeline analysis to determine movements prior to the collision.

The potential scope of analysis can vary, and the above list is not exhaustive. Investigators conduct analysis of CCTV footage based on the requirements of the investigation, but its use is becoming increasingly common in collision investigation.

5.1.2 Vehicle data

5.1.2.1 In-vehicle data recorder

There are a range of potential in-vehicle data recorders, but the most common are Event Data Recorders (EDRs). An EDR comprises software and a memory chip, which are integrated into controls systems used as part of the vehicle's restraint system. This includes the airbag control module/unit (ACM/ACU) or restraint control module (RCM) which are now common on vehicles since active restraint devices such as seatbelt pre-tensioners[7] and airbags are standard equipment on most vehicles.

An investigator can connect to the EDR in one of two ways. Either through the vehicle's on-board diagnostic port (OBD2), or by a direct connection to the module[8]. Access to the data contained within EDRs can be problematic. EDR data is recorded in a proprietary format requiring knowledge of the format in which it stored the data. To understand the data, it must be 'translated' into a readily accessible format. Many manufacturers work with Bosch (around 70% of the UK fleet), who produces a Crash Data Retrieval (CDR) kit, but this is not the case for all manufacturers. For those that are not supported by Bosch there are alternative retrieval technologies, but this is often cost prohibitive for only a small number of supported vehicles. It often remains necessary to approach system manufacturers to translate the data into a readily accessible format. It is estimated that data can be obtained from approximately 15-20% of vehicles on our roads, although this is likely to increase significantly in a relatively short timeframe given a requirement for all new passenger cars to be fitted with an EDR by 2024. Currently more than 99% US vehicles have EDR in-use data.

Once translated, the data comprises high fidelity information relating to a minimum of the 5 seconds prior to a collision occurring. Many do return data for a longer period, but the extent varies by manufacturer and the equipment used. The ACM or RCM is used to trigger the recording and is based on the deployment of airbags or seatbelt pre-tensioners, crash trigger events such as roll detection, or specific advanced driver assistance systems (ADAS) related trigger events. There is a range of data captured by the EDR including;

- Vehicle velocity (speed)
- Engine throttle (expressed as a percentage)
- Accelerator pedal (expressed as a percentage)
- Manifold pressure
- Service brake (on/off)
- Brake lamps (on/off)
- Steering angle

[7] Seatbelt pre-tensioners are used to take slack out of a seatbelt when a significant enough event is detected. It ensures the driver remains restrained and can prevent free spooling of the seatbelt as would occur normally.

[8] This requires the removal of the module, which is normally located close to the vehicle's centre of mass.

- Airbag deployment
- Delta-V (change in velocity because of an impact)
- System activations (stability control or cruise control)

The EDR captures this data multiple times per second, enabling the data to be plotted on a graph. The data is extremely useful for collision investigators, as it allows for an accurate reconstruction to be made[9].

5.1.2.2 *Vehicle manufacturer telematics data*

During an investigation into a collision, the police can approach manufacturers seeking information. Prior knowledge about the information that the vehicle could hold forms the basis for subsequent requests. Often, there is limited knowledge about this type of data, including location, speed, steering, braking and acceleration inputs; status of lights and indicators; and the activation (or lack) of advanced driver assistance systems (ADAS). This data be very useful for any collision investigator, but there is a lack of industry knowledge around availability.

The police can sometimes access this information, but it requires prior knowledge of what types of information potentially exist within that vehicle. The lack of centralised knowledge sharing platforms within policing means that often information regarding potential sources of data is not shared widely. There is likely data, potentially commercially sensitive, that would assist collisions investigators, but there is no knowledge (or only partial knowledge) of it; thus, police do not, or are unable to, request it. This remains a challenge within policing, particularly in complex or high-profile inquiries. Road safety would benefit from these data being easily identifiable when a collision occurs, unfortunately, this is not presently the case.

It is possible to utilise a Vehicle Identification Number (VIN) lookup systems to enable investigators to support the forensic vehicle review. This enables a user to understand the relevant parts and equipment fitted to a vehicle. Service history information is also obtainable, but this often involves relying on the manufacturer or third-party vehicle databases; this data is often used in the insurance industry for claims handling and price estimation.

5.1.2.3 *Telematics & GPS*

As with other types of data, the range of telematics and GPS devices are broad. GPS devices range from navigation devices which record very little of the vehicle's movements, to GPS systems which offer live tracking.

Insurance telematics

Insurance telematics uses a wide range of in-use mobility monitoring. These devices calculate driving risk and provide some incident data to help support claims handling. Differing devices are used to optimise deployment, data gathering, and costs to best suit differing types of vehicles and policyholder demographics. Devices used can range from professionally fitted

[9] Further detail on EDR is provided in the WP5 Task 2 report (Chapman and Perren, 2021)

black boxes (typically only installed in very high value vehicles) or more commonly, either OBD2 diagnostic port devices (self-installed by policyholders) or smartphone-based mobility monitoring solutions. These solutions are commonly offered to young or inexperienced drivers and can monitor the operating condition of the vehicle. They can record driving standards, telemetry, and times of operation, to enable an actuarial assessment of risk. This enables the supporting insurance companies to levy a more accurate premium.

These systems are collectively called usage-based insurance (UBI) but vary in the data captured across telematics providers. It is often not possible to conduct a direct download of the information contained within these devices as each regularly transmits data to remote servers rather than storing the data on the device. Insurers have usually, in line with good practice and regulations hold this data to cover claims period for damage, negligence, fraud and personal injury (up to 7 years). Accessing the information captured by insurance telematics requires approaching the insurance companies involved. Many insurance systems include threshold-based trigger events to identify potential incidents, although these systems vary in performance, data storage, and implementation.

Fleet telematics

Company operators commonly, but not exclusively, install fleet telematics on vans and goods vehicles. The telematics devices are most commonly either installed by manufacturer or user installed, but a wider range of devices are becoming more prevalent. Each device typically contains some element of live tracking to support business optimisations, logistics or enabling back-office staff to understand the driving standards of their employees. Fleet telematics commonly provide only periodic position and speed updates alongside various types of event-based triggers when driver behaviour alters, rather than continuous telemetry at all points throughout the vehicle's journey. Access to this recorded information would be through an approach to the fleet operator. It is not always possible to conduct a direct download of the device, although this is sometimes possible.

e-Call

An abbreviation of emergency call, e-Call systems enable an automatic emergency call to be placed in certain circumstances. Through the use of vehicle sensors, the system can detect a 'significant' event where it seems likely it could have caused injury. The system can then initiate a telephone call to the emergency services passing over the vehicle's location and delta-V[10].

Some vehicles also contain an S.O.S button within the vehicle's cabin, but this system operates slightly differently. A driver/passenger can push the button to enable a call to be placed to a dedicated call centre. The system provides the vehicle's location to the call centre as part of this call, who could, if necessary, initiate a call to the emergency services, but this is not automatic.

[10] Delta-V is the change in velocity. It can be a good indicator of collision significance. Higher delta-V indicates a higher likelihood of injury (Gabauer & Gabler, 2006).

Many insurance and fleet solutions also include threshold trigger events to identify potential incidents. However, these systems are variable in performance and data storage and implementation.

GPS

The range of GPS devices is wide, and the features provided by these systems varies. Manufacturers design some GPS systems solely for navigation, whilst others can even include a built-in 'dashcam'. Often further investigation will be required to find out the type of information the device could have captured.

5.1.2.4 Other telematics systems

There is a range of other telematics systems that individuals can purchase for a relatively low cost. These include devices which can plug into a vehicle's OBD2 port, or other devices that can connect to a system's application programming interface (API)[11] to obtain access to information stored by the vehicle.

For example, Tesla has an API that enables their Tesla app to communicate with the vehicle and get information such as its charge status and the state of the doors. Various developers have unofficially reverse-engineered Tesla's API to enable them to develop their own apps, which users can interact with for a variety of purposes (Bailey, 2020). One of such purpose could be to log and track historical vehicle information. Much of the information surrounding this is anecdotal, and it appears the use is not widespread, but this remains an example of the advancements being made in this area. It is expected that the use of app-to-vehicle interfaces will increase over time.

Access to this type of information could be problematic as it would require knowledge that such systems were being used. It may become apparent if/when there was an interrogation of the driver's telephone as part of the investigation. Again, any other information would require an approach to be made to the manufacturer and/or an owner's consent.

5.1.2.5 Diagnostic information

Investigators can also access diagnostic information through the vehicle's OBD2 port. This typically contains fault information and can provide some insight into the reasons behind the activation of dashboard warning lights. This information is easy to access through a range of devices which are widely available. Such information can be useful to collision investigators and can identify further lines of enquiry. Physical access to the OBD2 port is straightforward and requires nothing more than access to the vehicle. It should also be noted that vehicle faults maybe included in fleet telematics solutions, maintaining long term records of prior faults that can be of interest to investigators. However, many canBus codes are proprietary

[11] An API lets your product or service communicate with other products and services developed by other companies. A good example is the Camera API in smartphones. Various applications can use the camera API to utilise the camera on a smart phone. The application does not need to be developed by the manufacturer of the camera (phone) for this to work owing to the API.

meaning access to the full range of available data may again be limited without OEM knowledge.

5.1.2.6 Infotainment

The increasing use of infotainment systems by manufacturers has enabled collision investigators to consider this as a source of data in collision reconstructions. Berla iVe is one of the most commonly used tools to download infotainment systems. Infotainment data can be useful to collision investigation and generally comprises the following;

- Route & location data,
- Vehicle events (doors opening, ignition status, speed etc.),
- Connected device information,
- Media (music or images).

Investigators can interpret the information using software. Where a vehicle is not supported, investigators can approach the manufacturer, although this is often unsuccessful.

5.1.3 Driver / operator data

5.1.3.1 Tachograph

A tachograph is a calibrated device, which is fitted to Large Goods Vehicles (LGV) and most Passenger Carrying Vehicles (PCV). Its purposes include monitoring and recording data about the vehicle's speed, mode of operation and the driver's working hours. Depending on the type of unit, this may also include location data. Whilst tachographs are calibrated devices, there are tolerances of inaccuracy permitted within the regulations.

A sender unit fitted to the vehicle's drivetrain (usually the gearbox) records the vehicle's speed although the tolerances of the device usually mean that only speeds over 6 km/h are recorded by the device so investigators must exercise caution particularly when analysing data from a slow-moving vehicle.

Digital tachographs store some data in the vehicle unit (VU) and some on a so-called smart card issued to a driver by Driver and Vehicle Licensing Agency (DVLA). These cards are required by law to be inserted into an appropriate slot in the vehicle unit whenever a driver is working. Drivers are required to take their cards with them from vehicle to vehicle. Investigators can download digital tachograph data and interpret it using computer programs. Analogue tachographs are becoming increasingly rare, owing to the requirement for vehicles to be fitted with digital tachographs since 2006. Where an analogue tachograph is installed, a wax chart inserted into the tachograph head unit records distance, speed, mode, and time information. A needle moves across the wax chart, causing marks to be recorded. Trained analysts can interpret these marks to draw conclusions.

5.1.3.2 Mobile devices

Mobile devices offer the potential to gain a significant amount of data relating to the individual including their actions in the lead up to, or during the collision. Often data falls into two main categories;

- Cellular data: this involves positional information provided by cell-sites, subscriber information relating to the owner/operator of the device, and call data which gives information regarding the time/date calls or messages were sent. This type of data is available through direct contact with the service provider.
- Application data: this is a potentially limitless data stream and depends upon the applications installed upon the specific device. Investigators would require access to the device in order to obtain this information.

Smart phones can also capture and record telemetry and there are other devices on the market designed for 'theft' tracking which can ascertain a vehicle's location. The systems vary significantly, and it is often not possible to determine the information captured by these devices without further investigation. The access to data captured by these systems can be difficult and often involves the co-operation of manufacturers and/or system owners.

5.1.4 Summary

Summary

- A wide range of data may be available with differing degrees of evidential certainty.
- Accessing & interpreting the data can be difficult.
- Rarely are all data types available.
- Some information may require court orders to obtain.
- A lack of knowledge of the types of information captured by the devices on the market can be a barrier.
- Often, the most useful data to collision investigators is CCTV and EDR data owing to the ability to obtain high accuracy data.

