MOBILITY INDUSTRY INSIGHTS

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In Mobility Industry Insights we will investigate and debate the issues that affect how people and goods are transported, how governments attempt to enable and restrict transport, how consumers decide which transport options they will use, and the methods being used to make mobility safer, more convenient, and more affordable for all. We will discuss and debate the issues, presenting multiple perspectives, and will solicit views from a variety of sources.

Merging Silos: Building and Testing Automated Driving Systems for Driverless Driving

The question of whether to have prescriptive standards which define how automated driving systems should and should not work has not yet come up for a vote. Concern over limiting creativity has eclipsed fixing the rules of the game so that everyone can play. Shifting focus to testing results is about to let the game begin.

ABRIDGEMENT

YOU CAN'T PLAY the game unless you know the rules. You can't get much out of watching a game unless you have a basic understanding of why the players and referees are doing what they are doing. If you have ever taken a friend to your favorite sporting event, and that friend has never experienced the sport before, you realize that the rules are both difficult to explain and often seemingly contradictory. You watch the game with no effort, understanding all the nuances, and your guest is simply confounded. Some games are easy to explain, like swimming or running, while others were apparently invented to be obscure, like baseball or American football.

Driving is one of the latter types of games, confounding and obscure, not only because of the rules that apply but because the rules are often ignored. It is the most difficult and dangerous game we have invented because the arena is immense, the opponents are varied, often hidden from view and endless in numbers, and the conditions change while the game is in action. In order for a human to play the game of driving, he or she must know the rules of the game and have the skill to win every time they play, with winning being the equivalent of getting to where you want to go without harming yourself and anyone or anything else. And now we want to teach robots to play it.

It is one thing to build a robot that is capable of running a one-hundred-meter dash. Its algorithm would consist of four rules: line up with your robot feet behind the starting line; start to run only after hearing the pop of the gun; stay in your lane; and run at top speed until after you have passed the finish line. It is also one thing to build a robot that can plow a field with hundreds of straight rows, or to build a robot that can maneuver around a warehouse and pack a box full of products which have been ordered by a customer. It is quite another thing to build a robot that can drive a motorized vehicle on all public roads. Robots will need to know the rules and do what humans have done in all the situations they have encountered in order to win every time they play, keeping their riders and themselves alive. During the past twenty years, one group of humans has been trying to advance robot skills beyond running a hundred-yard dash, while another group of humans has been trying to make a set of rules for the game of driving which will be played by humans and robots on the same field. The groups have been working in different silos. Finally, they are now ready to meet.

Teaching a robot to play the driving game

Part One: Thinking like a (good) human driver

WHOEVER DECIDES HOW their particular automated driving systems work—whether it is the boss of the company doing the programming or the individual programmer—that person will use his or her own biases to determine what their algorithms or frameworks do. If there is no standard and associated legally binding regulation to make certain that a vehicle always comes to a complete stop at a stop sign, or always stays within the posted speed limits, algorithms or frameworks can be designed to operate just like humans, selectively deciding when they will obey the law and when they will not. The first task for standards bodies developing the specifications for Automated Driving Systems (ADS)[1] is to decide whether all algorithms and frameworks installed in vehicles in which the Dynamic Driving Task (DDT)[2] is being performed by an ADS and not a Driver (a human) are programmed to do approximately the same thing as drivers, meaning applying their individual biases to how they play the game of driving, or to eliminate to the greatest extent possible individual biases so that all ADS vehicles in which the DDS is being performed by the ADS and not a Driver can be reasonably certain that they know approximately what other ADS-controlled vehicles will do.

Getting the terms in order - *When I use the word 'driver', I am referring to a human being performing the Dynamic Driving Task (DDS), that is, driving the vehicle in real time. So, when I use the word 'driverless' I am referring to a vehicle equipped with an Automated Driving System (ADS) which is having its Dynamic Driving Task performed by the ADS and not by a Driver. A Driver is one of three definitions for an ADS User who is a human. The other two ADS Users are Occupant and Fallback User. These are definitions developed by* UNECE's WP.29, Working Party on Automated and Connected Vehicles (GRVA) Informal Working Group (IWG) on Automated Driving Systems. *This IWG has prepared a document with the title* Proposal for a new United Nations Global Technical Regulation (GTR) of Automated Driving Systems (ADS) *in which these definitions are used. This is the focus of Part 2.*

In order to develop these standards, we (humans) will have to use our own experiences to provide best practices for the eventual robots doing the driving. We do not always make the best decisions. What makes us turn off our brains and follow ridiculous directions delivered by our onboard navigation systems? In the popular television series, "The Office" (the U.S. version of it was filmed in my hometown, Scranton, PA), the character who is the boss (who also happens to be named Michael), ignores common sense, interprets the directions given by the car's navigation system literally, and ends up in a lake. I recall when this actually did happen in the early days of navigation on a country road in Germany. It made the news everywhere. We pass on blind curves, run through red lights or stop signs, speed when conditions indicate that road surfaces

[1] Automated Driving System (ADS) means the vehicle hardware and software that are collectively capable of performing the entire Dynamic Driving Task on a sustained basis.
[2] Dynamic Driving Task (DDT) means the real-time operational and tactical functions required to operate the vehicle.

are likely to be icy. If we can do it, will the robots that are "just following orders" from the algorithms do it as well?

