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Vehicle Technologies and Accident Investigation – From Airbag Control Modules to Automated Vehicles

I. Varieties of Data Currently Available

Current state-of-the-art in evidence preservation

Multiple sources of crash-related data are available from modern automobiles. Current best-practices in evidence preservation include obtaining data from the vehicle's event data recorder, infotainment system, and telematics systems.

The types of data available on vehicles have increased over the past decades. Initially, data from event data recorders were limited to information on the vehicle's crash pulse. 49 Code of Federal Regulations (CFR) Part 563 specifies minimum requirements, as well as data ownership, for vehicles that have an event data recorder. However, this regulation does not require vehicles to include event data recorders.

While the types of data on these systems still vary widely, the types of data when information is made available to researchers include information on driver inputs, crash sensing, and even (on some newer model vehicles) deployment of supplemental restraints (e.g., seatbelt pretensioners and active headrests) and pedestrian protection modules (e.g., raised hoods and external airbags).

Further, while tools to directly access most vehicle's event data recorders are commercially available, some manufacturers have opted to require their own internal processing of the raw data.

Infotainment (the screens providing entertainment and vehicle information) system downloads have also become available. The data available from these systems vary widely – both across and within manufacturers – and can include information about paired mobile phones, active and prior telephone calls, texting history, vehicle location and speed, and the status of vehicle equipment such as headlamps (on/off) and doors (open/closed).

While some vehicles keep a record of these events indefinitely, there are no standardized formats for recordkeeping for these data, and no guarantee that these systems will have crash-related data. This type of data is continuing to evolve and become increasingly available.

Telematics systems that are built into the vehicle, such as the OnStar system found on General Motors vehicles, can provide important information for understanding vehicle collisions. These data can include timestamped information as to the location of the vehicle, as well as route information, that may be useful in accident reconstruction. Further, there are no limitations as to how long OnStar retains data collected by the system.[1] While OnStar's data retention allows for the potential to retrieve accident data after the destruction or disposition of a vehicle involved in an accident, it also serves as a common example of retention policies for automotive third-party data.

II. Current Vehicle Technologies and Evidence Preservation Techniques

Classifications of vehicle technologies

The vehicle research, development, and manufacturing communities use different taxonomies to describe vehicle technologies. These differ from the conventions used by the general public. Vehicle safety systems are generally grouped as either passive or active safety systems. These two types of systems may be distinguished from one another based on whether they work to prevent or mitigate a

[1] https://www.onstar.com/us/en/footer-links/privacy-policy.html

collision. Passive safety systems in automobiles enhance survivability *during or after* a collision. Examples of passive safety systems include seat belts, air bags, crumple zones, and fuel pump cutoff switches.

In contrast, active safety systems act in the *pre-crash* period and serve to either completely avoid, or to mitigate the severity of, a collision. Examples of active safety systems include stability control (a system that detects loss of steering control and compensates at the wheels; required under a phased-implementation starting in 2009 US-market vehicles; 49 Code of Federal Regulations (CFR) Parts 571 & 585), brake assist (a technology that increases braking pressure under emergency braking), and collision avoidance/mitigation braking (a technology that detects objects ahead of the vehicle and, in the case of mitigation braking, attempts to brake to avoid contact). Recently, the United States Department of Transportation, the Insurance Institute for Highway Safety (IIHS), and 20 automakers announced an agreement to make collision mitigation braking standard on practically all US-market vehicles beginning mid-2022. This agreement has the potential to change both the type, frequency, and analysis of a common collision type.

Self-driving and automated vehicles

Similarly, automated vehicle technologies may be classified in different manners. SAE International (SAE) provides a taxonomy of vehicle automation in standard J3016[2] and has five levels. These range from Level 0 (no automation) to Level 5 (optional human management). This taxonomy has been accepted by the US Department of Transportation[3] and is the most widely-used method of describing different vehicle automation technologies in the industry.

[2] SAE (2016). J3016: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. Warrandale, PA: SAE International.