5.2 Data required for collision reconstruction

It is difficult to specify the data required for collision reconstruction, as this depends on the collision circumstances. Collision investigators are concerned with reconstructing collisions in order to find out what happened. Reconstruction methods often involve the application of the laws of physics to determine the position of vehicles at key stages. Any information relating to velocity, distances, or time is likely to be highly useful to collision investigators. Several reconstruction methods are discussed in Table 2, with the required variables listed in the next column. This provides some idea of the common information that collision investigators seek when carrying out a reconstruction. Not all variables are required, but they indicate the type of information sought as part of a collision reconstruction. There are many other methods and calculations which are event specific, such as minimum aquaplaning speeds, but these are not discussed.

Table 2: Reconstruction methods with associated variables

Reconstruction method	Variables involved
Vehicle motion	Distances (tyre marks etc.) Velocity Co-efficient of friction (road versus tyre) Time (taken to cover distances etc.)
Momentum	Mass of the vehicle(s) involved Velocity (pre- or post-collision)
Rotation / loss of control	Roadway dimensions Vehicle dimensions Co-efficient of friction (road versus tyre)
Pedestrian / pedal cycle collisions	Distances (of pedestrian projection) Roadway dimensions Co-efficient of friction of objects post-collision (car and pedestrian)

Physical evidence is key to a collision reconstruction. Collision investigators often conduct a detailed examination of the scene of a collision in order to provide some insight into how the collision could have occurred. Understanding the evidence in the case is key to qualifying any expert opinion that an investigator may provide in the reconstruction report. Collision investigators often act as expert witnesses for the court, with impartiality being key in this process. The role of an expert witness is to help the court with matters outside of their expertise. The reconstruction report will often cover several aspects, including:

- *Scene descriptions* – this is used to outline the physical layout of the collusion locus and provide discussions on aspects which may have caused or contributed to the collision.
- *Vehicle information* – this section will often cover the vehicle's mechanical condition and discuss the damage sustained because of the collision. This is a key part of any reconstruction report and will often outline vehicle-borne data captured. In addition, vehicle defects will be discussed to understand whether they could have caused or contributed to the collision.
- *Human factors* – this involves examining the psychological aspects of driving and often involves applying previous academic research to interpret and understand the events of the collision.
- *Analysis of data* – this would involve interpreting any digital data obtained during the investigation, including CCTV, but often also involves the analysis of witness evidence.

Once the investigator has obtained and interpreted the data, there is often a detailed discussion whereby the collision investigator will set out their opinions and interpretation of the data obtained.

5.3 Exemplar case overview

In 2018, a fatal collision occurred between an ADS-equipped vehicle and a pedestrian in Arizona, USA. The pedestrian was killed in the collision, which occurred due to the impact of the Volvo XC90.

The National Transportation Safety Board (NTSB) investigated the collision and found that the operator's "inadequate safety culture" contributed to the collision (NTSB, 2019a). The operator had modified the vehicle to include a developmental automated driving system. During the test, the operator had deactivated the vehicle's manufacturer's installed Autonomous Emergency Braking (AEB) and Forward Collision Warning (FCW) systems. Whilst there was a person in the driver's seat, they were not operating the controls. The vehicle collided with the pedestrian at 39 miles per hour.

The most immediate cause of the collision was the driver failing to pay attention to the road because their mobile phone was causing a distraction. They also cited inadequate safety risk assessment processes and ineffective oversight by the operators as contributory factors. Among the findings (NTSB, 2019b) were:

- "The automated driving system detected the pedestrian 5.6 seconds before impact. Although the system continued to track the pedestrian until the crash, it never accurately identified the object crossing the road as a pedestrian -- or predicted its path".
- "Had the vehicle operator been attentive, the operator would likely have had enough time to detect and react to the crossing pedestrian to avoid the crash or mitigate the impact … The vehicle operator's prolonged visual distraction, a typical effect of automation complacency, led to her failure to detect the pedestrian in time to avoid the collision".
- "Managers had the ability to retroactively monitor the behaviour [sic] of vehicle operators, they rarely did so. The company's ineffective oversight was exacerbated by its decision to remove a second operator from the vehicle during testing of the automated driving system".

The NTSB investigation highlights the potential multi-factorial elements of the AV collision. The investigation highlighted failings in the deployment's management, the system itself, the user-in-charge, and the regulatory bodies. The NTSB provided the organisations overseeing the deployment of the AV with the following recommendations (NTSB, 2019b);

To the National Highway Traffic Safety Administration:

- Require entities testing or who intend to test a developmental automated driving system on public roads to submit a safety self-assessment report to your agency.
- Establish a process for the ongoing evaluation of the safety self-assessment reports and determine whether the plans include safeguards for testing a developmental automated driving system on public roads, including adequate monitoring of vehicle operator engagement, if applicable.

To the state of Arizona:

- Require developers to submit an application for testing automated driving system (ADS)-equipped vehicles that, at a minimum, detail a plan to manage the risk associated with crashes and operator inattentiveness and establishes countermeasures to prevent crashes or mitigate crash severity within the ADS testing parameters.
- Establish a task group of experts to evaluate applications for testing vehicles equipped with automated driving systems before granting a testing permit.

To the American Association of Motor Vehicle Administrators:

- Inform the states about the circumstances of the Tempe crash and encourage them to (1) require developers to submit an application for testing automated driving system (ADS)-equipped vehicles that, at a minimum, details a plan to manage the risk associated with crashes and operator inattentiveness and establishes countermeasures to prevent crashes or mitigate crash severity within the ADS testing parameters, and (2) establish a task group of experts to evaluate the application before granting a testing permit.

As part of the investigation, the NTSB obtained an array of data on which they base their investigative conclusions. These data included EDR, telematics and video footage. The vehicle contained a range of sensors, including LiDAR, RADAR, GPS, infrared motion sensor (IMS), and ultrasonic proximity sensors.

Whilst most of the technology is relatively common in collision investigation, it is not in the context of ADS driving systems. Ultrasonic proximity sensors are an uncommon aspect of an FCIs work, as are infrared motion sensors (IMS) in the context of AVs. However, Collision investigators trained in CCTV analysis may be familiar with IMS. The presentation of the data from these sensors may require specialist knowledge or techniques to enable interpretation by an FCI, but this would need to be assessed on a case-by-case basis.

6 Recommendations for a post-event investigation process

Any post-event investigation process should seek to reduce fatal or serious injury collisions. Any framework should not solely focus on the investigation of collisions, although this will clearly be an important aspect. Instead, any investigation should adopt a holistic approach whereby the regulatory approval process, in-use monitoring, and post-event investigations combine to create an interconnected framework to ensure the best levels of safety for AV operations. Insights and evidence from each aspect, as well as industry best-practice and academic research, should inform each other using an open and transparent communication process.

Demonstrating learning from post-event investigations as well as other in-use monitoring is an important step as it will enable approval, authorisation and in-use safety assurance requirements to be refined and permit data collection from real-world interactions between AVs and their operating environment. This could inform an information hub that manufacturers of AV can freely access, meaning that there is no commercial advantage when it comes to safety. This would prevent a situation where a significant number of miles would have to be driven by a specific vehicle type so that they encounter a particular scenario. Instead, the learning can be captured on the first occasion ***any*** AV encounters the scenario. Adopting an iterative and evidence-based approach across the entire process will help inform what needs to be monitored and how an automated system and its operators should interact to provide the highest levels of road safety. By adopting a proactive approach, the community will continually drive safety and performance improvements whilst speeding up innovation.

To achieve this, this post-event investigative framework will require significant industry support, as well as support from regulatory, investigative, and governmental organisations. Mandating the collection of certain data and a duty of candour (Law Commission & Scottish Law Commission, 2020) will require honesty and transparency on behalf of manufacturers and operators. Nevertheless, garnering wider support of this framework will help prevent degradation of safety standards and an erosion of public trust. Ongoing discussion between stakeholders will ensure refinement of the system of regulation, in-use monitoring, and post-event investigation to enable the potential road safety gains from AV operations to be realised.

6.1 Event reporting

The requirements for in-use monitoring and the associated triggers for reporting are dealt with outside of this report (Chapman and Perren, 2021). This section deals with the process for managing reports, including those arising outside of the in-use monitoring process. It is important that a clear set of guidelines are produced in order to promote compliance and prevent confusion. In any post incident response and investigation, the following entities would be involved:

- In-use regulator

- The IIA (if required[12])
- Manufacturer
- Operator or service provider
- Police

However, there is potential for others to be involved (such as FCIs). We set out the roles and responsibilities of each in Section 7 of this report.

6.1.1 Reporting types

Reporting types will vary, but they are likely to fall into one or more of the following categories:

- *Public reports* – this could be passengers utilising an AV, or a passing member of the public who wishes to report an incident involving an AV.
- *Enforcement reports* – this could include reports from Police or Highways Agency staff, for example. These could arise out of incidents attended by these organisations, or incidents reported to them.
- *Market surveillance reports* – this would involve reporting arising from ongoing market surveillance, a role currently undertaken by the Department for Transport.
- *Manufacturer reports* – this would involve the manufacturer reporting matters which come to light as part of, or outside, in-use monitoring.
- *Operator or service provider reports* – this would involve the operator reporting an incident. This would likely result from after-the-fact assessments or vehicle inspections undertaken after operations.
- *Automatic reports* – this would include e-Call systems, or any other telematics enabled device able to provide notification to the emergency services.

There are likely to be reports that would not require any further action or investigation. A careful approach needs to be adopted to not discourage reporting from the public or others, at least in the initial period of AV operations. It is also possible that false or misleading reports may be received, which would still require the regulator to analyse to determine their veracity.

The Law Commissions recommend that a mechanism for public reporting is set up by the In-Use Regulator (Law Commission & Scottish Law Commission, 2020). To support this, the regulator could issue guidance and a marketing campaign around the types of incidents to report, and the process involved to maximise participatory involvement. Further to this, it is recommended that individual service operators maintain a mechanism for public reporting with requirements to escalate all collision reports to the In-Use Regulator.

For non-public reports (e.g., from a manufacturer), there will be a legal obligation on manufacturers and operators to report events in certain circumstances. Guidance on

[12] This report recommends that the IIA is involved for all Level 3+ collisions. The in-use regulator could also request the IIA to get involved for other complex, serious, or high-profile incidents.

reportable occurrences should be developed to ensure the accuracy of reports and minimise the number of unnecessary reports made[13]. This would ensure reporting occurs only for those incidents deemed necessary to support the objectives of the regulatory and safety framework for AV operations.

6.2 Current legislation

Irrespective of subsequent regulations or legislation requiring the reporting of incidents involving an AV, current legislation requires mechanically propelled vehicles to report collisions in certain circumstances. Section 170 of the Road Traffic Act 1988 (Appendix B) sets out these requirements. It could be the case that in minor collisions and where parties exchange details at the scene, there would be no obligation on the operator of an AV to report the collision.

6.3 Incidents requiring report

The scenarios that could require reporting, and the origin of those reports, are discussed in section 7.1. Nevertheless, it is important to consider the specific criteria that would signify the necessity for a report. There is a range of requirements from other countries that have undertaken similar AV operations. Those are summarised in Table 3.

Table 3: Requirements by Country

Source	Summary of requirements to report
Singapore	Reporting is required in case of malfunctions of the AV or ADS. Reporting is also required for any incident involving personal injury or property damage. The latter part of the requirement is similar to the requirements set out under Section 170 of the Road Traffic Act 1988.
Australia **(NTC; Austroads, 2020)**	Any serious incident must be reported to the relevant road transport agency with data in a form that the agency can easily read and interpret. There are data requirements which should be submitted within 24 hours, with a full report within 7 days of the incident. Australia also requires near misses to be reported. They define this as a scenario where a human takes back control. Australia also requires data to be submitted following public reports. This is done monthly, or within 7 days if specifically requested.
USA – California	There is a requirement to provide a report to the Department of Motor Vehicles within 10 business days of collision. Disengagements of the technology during testing should be reported annually.

[13] Recommendations for reportable occurrences are provided in the In-Use Monitoring Framework report for this project (Balcombe and Perren, 2022)

USA – Arizona	There are no specific reporting requirments for AV incidents, but the operation must comply with existing road traffic legislation.

As Table 3 demonstrates, the range of requirements for reporting differs across the world. The most specific requirements for AV operations appear in the United States and Australia. Sub-categories of incidents have been classified for in-use monitoring of AV operations. It would be possible to adopt these categories as part of a post-incident response framework. This would also prove beneficial, as it would enable a standardised set of criteria to be used.

