

Ensuring the Safe Design of Autonomous Vehicles

Suggestions to Help Resolve the Issues

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The claimed promise of automated features and autonomous vehicles is that they will be superior to the human driver's judgment and skills in preventing accidents. With a large percentage of accidents historically attributed to the driver's poor judgment, poor skills, poor reaction time, and various impairments, the promise of automated vehicle technology is that it will eliminate those human driver flaws and, thereby, many accidents will be avoided.

But just how safe are autonomous vehicles? What policies should be implemented by an automated systems supplier or autonomous vehicle manufacturer? What safety regulations do such vehicles have to comply with, both Federally and on a State regulation basis? If there's an accident with a "self driving" autonomous vehicle, with severe to fatal injuries, then which parties are liable? After a minor accident and repairs, how do we verify that the vehicle and its sensors and computers and servos are fully restored? Can autonomous vehicles be hacked and then controlled by someone who wants to do harm? Can a snowstorm or fog cause sensors to become ineffective?

LEVELS OF AUTOMATED VEHICLE TECHNOLOGY --- Let's first understand that there are varying levels of autonomous features, from pre-crash braking to electric power steering and up to a full-autonomous "self driving" vehicle. In brief, NHTSA has adopted the automated vehicle levels formulated by the Society of Automotive Engineers (SAE), which are summarized as:

- ❖ **Level 0** – Human driver does everything
- ❖ **Level 1** – Automated system sometimes assists driver with some parts of driving tasks
- ❖ **Level 2** – Automated systems conduct some driving functions, while human monitors
- ❖ **Level 3** – Automated control and monitoring – but driver must be ready to take over
- ❖ **Level 4** – Automated systems do the driving and monitoring under certain conditions
- ❖ **Level 5** – Automated in all functions – performs all driving tasks, just like a human

RESPONSIBILITY OF ALL PARTIES --- According to the National Highway Traffic Safety Administration (NHTSA), as expressed in the "Federal Automated Vehicles Policy" of 2016, the responsibility in applying automated technology for vehicles, at all levels including fully-autonomous vehicles, should be considered by all individuals and companies that design, test, manufacture, and market, and operate automated vehicle systems in the United States. Thus, the NHTSA policy covers *everyone* involved with automated technology and autonomous vehicles.

FEDERAL MOTOR VEHICLE SAFETY STANDARDS (FMVSS) --- NHTSA issues Federal Motor Vehicle Safety Standards that must be complied with, and each automaker conducts their own testing and certification that the vehicle fully complies with all applicable FMVSS. By law, the safety standards are only *minimum* requirements, and many are obsolete and well below the state-of-the-art. The standards are grouped into series, as follows:

- ❖ **100 Series -- *Crash Avoidance*** – Controls and Displays, Transmission Shift Lever Sequence, Hydraulic and Electric Brake Systems, Rearview Mirrors, Accelerator Control Systems, Light Vehicle Brake Systems, Warning Devices to Alert Drivers to a Stopped Vehicle.
- ❖ **200 Series --- *Crashworthiness*** -- Occupant Protection in Interior Impact, Head Restraints, Driver Protection from Steering Control System, Glazing Materials, Door Locks, Seating Systems, Occupant Crash Protection, Side Impact Protection, Roof Crush Resistance, Underride Protection for Rear of Trailers.

- ❖ **300 Series --- Post Crash Standards** --- Fuel System Integrity, Flammability of Interior Materials, Compressed Natural Gas Fuel System Integrity.

Because of the complexities and interdependencies of autonomous vehicles with other vehicles, roadways, traffic controls, telecommunications, security issues, hacking, crash notification, data retrieval, operational safety validations, and much more, there will need to be an interdisciplinary approach to new standards set by NHTSA and DOT and other Federal and State agencies. I recommend that NHTSA consider a new 400 Series for Autonomous Vehicles with their highly complex, interactive technology and performance requirements, while maintaining all other safety standards as applicable.

SAFETY VALIDATION AND INSPECTIONS --- Each autonomous vehicle must be pre-tested prior to any release to the public. This will require a comprehensive on-road evaluation and assessment of all Diagnostic Trouble Codes (DTCs), and the correction of any issues that may occur.

I recommend that States should consider autonomous vehicle inspections on a regular basis, and re-certification after any significant repairs that involve any automated systems or components. For example, replacing a windshield will require recalibration and testing of any cameras or sensors that are located on or adjacent to the windshield. It will be useful to have an in-vehicle status display that shows all DTCs as they may occur, rather than having any such DTCs only downloadable at dealerships.