[3] National Highway Traffic Safety Administration (NHTSA). (2017). Automated Driving Systems 2.0: A Vision for Safety. Available from https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf.

III. Emerging Technologies and Accident Reconstruction

Active Safety Technologies

Active safety systems (such as the aforementioned collision mitigation braking) are becoming more common on new United States-market vehicles. These systems hold the potential to reduce the severity of, or even completely avoid, a substantial number of collisions. For example, research has indicated that a forward collision warning system can reduce the rates of rear-end impacts by 20%, with reductions of up to 56% possible for systems that warn the driver and then provide collision mitigation braking.[4] Data access to these systems for claims-handling and accident analysis is not uniform and varies greatly by manufacturer.

Level 2 Automation

The US vehicle market now includes vehicles with limited self-driving capabilities. These currently-available vehicles have limited abilities to control steering, acceleration, and braking. They are also limited to very specific operational conditions (such as limited-access interstate highways or stop-and-go traffic).

General Motors' Cadillac division offers SuperCruise, which allows for hands-off and feet-off driving on certain areas of interstate. Other highway automation systems are available from Mercedes-Benz (Distronic Plus Lane Keeping Assist), Tesla (AutoPilot), and other manufacturers. These systems typically require limited interactions with the vehicle (such as holding or touching the wheel on a regular basis) to ensure the driver is engaged. Similarly, vehicles with Traffic Jam Assist (TJA) systems control the vehicle in stop-and-go traffic. However, in all current systems the driver is required to monitor the roadway as the vehicle could require driver intervention without warning.

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[4] Cicchino, J.B. (2017). Effectiveness of forward collision warning and autonomous emergency braking systems in reducing front-to-rear crash rates. Accident Analysis & Prevention, 99, 142-152. doi: 10.1016/j.aap.2016.11.009.

Evidence preservation and collision reconstruction

Capturing the evidence for, and performing a scientifically-valid reconstruction of, a collision involving a modern vehicle requires an approach utilizing all current best practices of forensic data collection. That includes obtaining data from the vehicle event data recorders, infotainment system, and vehicle manufacturer, as well as undertaking a comprehensive evaluation of the accident site to understand the confluence of driver, vehicle, and environmental factors that could have contributed to the collision event.

In the case of vehicles offering some form of automation, this process is complicated. Information regarding the automation state of the vehicle may not be provided via the airbag control module or infotainment system. Therefore, obtaining data from the vehicle manufacturer may be required. An example of this is the National Transportation Safety Board's (NTSB) examination of the collision between a 2015 Tesla Model S and a 2014 Freightliner Cascadia tractor with a 53-foot refrigerated semitrailer. The subject Tesla was in AutoPilot (an automated vehicle control system) at the time of the crash. Although the Tesla was collecting extensive data (including radar, machine vision, ultrasonic, and camera data), the vehicle did not and was not required to have an event data recorder (49 CFR 563). Therefore, the NTSB obtained the assistance of Tesla to obtain data relevant to the collision investigation.[5] As regulation has not addressed highly automated and self-driving vehicle technologies, scenarios such as this will likely become increasingly common.

[5] Gregor, J.A. (2017, May 7). Driver Assistance System Specialist's Factual Report (NTSB Report No. HWY16FH018). Washington, DC: National Transportation Safety Board.

IV. Near-Future Technologies and Accident Reconstruction

Level 3+ automation

While there is generally little public awareness of the automated driving capabilities of current vehicles, there is also little awareness of the state of development of Level 3 and higher automated vehicles. Numerous automakers, industry suppliers, and technology companies are actively developing and performing limited public-road testing of Level 3-5 automated driving systems.

These vehicle designs are largely centered on removing the need for a driver for certain types of operations or removing the need for a driver altogether. This can include vehicles that retain steering wheels but offer the ability to have the vehicle control all aspects of the drive (including emergency responses). It can also include vehicles that do not offer the ability for the driver to have any control over the vehicle except for specifying a destination.