6.4 Methods of reporting

The source of the report would need to dictate how the subsequent management of it is carried out. The concept of an 'infraction' has been introduced by the Law Commissions. It refers to any driving behaviours which would attract prosecution or a civil penalty if brought about by a human driver. There are requirements under Section 1 of the Road Traffic Offenders Act 1988 (Appendix D) which requires a prosecuting agency to inform the individual of an intended prosecution within 14 days[14]. These requirements relate to a range of offences which are set out in Schedule 1 of the Act but includes:

- Dangerous, careless, or inconsiderate driving (or cycling)
- Excess speed
- Failing to conform to a traffic sign/signal
- Failing to comply with traffic directions
- Leaving a vehicle in a dangerous position

If committed by an AV, these infractions would be considered an infraction and dealt with by the In-Use Regulator. However, It is also perceivable that other vehicles near an AV could commit such offences which may result in an incident involving an AV. Where potential offences by a human driver in a conventionally driven vehicle, the police would need to inform those responsible within 14-days of an intention to prosecute, if necessary. It would be reasonable, therefore, for the police to assess any public report, at least initially. This would equally apply to any non-public report where another vehicle was involved, or there was a risk to life or damage to property. In those cases, the police would need to make an initial determination. If the police identify criminal offences, the police could progress these in the usual way, with support[15] from the regulator or an independent investigative body (if needed).

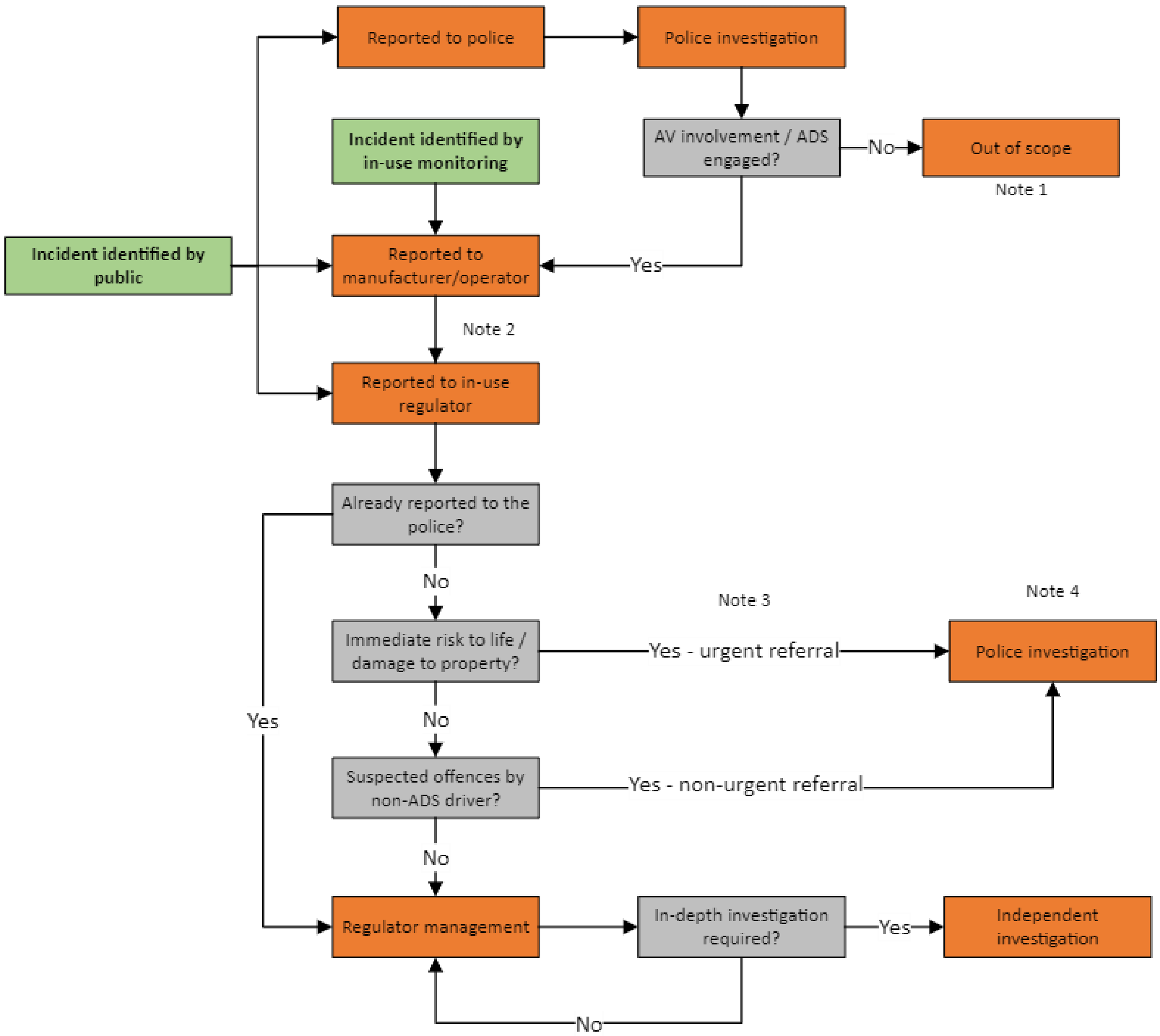
The police could then notify the manufacturer and operator that they were aware of an event involving their AV. Following this, the manufacturer should report this to the in-use regulator. It is recommended that this is a legal obligation. The In-Use Regulator would then undertake their investigation to determine whether an obvious infraction occurred indicating that the

[14] This is often referred to as a Notice of Intended Prosecution (NIP).

[15] There would be a range of data from automated vehicles which the police may not be experienced or qualified to interpret.

incident meant the AV had breached its approval or authorisation requirements, and impose sanctions as required. The In-Use Regulator could then determine if further independent investigation is necessary. The IIA could become involved in the investigation upon request by the regulator, or if a severe collision occurred (see Section 4.5) with the investigation aimed at improving overall safety and informing the approval process. Where this is not the case, the regulator could file the report for future thematic analysis by the IIA.

Investigations by the In-Use Regulator and the police would happen in parallel, but completely separately with information shared as necessary. The process map in Figure 3 summarises the reporting process highlighting areas for collaboration between investigating bodies depending on the circumstances of the event. Further detail around the types of report is provided in Section 6.6.



Note 1	Police manage the report in line with their standard operating procedures as the incident does not involve an AV.
Note 2	This is a mandatory referral requirement on the manufacturer to notify the regulator.
Note 3	This would be an immediate notification and may well involve the deployment of other emergency services as required.
Note 4	The police will manage the investigation into any offences involving the non-ADS vehicle.

Figure 3: Overview process map

Essentially, the regulator would receive any report involving an AV, and an assessment made about whether the incident warranted an independent investigation. Where there was a risk to life or damage to property, or where there was a likelihood that an individual had committed a criminal offence, the police would manage these, at least initially, with a subsequent referral to the regulator for triaging. The proposed regulator's triaging process is discussed later in Section 7.7 of this report.

6.4.1 Public & Operator reports

Public confidence in the ability of an AV to operate safely is key to achieving acceptance. It would benefit the deployment of AV if the public had a mechanism through which they could provide relevant feedback. Whilst there is the option of having dedicated systems to capture public reports, such as mobile phone applications, telephone hotlines, or web forms; it is possible that this would present some issues in terms of the ability for the police to deal with incidents requiring an immediate attendance.

It is perceivable that reports to organisations other than the police could cause delays in the policing process which is time-limited by a requirement to send a Notice of Intended Prosecution to the registered keeper of the vehicle committing a motoring offence within 14 days. This would be even more significant where there was risk to life or damage to property, and a member of the public, albeit with the best intentions, reported the matter directly to the regulator for it to be actioned days later. For this reason, it would be helpful if the police were initially informed of all public reports. This would allow the police to review the report, determine whether or not any criminal offences or risk to injury was made and decide whether to act to serve a notice of intended prosecution within their mandatory 14-day period. Where there was no risk to life or damage to property, or there was no requirement for any further police involvement because of the lack of criminal offences having been committed, the police would not need to take further action.

There is a risk that the ability of the public to report matters results in a significant number of unnecessary reports. This has the potential to result in excessive burden on policing and the In-Use Regulator. However, it is highly likely that the volume of such reports would be very low, at least initially. It would be useful to review the reporting process at regular intervals to ensure it is adequate. The regulator could conduct this 6-monthly until the process satisfies the regulator that it is operating as expected.

6.4.2 *Manufacturer reports*

The manufacturer is a key element in the post-incident process. It is likely that the manufacturer will have at their disposal a vast array of data which would support any post-incident response or investigation. The manufacturer is expected to have a legal obligation to share any associated data along with any incident reports to the In-Use Regulator (Law Commission & Scottish Law Commission, 2020). Vehicle Data provided should be standardised in line with the minimum dataset specification proposed for this project to maximise the consistency of data shared to the regulator, plus any other additional data to establish event causation (Balcombe and Perren, 2022).

The manufacturer would report any matters which invalidated the AV approval or authorisation, or where there was a collision or an infraction. The manufacturer could identify these incidents from in-use monitoring, or otherwise. The manufacturer would immediately submit the reports upon identifying the associated incident. Where there is another vehicle involved, or where there is a risk to life or damage to property, the regulator could refer this to the police for actioning in line with their normal procedures. This could be established through a Memorandum of Understanding between the In-Use Regulator and Polices Forces

We do not expect that the manufacturer would be the first body to be aware of a collision and the need to report[16], as the most likely first report would be from the public present at the incident locus, but where this is not the case, in matters requiring swift police attendance, the manufacturer should be obligated to contact the In-Use Regulator immediately as well as the police if attendance at the site is required[17]. The service operator should also have a duty to report to the In-Use Regulator, though this could be escalated via the manufacturer who can then collate the reports and data from both parties and then report to the In-Use Regulator

6.4.3 *Enforcement reports*

Besides those types of reports already discussed, it is feasible that agencies such as the police, DVSA or National Highways could deem it necessary to report matters involving an AV to the In-Use Regulator. For police reports, this would be for matters not related to public reports and could be, for example, a police officer observing an AV committing a traffic infraction. Where enforcement agencies identify such matters, we propose they utilise a standardised reporting form. Anyone could use the form irrespective of the report type. This would enable a simplified process and prevent confusion.

6.5 Reporting timescales

TRL have proposed reporting timescales as part of the in-use monitoring framework (Balcombe and Perren, 2022). This sets out that immediate reports are sent to the regulator if an incident breaches the vehicle’s type approval, or if a road collision has occurred. There

[16] There is expected to be some time-lag in reporting by the manufacturer in order for the data to be transmitted, processed and reported.

[17] i.e., there is an immediate risk to life, or a serious offence is likely to have been committed

are other events which are reportable to the regulator, but these occur periodically (6-monthly) where the event has not invalidated type approval.

6.6 Events in scope for Regulator investigation[18]

Once the regulator receives a referral, it would be reasonable for a triaging process to take place. This would involve considering the report and associated data to determine whether further investigation would be appropriate. As already discussed, it would be appropriate for any incident which invalidates type approval or authorisation to be subject to further investigation, as would a road traffic collision. Initially, it may be the case that, owing to the low number of incidents (given the low number of vehicles that will be operational initially) the regulator investigates all collisions and any incident discussed in section 6.3 of this report. In addition to this, it is recommended that the IIA investigate all severe collisions (see Section 4.5) Once the regulator has reviewed the initial deployment phase of AV, it would be possible to reduce the investigative burden to only higher risk incidents. The regulator/IIA could tailor the volume of investigations following regular reviews of AV deployments.

Table 4: Event type with descriptions

Event	Definition
Collision	An incident in which the LSAV makes contact with an object, either moving or fixed, at any speed, in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, objects on or off the roadway, pedestrians, cyclists, or animals. (NB Five levels of collision severity are also defined.)
Near-collision	Any circumstance that requires a rapid, evasive manoeuvre by the LSAV (or any other vehicle, pedestrian, cyclist, or animal) to avoid a collision. A rapid, evasive manoeuvre is defined as steering, braking, accelerating, or any combination of control that is significantly greater than that expected in normal operation.
Safety critical event	Any circumstance that requires a collision avoidance response on the part of the LSAV or any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive manoeuvre but greater in severity than a normal operation to avoid a crash. A collision avoidance response can include braking, steering, accelerating, or any combination of control inputs.
Proximity conflict	Any circumstance resulting in extraordinarily close proximity of the LSAV to any other vehicle, pedestrian, cyclist, animal, or fixed object when, due to apparent unawareness on the part of the vehicle, driver, pedestrians, cyclists or animals, there is no avoidance manoeuvre or response. Extraordinarily close proximity is defined as a clear case in which the absence of an avoidance manoeuvre or response is inappropriate for the driving circumstances (e.g., speed, sight, distance, etc.).
Non-conflict critical incident	Any event that increases the level of risk associated with driving but does not result in any of the events as defined above.
Safety-relevant violation	Road rule violations that have direct safety implications even if another event type (e.g., collision, near collision etc.) does not occur.
Road rule violation	Road rule violations not directly related to safety but that negatively impact the flow of traffic or safe movement of other road users.