FAILURE MODES AND EFFECTS ANALYSIS --- Failure Modes and Effects Analysis (FMEA) is a pro-active rigorous analytical method to identify when and how a vehicle system might fail, then evaluate what caused the failure and its effects, and then figure out how to prevent the failure or defect from occurring again. *Design out the defect before the vehicle is released to the public.*

FMEA should be an inherent part of the design and testing process *prior* to mass production or implementation of the system. If not done comprehensively, there may be subsequent failures and accidents and then the uncovering of defects that would prompt a recall and remedy of the defective system, whether it's in hardware or software.

I recommend that each automated system company, whether a supplier or vehicle manufacturer or fleet operator, have a top-level designated individual and knowledgeable committee to establish and conduct FMEA methods applicable to their automated system or autonomous vehicles or operational use of such vehicles. The company's Safety Director or FMEA Director should keep detailed records of all data, tests, and inputs, and report to the highest levels of the company.

POTENTIAL LIABILITY OF ALL PARTIES --- The issue of liability is of great concern in this emerging area of automated vehicle systems up through autonomous "*self-driving*" vehicles. There are four basic influences that help in understanding the liability concerns.

National Traffic and Motor Vehicle Safety Act of 1966, as amended --- Every manufacturer of motor vehicles shall furnish notification of any defect in any motor vehicle or equipment which he determines, in good faith, relates to motor vehicle safety, to the purchaser and to NHTSA. It must include a clear description of such defect, an evaluation of the risk to traffic safety, and a statement of the measures to be taken to repair such defect. Also, compliance with any Federal motor vehicle safety standard does not exempt any person from any liability under common law.

U.S. Constitution, Amendment VII -- The 7th Amendment preserves the right to trial by jury, where there is an alleged harm or injury to another, and the claim is for justice and compensation from the wrongdoer. In essence, these are personal injury or product-liability lawsuits, and they focus on whether the product at-issue was defectively designed or if the manufacturer acted with negligence.

U.S. Supreme Court Opinion in Geier vs. Honda --- This 2000 Supreme Court Opinion focused on whether the lack of an airbag in a 1987 Honda could proceed in a product liability case, and the Court allowed preemption due to the DOT specifically allowing automakers in that era to optionally select which passive restraint would comply with FMVSS 208 regulatory goals.

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U.S. Supreme Court Opinion in Williamson vs. Mazda --- This 2011 Supreme Court Opinion focused on whether the lack of a shoulder belt for a seating position in a minivan could proceed as a product liability case. The Court affirmed that FMVSS are only minimums and that compliance with an applicable FMVSS does not preempt liability at common law, and the state tort law case could proceed.

IDEAS TO HELP ADVANCE AUTOMATED SYSTEMS --- There have been various automated systems in use for years, such as electronic throttle control, electric power steering, cruise control, and pre-crash detection and braking. These automated features typically use sensors, computers, algorithms, and servos that do not require communication with other vehicles, nor stationary objects, nor system traffic controls. Yet, for optimal safety, autonomous vehicles should be integrated within a *total systems approach* of man-machine-environment with other vehicles, roads and signage and signals, and other objects.

- ❖ **Will autonomous vehicles take away the personal enjoyment of driving?** Will *Car & Driver* magazine be retitled as *Car & Rider*? Will BMWs be marketed as “*The Rider’s Car*”?
- ❖ **Autonomous vehicles should have visual indication to the driver** when the vehicle is now in autonomous mode, and there should be an obvious *On-Off* control that will immediately disable the autonomous mode and enable full control by the driver.
- ❖ **Vehicles that are in autonomous driving mode should have a light** on the front, the roof, and the rear to let other road users and enforcement know the situation. I recommend a blue or violet/purple light plus the words “*Automated Mode.*”
- ❖ **Automatic Crash Notification (ACN) should be mandated** for all autonomous vehicles (and preferably for all vehicles), so any accident with a likelihood of moderate to severe injuries will immediately alert local rescue services of the exact location, the severity of the crash, the likelihood of severe injuries, and other details. Response time by paramedics is critical.
- ❖ **Each autonomous vehicle must be certified to meet at least the same crashworthiness levels** as a non-autonomous vehicle, with *no compromise* in protecting the driver and passengers.

LET’S STAY IN COMMUNICATION -- As this emerging new area of automated systems and fully autonomous vehicles continues its rapid development and promotion, it will be important to stay in communication, to exchange issues and ideas, to continue in a constructive dialogue with each other. Perhaps you design or test or install automated systems for vehicles, or manufacture autonomous vehicles, or operate them, or are in Federal or State agencies that regulate transportation and related activities. It is constructive for us all to work toward the *Vision Zero* goal of eliminating vehicle-related fatalities of drivers and passengers, and of pedestrians, cyclists, and other road users. We must act together as a rational, compassionate society to help prevent such needless tragedies.



**Accident Causation
& Crashworthiness**

Vehicle Controllability
Rollover - Roof Crush
Side Impact Intrusion
Truck Underride
Fuel Tank - Fires
Airbags - Seatbelts

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