This is not an analysis of the so-called "Trolley Problem", where a runaway trolley with no driver can be controlled by an observer who must decide whether to intervene and save five lives at the cost of one life, or not intervene and let the trolley kill five people.[3] The Trolley Problem, which is an application of the 'doctrine of double effect', is often raised when discussions center around who bears responsibility for a driverless vehicle killing or injuring people. Thomas Aquinas, a Dominican friar, and philosopher who lived in the 13th century, is credited with being the first person who mentioned the topic of double effect with the example of self-defense. Is it wrong to kill someone in self-defense, he asked rhetorically. Only if you didn't intend to kill your attacker, he concludes. A doctor operates on a pregnant woman and saves her life, but the pregnancy is terminated and the fetus dies. The doctor is not a murderer, according to Aquinas's thinking. The Catholic Church has established conditions for the application of double effect, however the world in general does not operate under the rules set down by the Catholic Church or any religion, as the discussion of the question of abortion clearly indicates.

How should the algorithms that control the driverless vehicle be configured to react when a life-threatening event is imminent? Should they be programmed to do one of the following:

- Kill the occupants of the vehicle rather than killing one or more individuals outside of the vehicle (recently, we have taken to calling these individuals "vulnerable road users");

- Do everything possible to save the lives of the vehicle's occupants without regard for those outside the vehicle; or

- Refuse to decide to do either and simply stop the vehicle as quickly as possible and let whatever is going to happen happen? This is what a Waymo vehicle did on the 23rd of January 2026 in Santa Monica, California. It was near an elementary school during school dropoff hours. A child ran across the street from behind a double-parked SUV towards the school. The Waymo had no human safety driver on board. Waymo reported the incident to NHTSA immediately. It stated in its report: "Our technology (Waymo Driver Version 5) immediately detected the individual as soon as they began to emerge from behind the stopped vehicle. The Waymo Driver braked hard, reducing speed from approximately 17 mph to under 6 mph before contact was made. After the vehicle struck the child, the child stood up immediately, walked to the sidewalk, and we (Waymo remote assistance) called 911."

What happens if two driverless vehicles are going to crash head-on into each other and they have different programming biases?

[3] Duignan, Brian. "Trolley problem". Encyclopedia Britannica, 22 Aug. 2025, https://www.britannica.com/topic/trolley-problem. Accessed 30 September 2025.

At this point we should ask: “What would humans do?” If I meet a car on a two-lane undivided highway, and that car is in my lane driving very fast right toward me, I don’t know if the driver in the other vehicle: a) is intent on killing both of us by using my car as his suicide weapon;[4] b) believes he or she is in the correct lane and that I will realize I woke up in Britain and not in Sweden and move out of his way before we collide head-on; or c) has lost consciousness and the car is out of control. I have to decide with incomplete knowledge of the other driver’s intentions and basis of knowledge. Within less than a few seconds, I will have to take some action using my stored-up knowledge of all of my possible options and a very quick analysis of the immediate surrounding conditions. Do I swerve into the open lane and hope that he continues straight? Do I brake very hard and hope he will do the same? Is there a possibility to swerve onto the shoulder at the last moment in case he is suicidal? If we crash and both of us die, who will go to hell? Robots cannot worry, so the last question is not relevant for them, but it is for their programmers, and the laws written by humans will certainly require that culpability be assigned.

There is research on how humans feel if they have caused death or suffering as a result of their actions. Researchers at Columbia University looked specifically at the programming of a driverless car algorithm.[5] In one experiment, participants imagined they were programming a self-driving car and needed to decide how it would behave if it were involved in an accident with pedestrians. Would the self-driving car protect the rider at the expense of the pedestrians, or would the car protect as many pedestrians as possible, even if it meant sacrificing the rider?

The researchers found that the programmers felt more guilty if they had programmed the algorithm by following orders from their boss on how to configure the algorithm, irrespective of the alternative (protect the rider or protect the pedestrians) than if they had made the decision themselves. This was counter to what other research has found, in particular with respect to killings in WWII concentration camps, where those who ran the camps and those who actually carried out the killings excused themselves because they said they were “just following orders”. The Columbia University researchers dug deeper with additional experiments and found that people (presumably non-psychotic) want to avoid personal responsibility for other peoples’ suffering, and they attempt to do so by blaming others for actions they take that cause suffering. They will refuse to accept any culpability in order to avoid sharing in any of the guilt. In other words, they want the boss to tell them what to do.

[4] International research suggests driver suicides may account for up to 8–9% of all fatal road crashes. Some have put it as high as 17%. But studies indicate up to half of these cases may go unreported if there is no proof that it was intentional, like a suicide note or a statement made of the driver’s intentions before the incident. (https://theconversation.com/suicide-or-accident-the-hidden-complexities-of-intentional-road-crashes-in-australia-248673)

[5] Sharon Di and Eric T. Talley, Data Science Institute, Columbia University. (https://science.fas.columbia.edu/news/columbia-researchers-studying-how-to-ensure-safety-of-driverless-cars/)

Driving is both physical and psychological

Driverless cars are not guided by an invisible hand constantly hovering over the controls but are guided by a complex combination of technologies that comprise each automated driving system (ADS) devised by each ADS developer. These technologies include machine learning, deep learning, computer vision, sensor fusion, and decision-making frameworks in various mixes. The AI portions have been trained to respond to various types of stimulation, such as traffic signs and lights, speed limit signs, warning signs, actions of other vehicles, actions of pedestrians, actions of animals, and much, much more. Someone programmed the algorithms to do certain things under certain conditions or has established an AI decision-making framework so that an action can be based on different inputs and scenarios. Consider the Waymo example in Santa Monica. The official speed limit in school zones in Santa Monica is 30 mph. The Waymo was moving at 17 mph. Something caused it to reduce its speed to below the speed limit. Perhaps it was a combination of school zone plus double-parked car.

