Autonomous Does Not Mean Impervious

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The benefits of automated vehicles have long been touted: decreased roadway congestion, positive environmental impacts, economic relief, and most prominently, increased safety. The Center for Disease Control (CDC) estimates that in the U.S. alone, more than 32 thousand people are killed and 2 million are injured each year in vehicle crashes. Nearly every big name in the auto industry has pledged to have some level of smart vehicle within the decade with Volvo paving the way with its Vision 2020 campaign. In 2016, Hakan Samuelsson, president and CEO of Volvo, said, "Our vision is that by 2020, no one should be killed or injured in a new Volvo car." Auto manufacturers, government entities, and independent nonprofit scientific and educational organizations have been utilizing injury data to follow trends in vehicle crash outcomes. But how are we collecting and processing this data and what does it mean for the future of automated vehicles?

Crash injury data is out there. Research databases contain data about real-world crashes; by compiling them into cohorts, researchers can use statistics and injury scaling methods to find patterns in occupant injury, pre-crash scenario, and post-crash events. For example, the National Highway Traffic Safety Administration (NHTSA) has the Crash Injury Research Engineering Network (CIREN), which is a database that has data from severe vehicle crashes and describes injuries in terms of injury severity using the Abbreviated Injury Scale (AIS).

The AIS was created, managed, and copywritten by the Association for the Advancement of Automotive Medicine (AAAM). It is available in dictionary form and provides a link between injury descriptions and a numerical coding scale. AIS serves as an international standard tool for ranking the severity of injury. It is consensus derived, and anatomically based. In this way, when analyzing the outcomes of crash scenarios, the AIS may be used to study injury outcomes in an objective manner.

AIS development dates back to the mid-1960s and is the standard for injury coding for crash investigation teams, many of which are funded by the U.S. Department of Transportation as well as many university and industry-based research teams around the world. AIS severity values are guided by available evidence data rather than only from mortality data. There are six severity scores in AIS:

AIS Code	Description
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximal
9	Unknown

It is important to note that maximal does not indicate "fatal." For example, a herniated disc with no nerve root damage would have

a severity score of two. A penetrating skull injury involving the brain stem and cerebrum could carry a severity score of six. Multiple injuries may be followed using the Maximum AIS (MAIS) and the Injury Severity Score (ISS) methods. The MAIS is the highest (i.e., most severe) AIS severity code in a patient with multiple injuries. The ISS is frequently used within the clinical setting, and while regularly used in vehicle accident scenarios, AIS is applicable to many injury scenarios.

Being able to utilize the AIS requires a good working knowledge of human anatomy and medical terminology; the dictionary specifies when descriptions for clinicians and/or imaging validation are necessary for coding specific injuries. For quality control and to support the future of AIS, AAAM offers in-person and online training opportunities. AAAM additionally offers specialized certification through a testing program for which successful candidates receive a certification as AIS specialist (CAISS) (http://www.aaam.org). Re-certification requires re-examination, not just continuing education.

Analyses of patterns in injury outcomes utilizing AIS and vehicle crash features show that programmed responses to crash-imminent scenarios and rigorous testing are needed to provide insight into how increased safety for automated vehicles may be accomplished.

If a vehicle identifies a crash-imminent scenario, how should it act to mitigate injuries? Researchers have used techniques of injury epidemiology and injury scaling to describe that automated vehicles could respond to a pre-crash scenario using smart braking and steering to better align energy-absorbing structures and optimize reactive technologies to mitigate injuries. Additionally, airbag deployment timing via automated vehicle behavior implementation has the potential to optimize safety technologies to mitigate injuries.

Given the possibility that vehicles can be programmed with actions that improve occupant protection in a crash-imminent scenario, further testing needs to be conducted to determine the responses of the automated vehicles and the resulting AIS in various scenarios. Through expertise in data, cutting-edge robotic testing platforms, and vehicle dynamics testing, S-E-A and other testing and research facilities will continue to improve upon the safety of vehicles and stand poised to evaluate not just today's technology but more importantly, tomorrow's.

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