One of the better-known companies performing public-road testing is Waymo (formerly known as the Google Self-Driving Car project). Waymo has reported a fleet-total of over 10 million miles.[6] Waymo has recently launched Waymo One, a taxi-service utilizing a fleet of self-driving Chrysler Pacifica minivans. This service is only available in Phoenix, Arizona, and still utilizes a safety driver behind the wheel.

Other testing has had very high-profile collisions. The March 2018 fatal collision involving a Uber-modified Volvo XC90 and a pedestrian pushing a bicycle across a road is under investigation by the NTSB. The NTSB's preliminary findings[7] indicates that the Uber automation technology detected the pedestrian approximately 6-seconds before impact. However, the pedestrian was misclassified multiple times and then determined to have different path predictions. Further, the collision-mitigation system of the Volvo was disabled. Perhaps the most interesting finding was that the Uber safety driver of the

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[6] https://waymo.com/faq/

[7] NTSB. (2018, May 24). Preliminary Report HWY18MH010. Washington, DC: National Transportation Safety Board.

vehicle was not continually monitoring the roadway in the seconds before the collision. This is not an unexpected event given the infrequent interactions required of drivers in these situations.

The lack of a requirement for a driver creates the potential for a number of new operational concepts. Populations who would previously not be able to have automotive transport, such as disabled individuals, children, and the elderly) would be able to travel upon demand. Different ownership models, including ride sharing, become feasible. Transportation as a service may become more prevalent, replacing our traditional single-owner/single-operator model. This has the potential to greatly change the way most Americans approach vehicle ownership, driving, and commuting.

Significant legal and policy issues that must be resolved before any nationwide implementation of highly automated vehicles can proceed. Multiple states have enacted legislation addressing the operation of automated vehicles. The U.S. Department of Transportation has released a model policy for state and local agencies regarding automated vehicles.[8] Harmonization across these different entities will likely be necessary to allow for a unified nationwide implementation. But one of the most important unanswered questions in this space is liability and insurance. The technology to allow for self-driving vehicles is continuing to evolve at a much more rapid pace than the framework for insuring such vehicles. This will continue to be a major barrier to a nationwide implementation of self-driving vehicles.

Challenges to data accessibility

Self-driving vehicles continue to be a major development push for manufacturers, Tier-1 suppliers, and technology companies. However, data ownership is also becoming an important topic as the potential for additional revenue streams and different ownership models becomes likely.

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[8] National Highway Traffic Safety Administration (NHTSA). (2016). Federal automated vehicles policy. Available at https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf

Data is increasingly not stored on the vehicle, or only stored on the vehicle in a very limited fashion. As illustrated in the NSTB investigations of Tesla AutoPilot and Uber crashes, a very limited segment of data is present on the vehicle and a much fuller dataset resides with the manufacturer or developer. This is unlikely to be a unique approach due to the potential for developing profiles of individual operators. In addition to data from automakers, data from third-party telematics providers such as OnStar and other firms will be critical for gaining information that can be vital in reconstructing a collision involving an automated vehicle.

V. Summary

Many vehicles currently in-service have means of collecting collision-related data that can directly assist the claims-handling process. However, the types of, and access to, data vary widely. Systems to help mitigate or completely avoid certain types of collisions will become standard on almost all new vehicles in the very near future. Further, vehicles with limited automation capabilities are currently available in the United States and vehicles offering higher levels of automation are being actively developed.

These rapid changes in technology have the potential to reduce the number and severity of collisions. However, they also present new challenges to accident investigation and reconstruction in terms of the types of data and evidence collision requirements. These are factors that entities involved in the management of vehicle claims will need to be aware of and prepared for in the coming years.

A comprehensive approach to evidence preservation is required for the reconstruction of crashes involving modern vehicles with advanced technologies. As automated vehicles become increasingly common, understanding what data are available, how to obtain them, and how to apply them to the reconstruction becomes critical.