Is it really as simple and trivial as this:

"Essentially, Tesla sees FSD as a brain, and the cameras are its eyes. It has a memory, and that memory enables it to categorize and analyze what it sees. It can keep track of a wide array of objects and properties to predict their movements and determine a path around them. This is a lot like how humans operate, except FSD can track unlimited objects and determine their properties like speed and size much more accurately. On top of that, it can do it faster than a human and in all directions at once.."

Seti Park in Inside Tesla's FSD: Patent Explains How FSD Works. Not A Tesla App. (November 6, 2024).

One would think that if the person deciding how the algorithms or frameworks should work (the boss or the programmer) is an experienced, conscientious, and courteous driver, the result would be an ADS that would be better in terms of the vehicle driving safely than if the person does not even have a driver's license and is a card-carrying member of the Ban All Cars Club. However, even if the person is experienced, conscientious, and courteous, it does not mean that the person is not biased toward taking certain risks, like moving out into the slushy passing lane on a highway before the snowplows have cleared it or sticking to the speed limit at dusk on a forest road during moose mating season. Neither of these are illegal, but they are risky behavior. Does this sound familiar?

How do our brains process information and choose to accept or reject the signals (data) we receive from external sources, and then make decisions based on how our brains process that information? A sign says that the road has sharp curves ahead, and another sign says the speed limit is 70 kph, down from 100 kph in the earlier stretch of road. A driver ignores the speed limit sign and the sharp curve warning, maintains her speed of 110 kph, loses control of her car in the curve, crashes and dies. The driver believed something in her head, rather than the advice provided by the road authority. Why? Is it really as simple and trivial as the Tesla explainer says in the sidebar quote, just keeping track of stuff, magically predicting what everyone and everything will do, and then deciding what to do "is a lot like a human brain"? Sorry, Seti, but no it's not.

This comment—which I am <u>not</u> attributing to Tesla but to someone who believes he understands what Tesla is doing—illustrates the physical or technical approach to developing an automated driving system, while ignoring the psychological aspects of driving. Think of the groups developing ADS as football teams with a coach who is in charge of building a team's approach to playing the game. One coach believes that a solid defense is the best strategy:

if the other team doesn't score, we don't lose. Another coach believes that a superior offense is the best strategy: if we score more points, we win. A third coach believes that balance will always carry the day. With ADAS, there are those who lean toward the physical and technical approach, What You See Is All There Is (WYSIATI); there are those who count on deep learning to teach their systems to reason from what their sensors see (e.g., a double-parked SUV in a school zone will contain a child who might run in front of it so I won't see it until it's too late if I continue to move forward, so I will stop and wait a few seconds); and those who try to combine the two in the way that humans do (be ready to stop).

Biases determine actions for humans and robots

Let's first look at biases. Our psychological biases and predispositions make us vulnerable to falsehoods, claims Nathan Walter, a professor of communication studies at Northwestern University who studies the correction of misinformation.[6] In the example above, the driver was certain that the signs had an ulterior motive which had nothing to do with her safety, or they were meant for other drivers who were less experienced or who were driving cars that did not have (what she believed were) the road-holding qualities of her car. The falsehood in this case is what the driver believed, that at the speed she was travelling (40 kilometers per hour over the speed limit), she and her car would be able to manage to get through the curves safely. The driver was wrong, and the signs were there for a corrective purpose. Why did the driver ignore them?

In Walter's work, he examines "the continued influence of misinformation in the face of correction and the theoretical explanations of this phenomenon".[7] He found that corrective messages were more successful when "they are: i) coherent; ii) consistent with the audiences' world-view; and iii) delivered by the source of the misinformation itself" (i.e., the person who told the lie or gave incorrect advice admits that he lied or was mistaken). "Corrections are less effective if: a) the misinformation is attributed to a credible source (the person who lied or gave the bad advice is known for telling the truth and giving good advice, or people believe what he says without any proof that he is not lying or giving bad advice); b) the misinformation has been repeated multiple times prior to attempted correction; or c) when there is a time lag between the delivery of the misinformation and the correction". The curve and speed limit signs might have seemed coherent from the road authority's point of view, but they were not consistent with the driver's world view. The driver considered the correction as not coming from a credible source because she had proven many times that she doesn't die if she ignores their signs. Her bias finally caught up with her.

[6] Walter, N., & Salovich, N. A. (2021). Unchecked vs. uncheckable: How opinion-based claims can impede corrections of misinformation. Mass Communication and Society, 24(4), 500-526.
[7] https://www.natcom.org/publications-library/does-correcting-misinformation-really-work/

A bias can also cause a human or a robot to ignore incorrect information. The navigation system in the rental car that I was driving on a recent visit to my sister in my hometown gave me a route to a restaurant which I knew was incorrect. I knew the way, but I wanted to evaluate the system. I followed the route to try to understand the logic of why the system calculated the route. My sister and I did arrive at the restaurant and we did not drive into a lake (We actually drove by the lake that Michael in *The Office* did drive into. Honest), even if it took longer and we traveled on roads that were not meant for through traffic. The fact that it was a ridiculous route was not because the route calculating algorithm was programmed to generate ridiculous routes. The algorithm simply had incorrect information about the quality of the roads, ignored certain attributes that were in the database, such as road class, had a misconception about the value a driver would put on the directness of the route, rather than its theoretical shortness, or simply had an instruction to take the shortest route as the crow flies and everything else be damned.[8] Anyone not familiar with the area and who was predisposed (biased) to follow the instructions to the letter would have trusted the instructions and been rewarded for following them by arriving at the restaurant. My sister was laughing during the entire ride because she knew the right way to get there.