[18] Any investigation would be undertaken by the IIA.

Clearly, some of these event types may not result a high level of risk being posed to the public. We propose that the triaging process conducted by the In-Use Regulator involves an assessment of the risk following their own investigation. It would be reasonable to expect **all** incidents involving a fatality or life-changing injuries to be investigated by the IIA, but the In-Use Regulator could request investigation of less serious incidents including near-misses, in line with the potential for harm and/or likelihood for recurrence.

The Health & Safety Executive (HSE) produces a risk matrix to help determine the level of investigation following an "adverse incident" (HSE, 2014).

Likelihood of recurrence	Potential worst consequence of adverse event			
	Minor	Serious	Major	Fatal
Certain				
Likely				
Possible				
Unlikely				
Rare				

Risk		Minimal		Low		Medium		High
Investigation level		Minimal level		Low level		Medium level		High level

Figure 4: HSE (2014) risk matrix

The matrix provides helpful insight to determine which incidents an In-Use Regulator may investigate further (or may request that the IIA investigate further) should investigate further. While the matrix is qualitative, evidence may be collected to help inform the assessment of likelihood and severity. This includes review of previous accident statistics, evidence in a manufacturers safety case (which would include a risk assessment and may refer to failure rates of components or systems), wider in-use monitoring findings (such as the rate of occurrence of relevant near miss events as well as relevant academic research. Events considered necessary for further investigation will likely evolve as AV deployments increase. With AV deployment likely to occur in relatively small numbers with constrained operational design domains[19] (ODD) the volume of incidents from which we can gain learning will be low. By investigating lower risk incidents in the early stages of deployment, it will provide the opportunity to gain insights into the causal and contributory elements of incidents involving an AV. As more incidents are reported and investigated, it will be possible for the IIA to obtain a greater sample of incidents for thematic analysis on which to base safety advice.

[19] Operating conditions under which a given driving automation system, or feature thereof, is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. (SAE, 2021)

6.7 Investigative approaches

As discussed previously, we propose that any independent investigation focuses on learning in all but the most serious of cases. These investigations, when approached from a position of non-blame seeking, can identify issues systematically (Bills, 2008) and are more likely to generate recommendations to improve the overall safety of AV operations. Criminal offences would mean operators and manufacturers would have to report those causative or contributory issues that led to the incident.

Police investigations focus on establishing a criminal case against involved parties, with investigations concluded once this has been established (RAC Foundation, 2020). There is no reason this approach should not continue in the most serious of cases; however, with an AV, there is no driver, and therefore it is counter-productive to suggest the investigator adopt the same approach to understand why an incident involving an AV had occurred. Any investigation would benefit from drawing upon current practice within policing organisations and in addition utilising the wide range of data available from AV. HSE (2014) recommends four stages of investigations into understanding dangerous occurrences:

- Gathering information
- Analysing the information
- Identifying risk control measures
- The action plan and its implementation

This approach would work well for investigations undertaken by an IIA. The process is similar to that utilised already by the AAIB, MAIB and RAIB, and could benefit from their best practices besides those skills already used in policing to investigate road collisions. By commencing any investigation from a position of being blame-free, we expect this would encourage compliance with regulatory and investigative agencies seeking to improve overall safety.

The focus for the investigation should go beyond the analysis of the physical evidence at scene and, by using In-use monitoring data, aim to understand why an autonomous system failed to avoid the incident under investigation. Any investigation should focus on the following general principles:

- How the incident occurred[20]
- Why the incident occurred
- What caused the incident
- Were there contributory factors
- What can be done to prevent the incident recurring, or
- Where this is not possible, what can be done to reduce the severity of the incident

[20] This is likely to involve traditional forensic collision reconstruction techniques in the case of a road collision.

There are several aspects specific to AV which would become the focus of any post-incident investigation, including:

- The status of the autonomous system at the time of the collision
- The ODD of the vehicle and the environment in which it was operating
- Whether the vehicle is being tested or was the vehicle operating unsupervised
- Which systems were active immediately before and at the time of the incident, and were all systems functional
- Was the system functioning as expected
- Which objects were detected by the system, their relative position and current bearing and trajectory (as perceived by the vehicle) and how does this correlate with the evidence captured from the locus, witnesses or CCTV
- Were there any significant deviations between the systems perceived position, bearing and trajectory, compared to the evidence captured from the locus, witnesses or CCTV.

6.7.1 Joint investigations

Besides the above aspects, it remains likely that a non-ADS vehicle could be involved in the incident along with the AV. Where this is the case, it is likely the investigative approaches specific to AV would differ from that of the non-ADS vehicle. It would therefore be necessary for police investigations to happen in parallel with the In-Use Regulator.

Whilst the police are highly experienced in dealing with investigations that consider the incident locus', vehicle(s), digital data, and witness evidence, there are a range of additional data and regulatory frameworks specifically relevant to AV. Any investigation team would require the ability to investigate those aspects effectively. The data types discussed in section 6 of this report would equally apply to AV incidents, and it may be the case that an investigation involving an AV would involve a combination of two investigative approaches, and two different investigative agencies. This adds a layer of complexity to an investigation and may mean that the investigation sometimes adjourns until the conclusion of any police investigation. In other cases, especially where there is a need to obtain specific data which the police would not ordinarily obtain, investigations could run concurrently. During the police investigation, the IIA should work collaboratively with the police, but it would be important to prevent duplication of tasks or loss of evidence which could arise from two bodies investigating the same incident. Collaboration on joint investigations is expected to be on a functional level only with the police sharing evidence with the In-Use Regulator and IIA and vice versa where possible. Data/Evidence analysis - AcciMap

Stanton (2019) reviewed eight different approaches for analysing road collisions using a collision between a developmental ADS and a pedestrian as a case study (NTSB, 2019b). Stanton recommended the AcciMap approach (Rasmussen, 1997), finding it performed best across ease of use, application time, training demand, simplicity of interpretation, tools required, and evidence of impact. The AcciMap process begins by mapping not only the parties that potentially influenced the occurrence of the collision, but more importantly, the interactions between them. AcciMap does not intrinsically place sole blame on frontline operators (Underwood & Watterson, 2012), instead it provides a broad perspective on the incident and the conditions across society which could have led to it and works well in learning focussed investigations.

The process operates under the following headings:

- International influences (e.g., international standards bodies)
- National committees (e.g., national standards bodies)
- Federal and state government
- Regulatory bodies and associations (e.g., state regulators)
- Company management and local area government (e.g., vehicle manufacturer, technology developer)
- Technical and operational management (e.g., technology developer engineers)
- Driving processes (e.g., driver, pedestrian)
- Equipment and environment (e.g., automated vehicle, road)

With the actors in each aspect identified, the events, failures, decisions, and actions are mapped across the participants. This seeks to identify all influences that caused or contributed to the incident under investigation. The use of AcciMap does require training if it is to implement effectively (Branford et al., 2009; Salmon et al., 2010), which could pose a barrier to implementation of this approach. If the IIA was borne out of a new investigative body, such as the RSIB, it would be easier to implement this method of analysing collisions, as opposed to requiring the police to adopt two investigative methods, one for AV, and one for non-ADS vehicles. AcciMap provides a good framework for analysing the causative and contributory factors at play in collisions.

6.7.2 Operational design domain

The ODD of the AV will be a relevant factor in any incident. The ODD for an ADS will need to be defined at type-approval but could be revised by the regulator if deemed appropriate. These revisions could be as a result of potential safety issues being identified or following an approved fix for such safety issues. We expect that the AV Safety Case submitted during type-approval will define the in-use monitoring required to verify that the vehicle remains inside its approved ODD during operation. Where a stakeholder suspects this has not occurred, there will be a necessity in any post-incident investigation to understand exactly what the ODD was to enable comparison between the actual conditions in which the vehicle was operating. We propose that the ODD of AV be available in an easily accessible format to prevent delays in the triaging process conducted by the regulator. There will need to be a supply of data for this to occur, including those high-level attributes set out by BSI PAS 1883:

- Scenery: non-movable elements of the operating environment, including roadway characteristics
- Environment: weather and other atmospheric conditions, including the time of day

- Dynamic elements: all movable objects and actors in the operating environment (BSI, 2020b)

The data required to enable an assessment of these factors is discussed in section 7.9 of this report, but any data related to these aspects should be produced in a standardised and easily accessible format.

6.7.3 Thematic analysis

Besides detailed investigations, it would be beneficial to consider any themes which arise out of all reports received by the regulator, not just those which involve a road collision or the vehicle operating outside of the conditions of its approval. This type of approach would be more qualitative in focus and would involve a review of the causal and contributory factors involved in cases. It may be useful to classify the causal and contributory factors into broad categories, as with STATS19, to allow for an understanding of the general context. This aspect would involve a thematic analysis to be undertaken by the IIA to produce safety recommendations aimed at tackling those issues prior to more serious incidents occurring.

Whilst this type of analysis will provide a valuable insight, it may be difficult in the early stages of AV deployment owing to the small number of reports which we would expect. For an adequate thematic analysis to be conducted, several collision (or near-miss) investigations are usually required to produce significant results (RAC Foundation, 2020). Once the independent regulator identifies themes, it may be useful for the IIA to select cases for further investigation to gain a detailed understanding of the factors involved. This could mean that the IIA prioritises certain themes for investigation (e.g., ODD violations).

6.8 Future data requirements

The requirement for data will be vital if any investigation is to identify the causal and contributory factors in an incident. It will be the case that the data requirements in current investigations (Section 5.1.1.2) would equally apply to any investigation involving an AV. In addition, however, AV (and indeed any AV) captures data from the vehicle's sensors to be stored on either the vehicle's data storage system, or remote server storage[21].

The leading and lagging measures for use in this scheme have been defined separately (Chapman and Perren, 2021). They provide a good indication of the information available to those investigating AV incidents. The potentially fundamental barrier is being able to interpret the information promptly. For this reason, we propose that any such data provided to the regulator be in a standardised format. The Bosch CDR system obtains information from a vehicle's ACM or RCM and provides the information in an accessible and standardised format; manufacturers should utilise a similar solution for AV data. This would ensure a consistent approach across manufacturers and enable investigative agencies to process the information more efficiently.

[21] Vehicle data requirements are discussed in the In-Use Monitoring Dataset Specification report for this project (Chapman and Perren, 2021)

PAS 1882:2021 recommends data be captured ± 30 seconds either side of an incident. Data within this timeframe will be familiar to investigators. CDR data captures data T-5-seconds from a detected incident; again, collision investigators are already experienced handling such data. The provision of information relating to a vehicle's speed, along with time, is very useful to collision investigators, and is often a key aspect of any reconstruction, but it is important that involved parties cannot manipulate information prior to it being secured. There will need to be a separation of data to ensure that it is possible to prove the data integrity and authenticity (an appropriate standardised approach such as ISO 27037:2012 could be required). Flight data recorders are a good example, as are RCM/ACM. It would be important that integrity is maintained throughout transmission from the manufacturer to the regulator (and onwards). This is a technical aspect that would need to be explored separately, but one that requires a solution prior to any live AV deployment.

In addition, there would be a range of other information which would assist any investigation involving an AV, such as:

- *Software versions* - it may be the case that the manufacturer has corrected the cause of the incident in a subsequent software update
- *Passengers* – this would help identify witnesses on board the vehicle if available and GDPR compliant
- *CCTV footage from the AV or third parties*
- *Information from infrastructure owners* – this could include IoT/smart infrastructure
- *Surrogate Safety Measures (SSM)*[22] – for example, calculated time to collision[23] (TTC) or post encroachment time[24] (PET)

We expect all the data currently captured or available for a non-ADS vehicle would apply to the reconstruction of incidents/collisions involving an AV. In addition, there are likely to be many more sources of data which would provide an even deeper understanding into how AV collisions (or incidents) occurred. These data would support stakeholders in determining the causative and contributory factors involved in collisions.