On two occasions in 2022 in San Francisco, vehicles operated without safety drivers by now-defunct GM Cruise drove into ongoing fire zones, once driving over the firefighting hoses. The firefighters had to smash the window of one of the vehicles to make it stop. Driving over firefighting hoses violates California's Vehicle Code. A young or inexperienced driver may not have read the California Vehicle Code but managed to obtain his or her driver's license anyway. They might also have driven over a firefighting hose, in which case they would have been cited by a police officer for the traffic violation and received the appropriate punishment. The incident would not have made the national news channels. The inexperienced driver gained experience that they would use for the rest of their lives. Don't drive into a on-going fire zone. Perhaps the Cruise vehicles were not programmed with the entire California Vehicle Code so they didn't know what to do in case they encountered a fire scene. Maybe they were not yet programmed to recognize a fire hose. After the incident they would have been.

Is driving objective or subjective?

A 2015 dissertation by Michael Cale provides a wealth of information on this question.[9] He summarizes the main approaches used to affect driving safety, including those using applied perceptional and cognitive psychology, to get drivers to slow down and

[8] As it turned out, the settings for the navigation system were pre-set to avoid highways, either by the previous renter of the car or by the car rental company. I had not used the navigation system to drive from Newark Airport to Scranton, so I did not experience the routing problem until using the navigation system to route to the restaurant.

[9] Cale,M.(2015): Think fast drive slow. Daniel Kahneman's Theory and Traffic Psychology. Dissertation zur Erlangung des akademischen Grades Doctor rerum naturalium im Fach Psychologie. Berlin: Humboldt-Universität zu Berlin. Michael Cale is a Senior Traffic Psychologist at CogniTo Ltd, Haifa, Israel.

be more careful. He describes how these approaches compare to the classical motivational tools such as enforcement, fear, and rewards. The main aim of Cale's dissertation is to show that Daniel Kahneman's theory is very useful in describing and explaining why driving is both objective and subjective.

Daniel Kahneman (1934-2024) was an American psychologist and economist. He is noted for his work on the psychology of judgment, decision-making, and behavioral economics for which he and Vernon L. Smith shared the 2002 Nobel Memorial Prize in Economic Sciences. Kahneman provides a framework for answering the question of whether driving is objective or subjective. His empirical findings challenged the assumption of human rationality that was prevailing in modern economic theory, that human beings are capable of always making rational decisions and that markets and institutions, in the aggregate, are healthily self-regulating. His book, Thinking, Fast and Slow (Farrar, Straus and Giroux, LLC., 2011) brought his theories to the masses nine years after he was awarded the prize so that we could share in his insights.

Kahneman says that driving is both objective and subjective, and this is why you need to be a certain age and pass a driving test in order to be able to get behind the wheel of a car and mix it up on the roads. This is also why programming driverless vehicles has proven to be so difficult. Objective tasks require rules and explicit reasoning. For example, it's snowing, so the anti-lock braking system (ABS) will work differently than if the roads are dry. Subjective tasks require intuition, instinct, and implicit processing. "The car ahead hit its breaks, maybe a deer ran across the road. I'd better slow down.; or There's a SUV double-parked across from a school, maybe a kid is going to run out from the front of it. Maybe I should stop."

Kahneman's work, explains Cale, revolves around the assumption that humans have two different systems of thinking. He calls subjective thinking *System 1* and objective thinking *System 2*. He describes *System 1* as "effortlessly originating impressions and feelings that are the main sources of the explicit beliefs and deliberate choices of *System 2*". *System 1* is "instinctual, spontaneous, fast, automatic, frequent, emotional, stereotypic and subconscious". *System 2* is "slow, laborious, infrequent, logical, calculating, conscious and really lazy". Driving a car on an empty road is overseen by *System 1*, explains Kahneman, while parking a car in a tight space requires *System 2*. *System 1* is automatic and intuitive, while *System 2* is deliberate and requires that you pay attention. If you park a car in a tight space often enough, like an experienced parking attendant would do, the task becomes a *System 1* task.

System 1 is our default, says Kahneman. "People use it whenever possible (and frequently when it is not really recommendable) and try to rely on it without demanding proof of validity. *System 1* does not analyze or weigh contradicting facts but relies on general truths, preconceived notions, free associations, or heuristics."

Kahneman hypothesized that our ancestors needed such a system in the past to protect themselves against foes, explains Cale.

However, Kahneman warns that *System 1* has biases, trivializes problems so that it does not have to call in *System 2*, and it cannot be turned off. "Errors of intuitive thought are difficult to prevent. Biases cannot always be avoided because *System 2* may have no clue to the error (e.g., that driving over fire hoses is an offense). Even when cues are available, errors can be prevented only by the enhanced monitoring and effortful activity of *System 2*." He says that humans have learned to live with these two systems, and that it would be "enormously tedious" for *System 2* to constantly monitor *System 1* to check every routine decision. "The best we can do is compromise: learn to recognize situations in which mistakes are likely and try harder to avoid significant mistakes when the stakes are high." Near schools and playgrounds, for example.

Driving is not just intuitive

"Human memory happens in many parts of the brain at once, and some types of memories stick around longer than others," says Kahneman. He is a psychologist, not a neurologist, and he made it clear in his book that he was not describing brain systems. His 'systems' are a metaphor for how humans do things, how we use memory. I am neither a psychologist nor a neurologist, but I am reasonably certain that in order to put driverless vehicles on our roads and keep them there, we will have to convince the people who decide what is safe to operate on those roads (i.e., the "deciders") that the robot-controlled vehicles are able to do what human drivers have been doing for the past century, at least as well and hopefully better. Those "deciders" will require more proof for allowing cars to be delivered with driverless functionality than a statement from the seller (Trust me) that its vehicles can be driven onto an expressway, along an expressway, and off an expressway with no hands on the steering wheel and no eyes on the road.