6.9 Investigation outcome & sanctions

Detail regarding sanctions is provided within the 'in-use monitoring framework'; it would be appropriate to ensure the Department aligns the sanctions that apply to in-use monitoring to ensure a consistent approach. An overview of the framework for sanctions is provided here, in the interests of clarity.

[22] There is potential that the incident occurred because the vehicle failed to identify the potential for a collision, hence these may not have been captured by the vehicle.

[23] The length of time until a collision, should the vehicle continue in its current path.

[24] The time between one road user departing from a location of potential collision to the time another road user arrives in that same area.

Through this approach, the IIA would publish safety reports to inform stakeholders, and the public about the outcome of investigations. The IIA should release these safety publications in interim form (during an investigation) and later finalised (upon completion of the investigation). This approach would ensure the regulator/IIA produces and disseminates fast-track corrective actions as quickly as possible and will promote public confidence in these systems. Besides safety reports following investigations, the regulator should produce further safety bulletin to inform about best-practice and any trends identified through thematic analysis. We propose the DfT investigate the business case to allow the In-Use Regulator to maintain an open-access central repository (information hub) to enable learning to be shared openly and freely. Consideration will need to be given to the impact this could have on the victim or family members. We would propose that the Regulator engages victims and their families either directly or through the various charities mentioned earlier in this report to ensure they are supported and consulted prior to open publication[25]. The Department should consider whether a consultation period should follow the production of completed investigation reports prior to publication, but we do not believe this is essential.

Despite any investigation being focussed on learning, it may remain necessary for the regulator to apply a range of regulatory sanctions on the manufacturer (Law Commission, 2020). Ultimately however, regardless of police involvement, the in-use regulator will need powers to assign sanctions to the developer, including the power to take a vehicle off the road. However, if exercising those powers stems from a blame-free independent investigation, then manufacturers can have confidence that the sanctions are fair and proportionate.

The Law Commission (2020) considered the more serious types of occurrences, which were considered to be:

- Misreported test results
- Suppressed poor test results
- Claimed to have carried out tests it did not carry out
- Installed defeat devices, so that the system responded differently in tests than in real life, or
- Obtained confidential information about test scenarios, and then gamed the system by training only for the test and not for real life

Where these situations arose, the regulator could impose more serious sanctions. In addition, The Law Commission (2020) proposed new offences which could be prosecuted through the criminal courts relating to situations where a manufacturer or developer provides misleading information in its safety case, or where it fails to respond to the regulator's requests for further information. The Law Commission propose the offences be 'aggravated' where the offence leads to death or serious injury. This would attract higher penalties.

[25] Aligns with AIB approaches during fatal investigations

7 Roles & Responsibilities

This section summarises the roles and responsibilities proposed for each entity involved in the post-incident response or investigation to an incident involving an AV. It also summarises the likely powers required for each to operate effectively. While primarily focused on this projects scope – LSAV without driver/user in the vehicle, this approach is likely scalable to wider AV deployments. The main difference being the role of the operator, however this could feasibly transfer over to the driver, user or owner of the vehicle if an operator is not present.

7.1 In-use regulator

This role could fall within the remit of the DVSA given their current operational scope. Their role should be to manage the overall process surrounding AV investigations and take ownership of the post-incident investigation process. The role, powers and responsibilities of the In-Use Regulator are outlined in the Law Commission's Recommendations (Law Commission and Scottish Law Commission, 2022) and are as such not duplicated here. There are no gaps or deviations from the In-Use Regulator Role recommended by the Law Commission based on the findings of this report

7.2 Independent Investigating Authority

This role would need to fall to the IIA, and those stakeholders involved in the development and deployment of AV. It would be reasonable for this role to be undertaken by the RSIB when formed. This will enable specialist skills to be developed within one unit, as opposed to requiring 43 police forces to have trained personnel, as would be necessary if the police carried out this role besides their normal duties. If the police were to take on this role, it would add to their current workload, and in addition, would need significant investment to upskill the workforce to deal with the complex data which police could obtain from an AV. It is expected that over time, police collision investigators are likely to gain some understanding of AV operators through experience of managing such incidents, but this may be insufficient to provide a suitable level of understanding.

Collecting, investigating, and analysing AV safety data is a specialist, in-demand skill. Those who have this skill would likely work for OEM/developers researchers and academics and not public bodies. There are three potential solutions, either a public/private partnership between the IIA and organisations with the skills to interpret and analyse this data, or collaboration between the manufacturer and investigator, although this potentially leads to a possibility of bias. Another solution would be to recruit/upskill experts to the IIA which would prevent bias and ensure a truly independent investigation. Recruitment could pose a challenge so it may be necessary to consider the former options should that occur.

Role: To conduct detailed investigations into the causal and contributory factors of incidents involving an AV.

Responsibilities:

- Conduct investigations involving AV incidents
- Provide recommendations to the regulator regarding safety improvements

- Share the lessons learned from any incident
- Conduct regular thematic analysis of incidents

Powers:

- Gather evidence from the scene of an incident or related to it
- Access vehicle data
- Gather evidence from manufacturers/developers
- Power to obtain information relating to the operator at the time of an incident under investigation

7.3 Police

Role: The role of the police would remain unchanged, albeit there would be additional responsibilities.

Responsibilities:

- Receive, action, and (if necessary) refer reports of AV incidents to the regulator
- Investigate cases where there is suspicion of criminal offences committed by a conventional driver involved in an AV collision
- To respond to, manage, and process, collision scenes involving an AV
- Work collaboratively with the independent regulator on serious incidents (those involving fatalities)
- Ensure reports/notifications are made promptly, and in line with recommended timescales

Powers:

- Access vehicle data
- Gather evidence from manufacturers/developers

7.4 Manufacturer

Role: To ensure AV operates as per their approval and authorisation. Where this is not the case, work to improve the operation of the AV quickly and effectively.

Responsibilities:

- Support the police and IIA in any investigation
- Submit relevant reports to the regulator within the required timescales
- Ensure free-flowing data on in-use monitoring
- Action any request for further data or information in line with this framework, and to the agreed timescales
- Provision of data to investigative bodies

- Act quickly on recommendations, sanctions and best practice provided by the regulator and/or IIA

Powers: None required.

7.5 Operator or service provider

Role: The organisation responsible for the operation of the vehicle. The role of the operator is based on the Non-User In Charge (NUIC) Operator defined by the Law Commission (Law Commission and Scottish Law Commission, 2022).

Responsibilities:

The specific responsibilities in the post-incident investigation process are to[26]:

- Promptly report any near miss and safety critical incidents to the police where it involves another vehicle, or there is a risk of injury or damage to property
- Promptly report other relevant incidents to the regulator (potentially) via the manufacturer
- Provide operational data surrounding the time of the incident to the In-Use Regulator
- Act quickly on recommendations, sanctions and best practice provided by the regulator and/or IIA

Powers: None required.

[26] Note that this a subset of the responsibilities defined by the Law Commission but are the only ones relevant for this process. Nothing additional over the Law Commissions' recommendation is thought to be necessary.

8 Summary & conclusion

The report has set out proposals for a post-incident investigation process, allowing the Department to adopt a learning-based and continuous improvement approach to incidents involving an AV. Due to the nature of this work, and the importance of stakeholder engagement, the report aims to provide a robust starting point to enable discussion. The aim is to enable an iterative approach to the framework to ensure the Department can complete a robust, effective, and efficient framework to deal with the response to, and investigation of, incidents involving automated or autonomous vehicles.

The proposal is that the Department encourages a collaborative approach which ensures the free flow of information relevant to any post-incident investigation between infrastructure owners, AV operators, manufacturers, and investigative agencies. Whilst we expect collaboration would secure agreement, regulation and/or primary legislation is necessary to impose duties on the various parties, as recommended by the Law Commissions. The focus must be on ensuring that all necessary investigations can happen in the necessary timeframes in order for the police, In-Use Regulator and IIA to enact their responsibilities.

Irrespective of how incidents are reported, where the incident involves a risk to life, or damage to property, the police would likely need to receive the report. This would allow for an immediate response aimed at saving life and preventing damage to property. This will allow a determination to be made regarding whether criminal offences have been disclosed by a human driver and for the police to respond to them, as appropriate. Where this is the case, the police should conduct their investigation separately from, but parallel to the In-Use Regulator, but with the ability to share data between them. Once the risk to life or damage to property is no longer present, police involvement could cease, provided criminal prosecutions are not being pursued.

We propose the regulator and IIA jointly triage any referred case to establish whether the incident warrants further independent investigation, and, if so, the scope of any investigation. Where this is not the case, the regulator would ensure they log the case for ongoing monitoring as part of thematic incident analysis. As part of any triage, the regulator would determine if sanctions should be applied to the offending parties. We would expect the regulator to instruct an independent investigation where they propose a decision to cease operations. In any case we propose initially that the IIA directly investigate individual all AV collisions level 3+. Over time as more AV deployments occur and there is more data available, the IIA should focus more effort on thematic analysis. The IIA should then have powers to collect evidence from on-site, off-site and through conducting interviews. These powers reflect what is proposed for the RSIB however it is recognised the primary focus of the RSIB for conventional road traffic collisions will likely be thematic analyses.

When cases warrant an independent investigation, we propose that the IIA assemble an appropriately qualified multi-disciplinary team aimed at thoroughly investigating the causes and contributory factors involved. The independent investigation team could release interim reports which are shared with stakeholders, aiming to put in place fast-track corrective actions aimed at improving the operation of AV. The IIA would release a detailed investigation report later. There is no reason to prohibit the release of further action plans throughout the investigation, but this would need to be based on the evidence available. The aim of any finalised report would not be to support regulatory or legal action, but for the purposes of generating recommendations for improved safety. It is also necessary that any IIA has the autonomy to select cases for further investigation which they deem necessary. In addition, the IIA would conduct a thematic analysis or reports to identify causative or contributory trends.

We expect that through this framework, we can achieve road safety improvements whilst enabling safe AV deployments. We expect a robust and transparent framework for post-incident response and investigation to reassure the public and increase public trust in the deployment of AVs on our roads.

9 References

Unsupported source type (DocumentFromInternetSite) for source AA22.

Unsupported source type (DocumentFromInternetSite) for source Col20.

Unsupported source type (DocumentFromInternetSite) for source Col22.

Unsupported source type (DocumentFromInternetSite) for source PAC22.

Bailey J 2022, *How to build a tesla data dashboard with the Tesla API.*, <https://medium.com/initial-state/how-to-build-a-tesla-data-dashboard-with-the-tesla-api-4ebee4b9827c#:~:text=Like%20all%20good%2C%20web%2Dconnected,and%20their%20internal%20diagnostics%20tools.&text=That%20has%20not%20stopped%20the,www.teslaapi.io%20).>.

Balcombe B and Perren W (2022). *GB Safety and Security Approval Scheme: Safety Monitoring Framework*. TRL: Crowthorne, Berkshire.

Bills K (2008). No-blame Safety Investigation: some lessons and methodology. *SIA Visions Conference.*

Branford K, Naikar N and Hopkins A. Guidelines for a AcciMap analysis. In. Learning from high reliability organisations. *ed. A. Hopkins, CCH Australia*, 193-212.

BSI (2020). *PAS 1883:2020 Operational Design Domain (ODD) taxonomy for an automated driving system (ADS) – Specifi cation*. British standards Institute.

Chapman S and Perren W (2021). *In-use monitoring dataset specification (draft)*. TRL.

DfT (2011). *STATS19 road accident injury statistics – report form*. Department for Transport.

DfT (2021). *Deepening our understanding of road traffic collisions and how best to address them: Consultation on establishing a Road Collision Investigation Branch*. DfT: London.

FORS (2016). *CLOCS Toolkit: Managing collision reporting and analysis*. FORS.

Gabauer DJ and Gabler HC (2006). Comparison of delta-v and occupant impact velocity crash severity metrics using event data recorders. *In Annual proceedings/association for the advancement of automotive medicine.* Association for the Advancement of Automotive Medicine.

Haddon Jr W (1972). A logical framework for categorizing highway safety phenomena and activity. *Journal of Trauma and Acute Care Surgery, Volume 12 Issue 3*, 193-207.

HSE (2014). *Investigating accidents and incidents: A workbook for employers, unions, safety representatives and safety professionals*. Health and Safety Executive.

Law Commission & Scottish Law Commission (2020). *Automated Vehicles: Consultation Paper 3 - A regulatory framework for automated vehicles. A joint consultation paper*. Law Commission: London.