Developers of automated driving systems should have to prove that their algorithms and AI functions really can go beyond operating on *System 1* using heuristics.[10] This is an approach to problem solving that employs a practical method that is not guaranteed to be optimal, perfect, or rational, but is sufficient for reaching an immediate short-term goal, like navigating to a restaurant or handing over the wheel to the driver at the start of an on-ramp to an expressway and turning it back to the automated driving system once the vehicle has successfully merged onto the highway.

> "The whole thing started back at home after Adrian's mom told him, in no uncertain terms, that he couldn't have a Lambo. Like any determined five-year-old, Adrian wasn't about to let that stop him. So, he waited until his sister, Sidney, fell asleep, grabbed the keys, and made his daring escape."

A five-year-old boy in Utah named Adrian stole the family car and drove it for three kilometers, mostly on a limited access highway, before he was pulled over by a Highway Patrol officer. According to his parents, he had never driven before. If we believe them, intuition took this kid rather a long way. That intuition might have

[10] Heuristics - in cognitive psychology, a process of intuitive judgment, operating under conditions of uncertainty, that rapidly produces a generally adequate, though not ideal or optimal, decision, solution, prediction, or inference. (Britannica)

gotten him all the way to California—which is where he was headed, he asserted, to buy a Lamborghini—if he didn't have to do anything other than steer, accelerate and brake, or it could have gotten him or other drivers or pedestrians killed or severely injured.

There are several thousand vehicles on the roads in the U.S. that have been sold to customers who have been told that they have full self-driving capability. Those cars have shown that they can drive better than the Utah five-year-old on a highway. I can vouch for that. I have seen for myself that Teslas can drive in its Full Self-Driving mode on all types of roads and all types of conditions with very few takeovers by the driver who must always be behind the wheel. Driverless systems are getting better and better. They are not yet good enough for driving anywhere at any time, but they are close to being good enough to drive in some places some of the time. Getting them from the Little League to the Teener League and then into the Big League requires getting them to think fast and slow.

Prove that your robot can think fast and slow

This means that any entity offering such vehicles should have to show that its car has a memory system built into its automated driving system like that of a human, one that is explicit, called 'declarative memory', and one that is implicit, called 'nondeclarative memory'. Declarative memory has the sorts of memories one experiences consciously, like the rules of the road. Explicit memory is subdivided into semantic memory ("knowing that") and episodic memory ("remembering"). Nondeclarative, implicit memory ("knowing how"), builds up over time, and does it without our conscious involvement, in background mode. It includes procedural memories which our bodies use to remember skills that we have learned, like playing an instrument, riding a bicycle, or driving a car. It takes less time to learn that a sign with a 50 on it means 50 miles per hour or 50 kilometers per hour (depending on where you are in the world) than it does to learn how to play a guitar or drive a car. If you are stranded on an island in the Pacific Ocean for thirty years, you may need to take a refresher course in sign reading, but you should be able to slide into the seat of your old car and take it out for a spin without endangering yourself or everyone else around you.

Whenever we do anything, we use the two memory levels in our brains. Michael Greshko in his well-formulated article on memory explains that different kinds of memories are held in different areas of the brain, and there are different processes that the brain uses for recalling the memories so that they can be used.[11] For instance, it is the hippocampus region that is used for forming, retaining, and recalling declarative memories. It is believed that "memories are held within groups of neurons, or nerve cells, called cell assemblies. Those interconnected cells fire as a group in

[11] Greshko, M. *Human memory: How we make, remember, and forget memories*. National Geographic. (March 4, 2019).

response to a specific stimulus, …and the more the neurons fire together, the more the cells' interconnections strengthen". Scientists are still not sure how it all works, but what we know so far goes a long way toward helping us understand what needs to be classified as declarative and what needs to be stored and managed as nondeclarative memory.

What is also important for our brain and for driverless cars is that in order for short-term memory to become long-term memory, it has to be "strengthened" for long-term storage, a process called "memory consolidation". The nerves in our brain actually modify themselves to "grow and talk to their neighboring nerves differently," explains Greshko. Some memories must be "reconsolidated" each time they are recalled, and these types of memories must be categorized differently. Such memories might be more subject to biases or misinterpretation.

It's more like two *Systems* and two *Types*, says Gregg Henriques, who claims that two "metatheories", one for psychology and one for cognitive science, work together in a "highly synergistic fashion".[12] He refers to a cognitive process theory developed by Professor John Vervaeke which he calls the 3Rs for "recursive, relevance, and realization". He posits that the mind scans inputs for relevant information and then moves to realize both what is the case and what paths of action can be taken. This is what he calls *Type 1.* Then there is also a secondary recursive process that functions to place a check on the initial grasp that relevance/realization had formed of the situation. This recursive process "updates the initial inference based on how it conforms to anticipated expectations and based on how it aligns with other modeling processes held in the mind". This secondary recursive process is called *Type 2*. There is no dividing line between *Type 1* and *Type 2* cognitive processes. The brain manages them simultaneously, and it does this for all primates.

It takes something special to be human

Where do Kahneman's *Systems* come into this picture? Just as robots are not humans, humans are not just primates. Humans have the animal-mammal-primate cognitive structure of primates, but we also have the more verbal, rational, self-conscious, self-reflective, justifying "person" mind, says Henriques. According to Henriques, the human ego is a "mental organ of justification that evolves in response to the evolution of propositional language and the resulting question-answer dynamics of justification that emerge with it". The primate-experiential system can be thought of as Kahneman's *System 1* and the person-propositional system can be considered *System 2.* The catch is that primates, not just humans, can perform *Type 1* tasks, but only humans can operate with

[12] Henriques, Gregg. *There Are Two Types and Two Systems of Cognitive Processes.* Psychology Today. (April 29, 2022). Professor Gregg Henriques (PhD) is Director of the Combined-Integrated Doctoral program at JMU. He has developed an integrative metatheoretical framework for the field of psychology and is applying this to psychotherapy, well-being, character, and training doctoral students. He has a blog on Psychology Today called Theory of Knowledge where he posts on his latest thinking.

Task 2 tasks in *System 2* mode (at least as far as we know at the moment).

I did a computer search on "What is the most difficult physical and mental task for a human?" Most of the answers were emotional or brain-without-brawn types of tasks, like learning a new language. There were a number of references for learning to ride a bicycle, but driving a car took the prize for the most complicated physical and mental task for the brain. It is not a task for chimps and five-year-olds. Drivers must be able to see and responsively act, and they must also rationally reflect if they are going to successfully make a journey without injuring themselves or others. This is what all the talk of *Systems* and *Types* is about.

"Tesla is arguably the world's biggest robotics company," Elon Musk said, explaining the rationale behind the automaker working on a bot. "Our cars are basically semi-sentient robots on wheels."
Elon Musk at the first AI Day in August 2021.

It is precisely because driving is so complicated that we cannot allow solutions for it to be invented by individual geniuses who make up their own rules for how its automated driving systems will work. Although there is no disagreement on the fact that robots are not sentient (even if Elon Musk believed his robots were "semi-sentient" already back in 2021—see sidebar quote), no matter how artificially intelligent they are, driverless cars must replicate the mental and physical processes that humans perform if they are going to work at least as well as human drivers. In order to be reasonably certain that they do, there needs to be a set of results-based standards developed by experts in the fields of psychology, cognitive science, neuroscience, vision, automotive mechanics, physics, traffic safety, and driving. *Types* and *Systems* need to be built into the standards for ADS-driven cars and implemented by the developers.

These standards should measure results, not means.
It will take them time to create the codifying structure to achieve the desired results because, as far as we know, it has never been done, not from both a mental and physical perspective. There should be no shortcuts, just like there are no shortcuts for obtaining a driver's license (at least not in countries that follow the rules of law and not the rules of the jungle), and there are both age and functional requirements for becoming a driver. The amount of elapsed time this takes will depend on how much time the standards developers can devote to the task. If there is plenty of moral and financial support, it can be done more quickly than the normal ISO[13] processes which take years. One more thing: all of those involved should have driver's licenses and at least twenty years of experience in driving, the more the better. Albert Einsteins need not apply. He never learned how to drive.

In Part Two, I will discuss how the results-based standards process is proceeding.

⌘

[13] International Organization for Standardization

Part Two: Defining a common set of results

Part One was about the hurdles we humans face when trying to advance robot skills beyond running a hundred-yard dash or packing boxes in a warehouse to driving cars. Part Two is about the progress we have made in trying to create sets of desired results for the game of driving which will be played by humans and robots on the same field. I am careful to say "desired results", not just "rules". There is nothing in FMVSS[14] or Type Approval Regulations about what a driver should do in the case of being tailgated, that is, followed very closely from behind. Should he lightly tap the brakes, indicating a stop; speed up to put more distance between his car and the follower; or, if conditions allow, should he pull over to the side of the road and let the tailgater pass? Option one could result in a road rage incident, and option two could result in a race exceeding the speed limit. A Tesla owner recently informed me that his Model Y with the latest update of FSD (14.2.2.5.) pulled over to let a tailgater pass. That is real progress.

I hope I have convinced you in Part One that software systems with data processing algorithms and decision-making frameworks need to be built into vehicles to do most of what human drivers do: sense, anticipate, act, react. We cannot expect ADS robots to feel or empathize. The systems will be used to start, stop, turn, reverse, park, stay in lane, merge, pass, speed up, slow down, share the road (no tailgating, be nice to pedestrians and cyclists), adjust to weather conditions and time of day, adjust to incidents (entering fire scenes and construction zones), know when something is wrong with the vehicle and what to do about it, and know what to do if there is something wrong with a rider.

Because a driverless vehicle does not decide for itself where it will drive, it needs to have instructions for what it should do from the time it leaves its parking/charging/maintenance spot until it returns to this spot after it has completed its ride delivery run. The systems must calculate routes that are both logical and appropriate for the time of day and the real-time traffic conditions at the time of the trip. An improper or inappropriate route will ruin the entire trip for the ADS User (remember, Occupant, Fallback User, and Driver). The nature of the route will also determine what the automated driving software is required to do during a trip.

During the past twenty years or so, companies have been inventing how to do some or all of the tasks described in the paragraph above, and the inventors have been using their own imaginations to decide what to do and how to do it. They have been making up the rules for how their vehicles operate on the roads. One of the most common rules of the road is speed limit. Every road has a speed limit that is either posted or applied to roads of a particular type or within a designated area according a jurisdiction's laws. Let's look at how Tesla treats speed limits. Tesla has five speed

[14] NHTSA. *FMVSS Considerations for Vehicles With Automated Driving Systems: Volume 1* (April 2020). (https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/ads-dv_fmvss_vol1-042320-v8-tag.pdf)

control profiles in its Full Self-Driving (Supervised) software which can be selected by the user at any time during the drive. (The names are a clear indication of bias, don't you think?):

- *Sloth*
- *Chill*
- *Standard*
- *Hurry*
- *Mad Max*

Each one of these determines how fast the car moves relative to the speed limit, how far the car is from the car ahead, and how often the car will pass other vehicles. *Sloth* and *Chill* are more cautious. *Sloth* drives under the speed limit, and *Chill* drives near the speed limit, slightly below and slightly above. *Standard* tries to replicate how a general driver (in the opinion of the Tesla engineer who programmed it) would normally drive (e.g., 10-15% over the speed limit, moderate distance to the vehicle in front, and moderate amount of passing). *Hurry* and *Mad Max* are, according to Tesla, "for situations when the driver is late," says the Tesla manual. *Hurry* is 20% or so over the speed limit. *Mad Max* is "for big city driving where some drivers may want to be more aggressive". Clearly, Tesla does not by default adhere to the posted or legal speed limits.