Law Commission and Scottish Law Commission (2022). *Automated Vehicles - Final report*. HM Government: London.

NHTSA (2021). *Standing General Order 2021-01 Incident Reporting for Automated Driving Systems (ADS) and Level 2 Advanced Driver Assistance Systems (ADAS)*. NHTSA: Washington.

NTC; Austroads (2020). *Guidelines for trials of Automated Vehicles in Australia*. National Transport Commission.

NTSB (2019). *Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian*. National Transportation Safety Board.

Organisation WH (2001). *Injury surveillance guidelines (No. WHO/NMH/VIP/01.02)*. WHO.

Police.UK 2022, *Reporting a crime or incident.*, https://www.police.uk/pu/contact-the-police/report-a-crime-incident/, <https://www.police.uk/pu/contact-the-police/report-a-crime-incident/>.

RAC Foundation (2020). *International Review of Road Collision Investigation Approaches*. RAC Foundation: London.

RAND (2018). *Measuring Automated Vehicle Safety - Forging a Framework*. RAND: Santa Monica, California.

Rasmussen J (1997). Risk management in a dynamic society: A modelling problem. *Safety Science Volume 27, Issue 2-3* , 183-213.

Reed N (2022). *GB Safety and Security Approval Scheme: In-use monitoring taxonomy*. TRL: Crowthorne, Berkshire.

SAE (2021). *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*. Society of Automotive Engineers.

SAE International (2018). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (J3016_201806)..

Salmon P, Williamson A and Lenne M (2010). Systems-based accident analysis in the led outdoor activity domain: Application and evaluation of a risk management framework. *Ergonomics Volume 53, Issue 8*, 927-939.

Stanton NA (2019). *Models and Methods for Collision Analysis: A guide for policymakers and*. RAC Foundation.

UK Government 2022, *Government launches country's first ever investigation branch focused on road safety.*, <https://www.gov.uk/government/news/government-launches-countrys-first-ever-investigation-branch-focused-on-road-safety?utm_medium=email&utm_campaign=govuk-notifications-topic&utm_source=9efd79ef-5a9c-47e1-8726-a3c311625c11&utm_content=immediately>.

VMAD SG3-14-14 (2021). *Draft requirements for In-Service Monitoring and Reporting for the Automated Driving System (ADS)*. UNECE.

Appendix A Investigating bodies

There are existing investigative frameworks in use which may help inform any future operating framework for the investigation of AV incidents. This section of the report reviews the existing institutional structures and identifies those aspects relevant to ensuring the reliable and effective investigation of incidents involving an AV.

A.1 Learning-focused investigative organisations

The obvious examples of such organisations are the investigative agencies dealing with aviation, rail, and marine accidents. These organisations focus on obtaining the causal and contributory factors which lead to an accident. Most incidents involve several factors, but through a detailed investigation, these organisations seek to improve the aspects most important to improving safety. Once identified, the organisation disseminates learning to relevant parties with an emphasis on learning and preventing recurrence. Drawing upon the most appropriate operating methods within these organisations will inform any investigative framework involving an AV.

All three bodies responsible for the investigation of aviation, rail, and marine accidents have the legal power to investigate and make safety recommendations which are aimed at preventing recurrence. The recommendations by these organisations are not legally binding but enable Government to consider mitigations in line with wider priorities. The three branches operate in broadly similar ways, although there are some unique differences.

A.1.1 Air Accidents Investigation Branch

The Air Accidents Investigation Branch (AAIB) has been in operation since 1915. Their purpose is to "improve aviation safety by determining the circumstances and causes of air accidents and serious incidents and promoting action to prevent reoccurrence"[27].

Safety recommendations form an integral part of the investigations conducted by the AAIB. The recommendations identified as part of investigations are shared between stakeholders. Often this includes regulatory authorities, manufacturers, operators, and Government. AAIB reports are also available online. Formal reports are comprehensive and include both causal and contributory factors relevant to the incident. The AAIB also produces 'bulletins' which are released online. These are brief, compared to formal reports, and outline the circumstances and any current learning. These bulletins also outline any related ongoing investigation.

The branch adopts a proportioned response to incidents which vary in the level of detail depending on the nature of the accident. Some minor investigations involve completion of a questionnaire, whilst others can be more involved and include the analysis of digital data from the aircraft in question. The branch also conducts field investigations, which involve the deployment of a team to accident sites. The team comes from within four disciplines (operations, engineering, recorded data, and human factors), with larger scale investigations

[27] https://www.gov.uk/government/organisations/air-accidents-investigation-branch/about

involving the deployment of multiple staff from each discipline. These field investigations involve attendance at the scene of an accident, followed by a detailed investigation stage.

Following the completion of an investigation, the branch carries out a consultation process. The AAIB describe the process as involving a confidential report sent to:

> *"Those States* [countries] *that have been involved in the investigation and also those whose reputation may be affected by our report. Under the UK regulations this consultation lasts for 28 days. Representations made by those consulted are given due consideration before the publication of the final report".*

Following the consultation process, they publish the completed report online. The AAIB normally releases reports within 12 months of an accident.

A.1.2 Marine Accident Investigation Branch

The Marine Accident Investigation Branch (MAIB) follows a global multilateral treaty-based approach under the Convention on the International Maritime Organization supported by 174 member states. The MAIB conducts investigations relating to incidents within UK waters or involving UK registered ships worldwide but works closely with similar organisations globally.

Operating since 1989, the MAIB aim to "*prevent further avoidable accidents from occurring, not to establish blame or liability*"[28]. The MAIB comprise four teams of investigators (35 in total) based in Southampton. The team comprises individuals drawn from various disciplines (nautical, engineering, naval architecture, and fishing).

The branch investigates incidents which involve:

- The loss or abandonment of a ship
- Death, serious injury, or the loss of a person from a ship
- Stranding or disabling of a ship
- Material damage to a ship, another ship or marine structure
- Serious pollution

The team facilitates a 24-hour reporting line to promote prompt reporting of any incident which they would investigate. The branch receives in the region of 1000 reports annually but conduct investigations for around 25 of those. Like the AAIB, the branch response to incidents is based on the severity of the incident. The branch investigates more serious incidents immediately, whilst others are subject to preliminary assessment, which then dictates if the incident warrants further investigation. This assessment occurs within 2-weeks, in most circumstances.

The investigation involves consideration of the accident site, as well as the vessels involved. Investigations often involve the consideration of the human factors involved, as well as any

[28] https://www.gov.uk/government/organisations/marine-accident-investigation-branch/about

data recorder the vessel may contain. The branch aims to determine the causal and contributory factors the led to the accident under investigation.

Similar to the process involved in AAIB reports, the MAIB begins a 30-day consultation period once investigations are complete. The branch circulates the report to stakeholders, and anyone for whom the contents could affect their reputation. In addition, where the case involves death, the branch sends the report to their next of kin.

The consultation period enables parties to check the report and put forward suggestions or corrections. The MAIB adopts two principal routes of reporting: first, the branch publishes investigation reports online; second, the branch produces a series of safety publications. These safety publications include safety flyers, based upon the lessons learned from an investigation; and safety digests, containing concise and anonymous summaries of incidents highlighting the lessons from each. Investigators also give regular presentations to the industry to promote their safety messages. The branch also maintains a database of reportable accidents, including an overview of trends.

A.1.3 Rail Accident Investigation Branch

Having operated since 2005, the Rail Accident Investigation Branch (RAIB) state they "independently investigate accidents to improve railway safety and inform the industry and the public"[29]. The branch investigates any derailment or collision which results in, or could cause, death, serious injury to five or more people, or extensive damage. In addition, the branch investigates any other incident which has implications for railway safety, which may, under different circumstances, have led to an accident (near miss incidents).

The branch receives incident notifications from operators or maintenance organisations whose staff or property the incident involves. In line with the approaches adopted by the AAIB and MAIB, the branch tailors any response based on the factors involved in the accident or incident. Responses range from an immediate deployment to the site of an incident through to the overseeing of investigations. The RAIB can appoint individuals to assist them with investigations, including Accredited Agents who can assist with recording scene evidence. Investigations teams include trained inspectors from within the rail industry, or other investigative bodies. Team members have skills from across the industry including investigation techniques.

Whilst the branch leads the technical investigation, the police retain primacy for determining if there has been a breach of the law. The RAIB publish reports one of two ways. Formal reports focus on specific accidents or incidents, whereas there is the periodic publication of non-urgent safety issues. The branch produces interim reports and safety advice aimed at circulating safety information more quickly. All reports are available online.

[29] https://www.gov.uk/government/organisations/rail-accident-investigation-branch

A.2 In-use regulator

Currently, we understand that the Driver and Vehicle Standards Agency (DVSA) conducts some in-use safety assurance activities for conventional vehicles. It is possible that they may take the role of the In-Use Regulator, or that the In-Use Regulator may be partly modelled off of the DVSA. The DVSA operates across various areas, including regulation, licencing, and investigations. The agency comprises around 4,600 people from a range of disciplines. It is outside of the scope of this report to document the entire agency's role, but we focus on their regulatory and investigative roles.

A.2.1 Regulatory

The DVSA operates in a regulatory capacity for the Vehicle Certification Agency (VCA). The Vehicle Certification Agency conducts type approval with market monitoring undertaken by the DVSA. A Law Commissions' report (Law Commission, 2020) into the legal framework surrounding automated vehicles cited the results from a public consultation which found that respondents praised both organisations for their high reputation and saw no reason for a change. DVSA also undertakes a regulatory role regarding operator licensing for both goods vehicles and public service vehicles, where they manage applications and the ongoing monitoring of operations to ensure they meet the required standards. Where an operator cannot meet the required standards, through significant annual test failings for example, the DVSA can initiate investigations.

A.2.2 Investigative

Besides their regulatory role, the DVSA provides an investigative capacity. Their investigative activities operate in two broad categories: prosecution for road safety offences, and vehicle defects. In addition, the agency supports the role of the Office of the Traffic Commissioner. DVSA's investigations often involve vehicle examiners (VE) and/or traffic examiners (TE). The former focus on vehicle defects, and the latter on safety issues such as breach of tachograph or driver's hours rules. Once the agency identifies breaches, they deal with these in several ways: advice, prohibition, fixed penalties, prosecution, and/or referral to the Traffic Commissioner. When serious compliance failings or offences come to light following an investigation, the DVSA will refer the matter to the Traffic Commissioner who can launch a Public Inquiry.

The DVSA also conducts post-collision and market-surveillance investigations and has specially trained staff who undertake these investigations. Often, post-collision investigations focus on similar areas to that normally undertaken by the agency (vehicle defect/tachograph regulations). DVSA often circulates investigation reports to the police for further actioning, although this is not always the case. The reports are not subject to public consultation and the DVSA does not publish reports openly. Market surveillance investigations focus on public and industry reports on potential safety issues relating to vehicles or vehicle components.

The decision making for action taken by the DVSA depends upon several factors including the level of intent, previous offending history, and the risk posed to the public. Following investigations, the Vehicle Safety Branch collates the results, and can, where necessary, manage safety recalls.

A.3 Police

The Police currently manage the response to, and investigation of, road collisions. Investigations aim to establish if there is criminal culpability and assist in the Coroners' process. Police investigations vary across the United Kingdom with individual forces setting their own policies and procedures. Some forces have a dedicated roads policing unit (or Traffic Department) who respond to and investigate road collisions. Other forces do not maintain a roads policing unit, with collisions being managed as any other investigation would be.

Where cases involve fatalities (and sometimes serious injuries), most police forces deploy Forensic Collision Investigators (FCI) to assist the investigation team by reconstructing the events of the collision. Police train FCI to use scientific techniques to reconstruct collisions. The skills within forensic collision investigation are varied, with investigations involving the analysis of human factors, digital data (EDR / infotainment / telematics), CCTV analysis, and traditional reconstruction techniques. Skills vary depending upon the force involved and until recently there was limited standardisation of training. More recently, the Forensic Collision Investigation Network (FCIN) has sought to standardise the operating practices within police forensic collision investigation units, including training and skill levels. The requirement for standardisation is necessary if forces are to achieve accreditation under ISO/IEC 17020. UKAS (United Kingdom Accreditation Service) is currently undertaking a Pilot Assessment Programme for the accreditation of collision investigation involving assessment against ISO/IEC 17020.