What is Waymo's policy on adhering to speed limits? Waymo says on its web site in the section on safety that its policy is to always follow the speed limits.[15] It extends this policy to temporary speed limits.

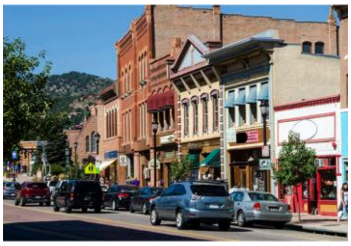
How about stopping at stop signs? Tesla states in its user documentation that "*Full Self-Driving (Supervised) slows down and stops at traffic lights and stop signs* as necessary (I have added the underline), *and reacts to pedestrians, cyclists, and other vehicles on the road.*" It continues: "*In rare cases, Full Self-Driving (Supervised) may not appropriately slow down, come to a stop, or resume control for a stop sign or traffic light. You may assist the system by lightly applying the accelerator or can override Full Self-Driving (Supervised) at any time.*" In other words, if you want to make certain you don't get a moving violation, stay alert.

Waymo says that its vehicles always come to a complete stop at stop signs and traffic lights.

I could continue with this exercise comparing Tesla's and Waymo's approaches for following the rules of the road, and I could add in how the other players like Zoox or Aurora perform. However, my goal is not to criticize any of these companies, but to indicate that they have each been applying their own rules for how their systems perform in the absence of well-defined standards for the results we expect for how driverless vehicles should operate (e.g., must they always drive at or under the speed limit, and if

[15] https://waymo.com/safety/

they don't, who gets the ticket?). Because at present there are no rules or expected behaviors for Automated Driving Systems included in the Federal Motor Vehicle Safety Standards (FMVSS) or Type Approval Regulations, there is no strict testing regimen for ADS vehicles based on the FMVSS or Type Approval, and therefore there is no way to ensure that a vehicle with ADS is allowed to operate on public roads. A Catch-22.



In 2018, in its Automated Vehicles 3.0: Preparing for the Future of Transportation NHTSA stated the following: "As documented in A Vision for Safety 2.0 (NHTSA-2016-0090), ADS developers should consider employing systems engineering guidance, best practices, design principles, and standards developed by established and accredited standards-developing organizations (as applicable) such as the International Standards Organization (ISO) and SAE International as well as standards and processes available from other industries, such as aviation, space, and the military and other applicable standards or internal company processes as they are relevant and applicable. They should also consider available and emerging approaches to risk mitigation, such as methodologies that focus on functional safety (e.g., ISO 26262) and safety of the intended functionality."

Those U.S. cities and states[16] which have allowed testing with Automated Driving Systems and with the Dynamic Driving Task performed by the ADS (i.e., driverless) have done so with the understanding that the companies doing the testing would comply with the one requirement NHTSA has established, which is the reporting within five days of crashes that "involve any fatality, hospital transport, striking of a pedestrian or cyclist, or airbag deployment". This requirement was instituted on June 29, 2021, in Standing General Order (SGO) 2021-01 issued by NHTSA under the National Traffic and Motor Vehicle Safety Act first passed in 1966.[17] NHTSA has "broad information gathering authority" according to this Act in order to carry out its authority to "reduce traffic accidents and deaths and injuries from traffic accidents". The motivation for issuing the SGO was "to obtain timely notice of incidents that may provide information regarding potential safety defects in ADS, in Level 2 ADAS,[18] or in vehicles equipped with these technologies". It was amended in 2023 and again in 2025.

In April 2025, NHTSA said it would be easing some of the reporting requirements while, at the same time, relaxing some of the FMVSS standards to make it easier to approve vehicles without human driver controls to access the roadways, keeping the number of such vehicles to a maximum of 2,500 per manufacturer, but speeding up the approvals process. The easing gives companies more time to report, filters out less severe crashes, eliminates continuous updates of reports even if there is no new information, and streamlines some fields in the reports. This pleased the ADS developers, but displeased vehicle safety groups as well as the U.S. National Institute of Standards and Technology, which is part of the Department of Commerce and which, during the previous administration, were busy developing stringent tests for ADS vehicles. The amended SGO went into effect on June 16, 2025. You can have a look at a sample form for Standing General Order on Crash Reporting.[19]

The current situation can be compared to a soccer match in which each team plays according to its own strategy, partly because they are not certain how the referees will apply the rules, and partly

[16] Waymo – California (Mountain View, Palo Alto, Sunnyvale, Los Altos, and Los Altos Hills, Los Angeles), Arizona (parts of Scottsdale, Tempe, Mesa, Chandler, and Salt River Pima-Maricopa Indian Community), Florida (Miami), and Washington, DC.; Zoox – Nevada (Las Vegas); Tesla – Texas (Austin)

[17] https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-06/Standing_General_Order_2021_01-digital-06292021.pdf

[18] Level 2 ADAS refers to SAE's six Levels of Automation (0-5), in which 0 is No Automation and 5 is Full Automation. Level 2 is Partial Automation in which two or more systems (e.g., automated cruise control and automated lane centering) work together while the driver remains responsible.