Appendix B Section 170 – Road Traffic Act 1988

170 Duty of driver to stop, report accident and give information or documents.

(**1)** This section applies in a case where, owing to the presence of a mechanically propelled vehicle] on a road [F2or other public place], an accident occurs by which—

(a)personal injury is caused to a person other than the driver of that [F1mechanically propelled vehicle], or

(b)damage is caused—

(i)to a vehicle other than that [F1mechanically propelled vehicle] or a trailer drawn by that [F1mechanically propelled vehicle], or

(ii)to an animal other than an animal in or on that [F1mechanically propelled vehicle] or a trailer drawn by that [F1mechanically propelled vehicle], or

(iii)to any other property constructed on, fixed to, growing in or otherwise forming part of the land on which the road [F3or place] in question is situated or land adjacent to such land.

(**2**) The driver of the [F1mechanically propelled vehicle] must stop and, if required to do so by any person having reasonable grounds for so requiring, give his name and address and also the name and address of the owner and the identification marks of the vehicle.

(**3**) If for any reason the driver of the [F1mechanically propelled vehicle] does not give his name and address under subsection (2) above, he must report the accident.

(**4) A** person who fails to comply with subsection (2) or (3) above is guilty of an offence.

(**5**) If, in a case where this section applies by virtue of subsection (1)(a) above, the driver of [F4a motor vehicle] does not at the time of the accident produce such a certificate of insurance F5... or other evidence, as is mentioned in section 165(2)(a) of this Act—

(a)to a constable, or

(b)to some person who, having reasonable grounds for so doing, has required him to produce it, the driver must report the accident and produce such a certificate or other evidence. This subsection does not apply to the driver of an invalid carriage.

(**6**) To comply with a duty under this section to report an accident or to produce such a certificate of insurance F6... or other evidence, as is mentioned in section 165(2)(a) of this Act, the driver—

(a)must do so at a police station or to a constable, and

(b)must do so as soon as is reasonably practicable and, in any case, within twenty-four hours of the occurrence of the accident.

(**7**) A person who fails to comply with a duty under subsection (5) above is guilty of an offence, but he shall not be convicted by reason only of a failure to produce a certificate or other evidence if, within [F7seven] days after the occurrence of the accident, the certificate or other evidence is produced at a police station that was specified by him at the time when the accident was reported.

(**8**) In this section “animal” means horse, cattle, ass, mule, sheep, pig, goat or dog.

Appendix C Exemplar scale plan

These are the types of scale plan sometimes produced by police forces and collision investigators during investigations. The aim is to help provide a visualisation of the evidence recovered at the scene of a collision, including the positioning of vehicles (or other involved parties). Evidence can be represented visually to enable an understanding of the location to those involved in judicial or regulatory processes. More commonly. 3D visualisations are being provided. Any new investigative body would need to be able to interpret such plans and produce similar visualisations to assist in any subsequent judicial or regulatory process.

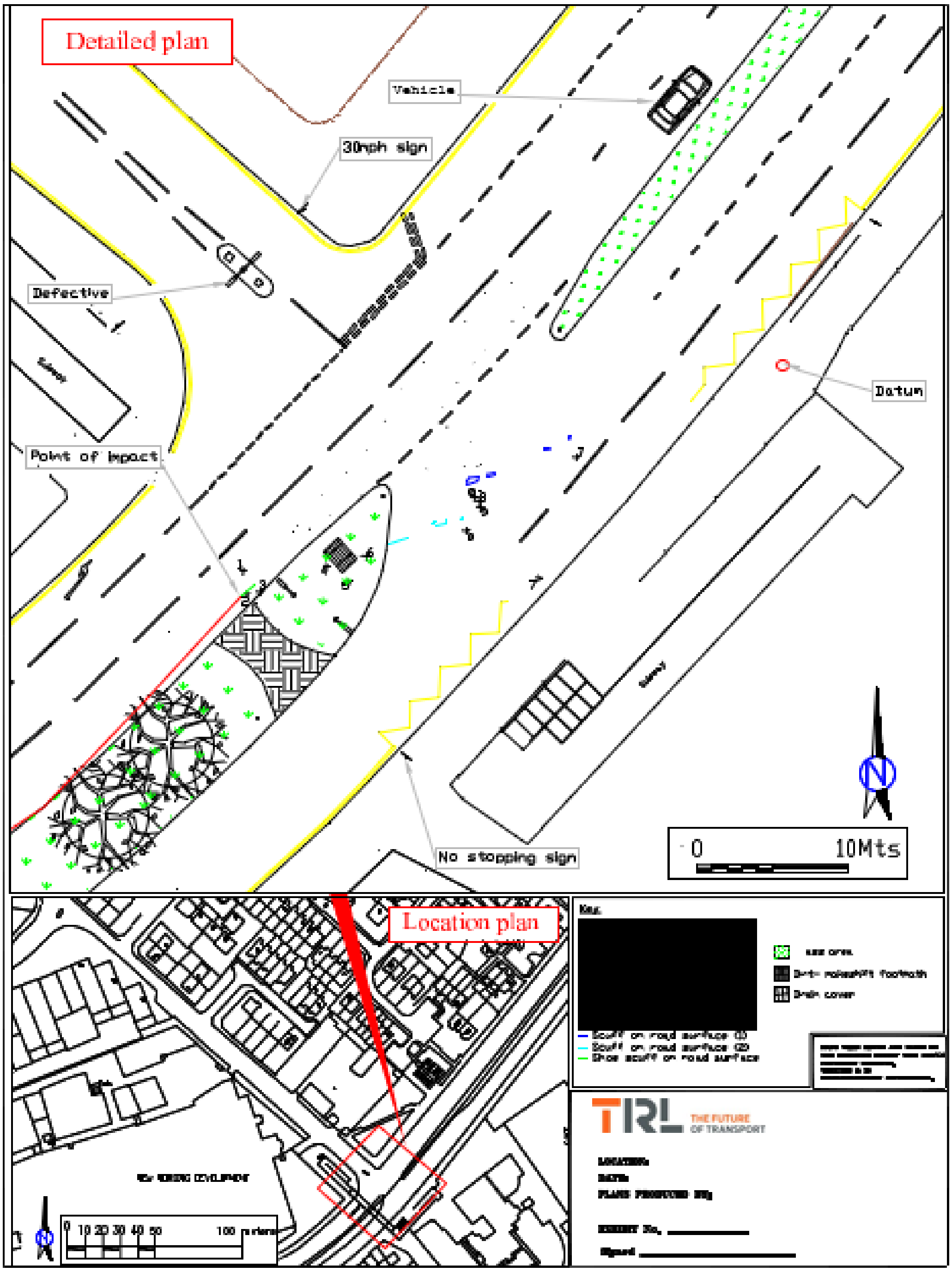


Figure 5: Exemplar scale plan

Appendix D Section 1 – Road Traffic Offenders Act 1988

1 Requirement of warning etc. of prosecutions for certain offences.

(**1**) Subject to section 2 of this Act, [F1a person shall not be convicted of an offence to which this section applies unless]—

(a)he was warned at the time the offence was committed that the question of prosecuting him for someone or other of the offences to which this section applies would be taken into consideration, or

(b)within fourteen days of the commission of the offence a summons (or, in Scotland, a complaint) for the offence was served on him, or

(c)within fourteen days of the commission of the offence a notice of the intended prosecution specifying the nature of the alleged offence and the time and place where it is alleged to have been committed, was—

(i)in the case of an offence under section 28 or 29 of the M1Road Traffic Act 1988 (cycling offences), served on him,

(ii)in the case of any other offence, served on him or on the person, if any, registered as the keeper of the vehicle at the time of the commission of the offence.

(1A) A notice required by this section to be served on any person may be served on that person—

(a)by delivering it to him;

(b)by addressing it to him and leaving it at his last known address; or

(c)by sending it by registered post, recorded delivery service or first-class post addressed to him at his last known address.]

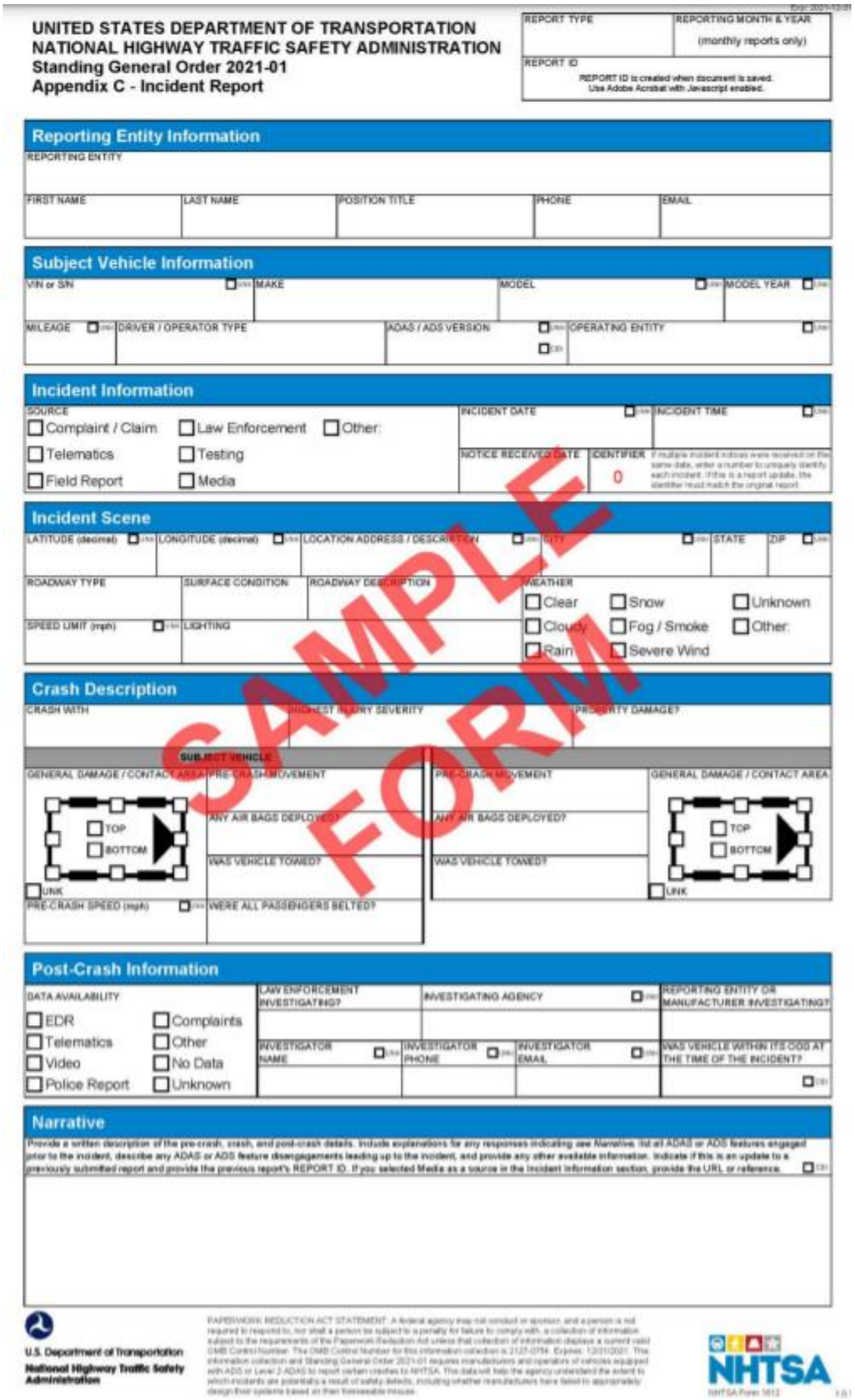
(**2**) A notice shall be deemed for the purposes of subsection (1)(c) above to have been served on a person if it was sent by registered post or recorded delivery service addressed to him at his last known address, notwithstanding that the notice was returned as undelivered or was for any other reason not received by him.

(**3**) The requirement of subsection (1) above shall in every case be deemed to have been complied with unless and until the contrary is proved.

(**4**) Schedule 1 to this Act shows the offences to which this section applies.

Appendix E Reporting Forms

E.1 NHTSA Report Form


UNITED STATES DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
Standing General Order 2021-01
Appendix C - Incident Report

REPORT TYPE | REPORTING MONTH & YEAR (monthly reports only)
REPORT ID — REPORT ID is created when document is saved. Use Adobe Acrobat with Javascript enabled.

Reporting Entity Information
REPORTING ENTITY
FIRST NAME | LAST NAME | POSITION TITLE | PHONE | EMAIL

Subject Vehicle Information
VIN or S/N | MAKE | MODEL | MODEL YEAR
MILEAGE | DRIVER / OPERATOR TYPE | ADAS / ADS VERSION | OPERATING ENTITY

Incident Information
SOURCE: Complaint / Claim; Law Enforcement; Other; Telematics; Testing; Field Report; Media
INCIDENT DATE | INCIDENT TIME
NOTICE RECEIVED DATE | IDENTIFIER 0

Incident Scene
LATITUDE (decimal) | LONGITUDE (decimal) | LOCATION ADDRESS / DESCRIPTION | CITY | STATE | ZIP
ROADWAY TYPE | SURFACE CONDITION | ROADWAY DESCRIPTION | WEATHER: Clear; Snow; Unknown; Cloudy; Fog / Smoke; Other; Rain; Severe Wind
SPEED LIMIT (mph) | LIGHTING

Crash Description
CRASH WITH | HIGHEST INJURY SEVERITY | PROPERTY DAMAGE?
SUBJECT VEHICLE
GENERAL DAMAGE / CONTACT AREA: TOP; BOTTOM; UNK | PRE-CRASH MOVEMENT | ANY AIR BAGS DEPLOYED? | WAS VEHICLE TOWED?
PRE-CRASH SPEED (mph) | WERE ALL PASSENGERS BELTED?
PRE-CRASH MOVEMENT | ANY AIR BAGS DEPLOYED? | WAS VEHICLE TOWED? | GENERAL DAMAGE / CONTACT AREA: TOP; BOTTOM; UNK

Post-Crash Information
DATA AVAILABILITY: EDR; Complaints; Telematics; Other; Video; No Data; Police Report; Unknown
LAW ENFORCEMENT INVESTIGATING? | INVESTIGATING AGENCY | REPORTING ENTITY OR MANUFACTURER INVESTIGATING?
INVESTIGATOR NAME | INVESTIGATOR PHONE | INVESTIGATOR EMAIL | WAS VEHICLE WITHIN ITS ODD AT THE TIME OF THE INCIDENT?

Narrative
Provide a written description of the pre-crash, crash, and post-crash details. Include explanations for any responses indicating see Narrative, list all ADAS or ADS features engaged prior to the incident, describe any ADAS or ADS feature disengagements leading up to the incident, and provide any other available information. Indicate if this is an update to a previously submitted report and provide the previous report's REPORT ID. If you selected Media as a source in the Incident Information section, provide the URL or reference.

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

SAMPLE FORM

Figure 6: NHTSA sample report form

E.2 California DMV AV collision reporting form

STATE OF CALIFORNIA
DMV
DEPARTMENT OF MOTOR VEHICLES
A Public Service Agency

REPORT OF TRAFFIC COLLISION INVOLVING AN AUTONOMOUS VEHICLE

DMV USE ONLY
AVT NUMBER
NAME

Instructions: Please print within the spaces and boxes on this form. If you need to provide additional information on a separate piece of paper(s) or you include a copy of any law enforcement agency report, please check the box to indicate "Additional Information Attached."

- Write **unk (for unknown)** or **none** in any space or box when you do not have the information on the other party involved.
- Give insurance information that is complete and which correctly and *fully* identifies the **company** that issued the insurance policy or surety bond, or whether there is a certificate of self-insurance.
- Place the National Association of Insurance Commissioners (NAIC) number for your Insurance or Surety Company in the boxes provided. The NAIC number should be located on the proof of insurance provided by you company or you can contact your insurer for that information.
- Identify any person involved in the accident (driver, passenger, bicyclist, pedestrian, etc) that you saw was injured or complained of bodily injury or know to be deceased.
- Record in the PROPERTY DAMAGE line any damage to telephone poles, fences, street signs, guard post, trees, livestock, dogs, buildings, parked vehicles, etc., including a description of the damage.
- Once you have completed this report, please mail to: Department of Motor Vehicles, Autonomous Vehicles Branch, 2415 1st Avenue, MS D405, Sacramento, CA 95818

SECTION 1 — MANUFACTURER'S INFORMATION

MANUFACTURER'S NAME		AVT NUMBER	
BUSINESS NAME		TELEPHONE NUMBER ( )	
STREET ADDRESS	CITY	STATE	ZIP CODE

SECTION 2 — ACCIDENT INFORMATION/VEHICLE 1

DATE OF ACCIDENT	TIME OF ACCIDENT ☐ AM ☐ PM	VEHICLE YEAR	MAKE	MODEL
LICENSE PLATE NUMBER	VEHICLE IDENTIFICATION NUMBER			STATE VEHICLE IS REGISTERED IN
ADDRESS/LOCATION OF ACCIDENT	CITY	COUNTY	STATE	ZIP CODE

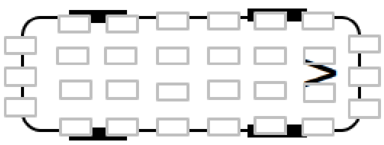
Vehicle was: ☐ Moving ☐ Stopped in Traffic **Involved in the Accident:** ☐ Pedestrian ☐ Bicyclist ☐ Other ______ | NUMBER OF VEHICLES INVOLVED

DRIVER'S FULL NAME (*FIRST, MIDDLE, LAST*)	DRIVER LICENSE NUMBER	STATE	DATE OF BIRTH
INSURANCE COMPANY NAME OR SURETY COMPANY AT TIME OF ACCIDENT	POLICY NUMBER		
COMPANY NAIC NUMBER	POLICY PERIOD FROM ______ TO ______		

Describe Vehicle Damage

☐ **UNK** ☐ **NONE** ☐ **MINOR**
☐ **MOD** ☐ **MAJOR**

Shade in Damaged Area



OL 316 (REV. 7/2020) **WWW**

Print **Clear Form**

SECTION 3 — OTHER PARTY'S INFORMATION/VEHICLE 2

VEHICLE YEAR | MODEL

LICENSE PLATE NUMBER | VEHICLE IDENTIFICATION NUMBER | STATE VEHICLE IS REGISTERED IN

Vehicle was: ☐ Moving ☐ Stopped in Traffic **Involved in the Accident:** ☐ Pedestrian ☐ Bicyclist ☐ Other ________ | NUMBER OF VEHICLES INVOLVED

DRIVER'S FULL NAME (*FIRST, MIDDLE, LAST*) | DRIVER LICENSE NUMBER | STATE | DATE OF BIRTH

INSURANCE COMPANY NAME OR SURETY COMPANY AT TIME OF ACCIDENT | POLICY NUMBER

COMPANY NAIC NUMBER | POLICY PERIOD FROM ________ TO ________

☐ **Additional information attached.**

SECTION 4 — INJURY/DEATH, PROPERTY DAMAGE

NAME (*FIRST, MIDDLE, LAST*)

ADDRESS | CITY | STATE | ZIP CODE

CHECK ALL THAT APPLY ☐ Injured ☐ Deceased ☐ Driver ☐ Passenger ☐ Bicyclist ☐ Property

NAME (*FIRST, MIDDLE, LAST*)

ADDRESS | CITY | STATE | ZIP CODE

CHECK ALL THAT APPLY ☐ Injured ☐ Deceased ☐ Driver ☐ Passenger ☐ Bicyclist ☐ Property

PROPERTY DAMAGE

PROPERTY OWNER'S NAME | TELEPHONE NUMBER ( )

STREET ADDRESS | CITY | STATE | ZIP CODE

WITNESS NAME | TELEPHONE NUMBER ( )

STREET ADDRESS | CITY | STATE | ZIP CODE

WITNESS NAME | TELEPHONE NUMBER ( )

STREET ADDRESS | CITY | STATE | ZIP CODE

☐ **Additional information attached.**

SECTION 5 — ACCIDENT DETAILS - DESCRIPTION

☐ Autonomous Mode ☐ Conventional Mode

☐ **Additional information attached.**

Print | Clear Form

OL 316 (REV. 7/2020) **WWW**

ITEMS MARKED BELOW FOLLOWED BY AN ASTERISK (*) SHOULD BE EXPLAINED IN THE NARRATIVE

	WEATHER (MARK 1 to 2 ITEMS)	VEH 1	VEH 2	MOVEMENT PRECEDING COLLISION	VEH 1	VEH 2	OTHER ASSOCIATED FACTOR(s) (MARK ALL APPLICABLE)
	A. CLEAR			A. STOPPED			A. CVC SECTIONS VIOLATED CITED ☐ YES ☐ NO
	B. CLOUDY			B. PROCEEDING STRAIGHT			
	C. RAINING			C. RAN OFF ROAD			
	D. SNOWING			D. MAKING RIGHT TURN			
	E. FOG/VISIBILITY			E. MAKING LEFT TURN			
	F. OTHER			F. MAKING U TURN			B. VISION OBSCUREMENT ☐
	G. WIND			G. BACKING			C. INATTENTION* ☐
	LIGHTING			H. SLOWING/STOPPING			D. STOP & GO TRAFFIC ☐
	A. DAYLIGHT			I. PASSING OTHER VEHICLE			E. ENTERING/LEAVING RAMP ☐
	B. DUSK – DAWN			J. CHANGING LANES			F. PREVIOUS COLLISION ☐
	C. DARK–STREET LIGHTS			K. PARKING MANUEVER			G. UNFAMILIAR WITH ROAD ☐
	D. DARK – NO STREET LIGHTS			L. ENTERING TRAFFIC			H. DEFECTIVE WEH EQUIP CITED ☐ YES ☐ NO
	E. DARK–STREET LIGHTS NOT FUNCTIONING*			M. OTHER UNSAFE TURNING			
	ROADWAY SURFACE			N. XING INTO OPPOSING LANE			
	A. DRY			O. PARKED			I. UNINVOLVED VEHICLE ☐
	B. WET			P. MERGING			J. OTHER* ☐
	C. SNOWY – ICY			Q. TRAVELING WRONG WAY			K. NONE APPARENT ☐
	D. SLIPPERY (MUDDY, OILY, ETC.)			R. OTHER*			L. RUNAWAY VEHICLE ☐
	ROADWAY CONDITIONS (MARK 1 TO 2 ITEMS)			**TYPE OF COLLISION**			
	A. HOLES, DEEP RUT*			A. HEAD-ON			
	B. LOOSE MATERIAL ON ROADWAY			B. SIDE SWIPE			
	C. OBSTRUCTION ON ROADWAY*			C. REAR END			
	D. CONSTRUCTION – REPAIR ZONE			D. BROADSIDE			
	E. REDUCED ROADWAY WIDTH			E. HIT OBJECT			
	F. FLOODED*			F. OVERTURNED			
	G. OTHER*			G. VEHICLE/PEDESTRIAN			
	H. NO UNUSUAL CONDITIONS			H. OTHER*			

SECTION 6 — CERTIFICATION

I certify (or declare) under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

I further certify that I am the authorized Administrator of the program for the above named employer.

PROGRAM DIRECTOR/AUTHORIZED REPRESENTATIVE PRINTED NAME AND TITLE	TELEPHONE NUMBER ( )
SIGNATURE **X**	DATE SIGNED

OL 316 (REV. 7/2020) **WWW**

Print | Clear Form

Figure 7: CDMV AV collision reporting form

Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring

Abstract

This report outlines a framework for managing the response to, and investigation of, incidents involving automated vehicles (AV). The report specifically caters for incidents arising out of low-speed autonomous vehicle (LSAV) deployments. The report sets out the requirements of any investigation along with the data requirements, which would inevitably form the basis of any investigation involving an AV or LSAV. The roles and responsibilities of organisations involved in the deployment of a LSAV trial in relation to supporting the response to, and investigation of, incidents which may arise from the trial is also outlined. We discuss the role of the in-use AV regulator, along with the requirements for an independent investigative body who would lead any investigation into LSAV incidents.

Relevant Reports

- Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring Task 1 – Road Incident Taxonomy; https://doi.org/10.58446/mvuc1823
- Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring Task 2 - Minimum Dataset Specification; https://doi.org/10.58446/nksn4732
- Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring Task 3 - Safety Monitoring Framework; https://doi.org/10.58446/sgxq7004
- Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring Task 5 - Outcome Reporting; https://doi.org/10.58446/qlpq9096
- Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring Task 6 - Data Privacy; https://doi.org/10.58446/dwll8689
- Automated Vehicle Safety Assurance - In-Use Safety and Security Monitoring Task 7 - Change Control; https://doi.org/10.58446/bpdl3309

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

ISSN: 2514-9652

DOI: https://doi.org/10.58446/egfa6491

PPR2019