[19] https://www.nhtsa.gov/sites/nhtsa.gov/files/2025-08/sgo-ADS-ADAS-Incident-Report-sample-form-3-2025.pdf

because they are trying to make the best use of the players they have. One team is more concerned with scoring goals and the other team is more concerned with maximizing ball possession, not making any unforced errors, and not committing any fouls that could result in a free kick goal.

The rule-making body has now produced a set performance-based and technology-neutral regulations

This is where WP.29 comes into the picture. **WP.29**, or the **World Forum for Harmonization of Vehicle Regulations**, is a Working Party under the United Nations Economic Commission for Europe (UNECE). It is a global forum for discussing and establishing regulations related to motor vehicles, ensuring harmonization across different countries.[20] It serves as both a coordinator and developer of international automotive regulations. Three United Nations agreements, adopted in 1958, 1997, and 1998, provide the legal framework for WP.29, enabling Contracting Parties (who are the countries that are members of the agreements) to establish regulatory instruments related to safety and environmental aspects for motor vehicles, their systems, parts, and equipment. These instruments include performance-oriented test requirements and administrative procedures. The administrative procedures address the Type Approval[21] of the vehicle systems, parts, and equipment, the conformity of production to produce a series of products that exactly match the Type Approval specifications, and the mutual recognition of the Type Approvals granted by Contracting Parties.

WP.29's *Working Party on Automated and Connected Vehicles (GRVA) Informal Working Group (IWG) on Automated Driving Systems*, has prepared a document with the title Proposal for a new United Nations Global Technical Regulation (GTR) of Automated Driving Systems (ADS).[22] The proposal is for establishing a new set of UN GTRs providing worldwide harmonization provisions for the safety of ADSs on Category 1 and 2 vehicles (not to be confused with the SAE's six levels of automation classifications).[23] This WP.29 document has been eleven years in the making, beginning in 2015. In 2018, a reference document with definitions and General Principles for developing a UN Regulation on automated vehicles was approved. A Task Force on Automated Vehicle Testing was also established in 2018, and subgroups were created to consider how automated vehicles could be tested. Other Informal

[20] https://unece.org/wp29-introduction

[21] Type approval in the automotive industry is a formal process that certifies that a vehicle or its components meet specific regulatory, safety, and environmental standards before they can be sold or registered. The manufacturer makes available about a dozen or more pre-production cars that are equal to the final product. These prototypes are used to test compliance with EU safety rules (installation of lights, braking performance, stability control, crash tests with dummies), noise and emissions limits as well as production requirements (of individual parts and components, such as seats or steering wheel airbags). If all relevant requirements are met, the national authority delivers an EU vehicle type approval to the manufacturer authorizing the sale of the vehicle type in the EU. The system is based on the mutual recognition of approvals granted by Member States (certified once, accepted everywhere in the EU)

[22] WP.29 was tasked with developing, harmonizing, and updating UN Regulations in order to enhance the performance of vehicles. The document prepared by the IWG has been submitted in conformity with that mandate.

[23] Category 1 vehicle" means a power-driven vehicle with four or more wheels designed and constructed primarily for the carriage of (a) person(s); "Category 2 vehicle" means a power-driven vehicle with four or more wheels designed and constructed primarily for the carriage of goods.

Working Groups were established to investigate and report on Automated Vehicle Categorisation, Event Data Recorders, Data Storage Systems for Automated Driving, Regulation Fitness. All of this work went into the creation of the Proposal.

The GTR "*provides a necessary first step to the safe deployment of ADS equipped vehicles on public roads as there are no existing global regulations nor regulations established in the Compendium of Regulations of the 1998 Agreement to support ADS deployment*". For the first time, a standards group comprised of representatives from all the major automotive markets (i.e., Europe, North America, and Asia) has consolidated in a single document a clear set of definitions for all of the systems and functions for what has been alternatively referred to as 'autonomous' or 'self-driving' vehicles. Some of the definitions first appeared in the 2018 Automated Vehicles 3.0: Preparing for the Future of Transportation, where they are referenced to SAE International.[24] SAE is and has been an active participant in WP.29, and has been instrumental in developing the GTR as well as all vehicle-related regulations.

The five most important definitions in the GTR are:

1. ***Automated Driving System*** (ADS) means the vehicle hardware and software that are collectively capable of performing the entire Dynamic Driving Task on a sustained basis.
2. ***ADS Vehicle*** means a vehicle equipped with an ADS.
3. ***Dynamic Driving Task*** (DDT) means the real-time operational and tactical functions required to operate the vehicle. The DDT functions are grouped into three interdependent categories:
    i. Sensing and Perception – monitoring the driving environment via object and event detection, recognition, and classification; perceiving other vehicles and road users, the roadway and its fixtures, objects in the vehicle's driving environment and relevant environmental conditions; sensing the operational design domain boundaries; and positional awareness.
    ii. Planning and Decision – predicting actions of other road users; response preparation; and maneuver planning.
    iii. Control – object and event response execution; lateral vehicle motion control; longitudinal vehicle motion control; and enhancing conspicuity via lighting and signaling.
4. ***ADS User*** means a **HUMAN** user of an ADS Vehicle. An ADS User can be a Driver, an Occupant, or Fallback User. The Fallback User means an Occupant who becomes a Driver.
5. ***Driver*** means an ADS user who performs in real time part or all of the DDT for a particular ADS Vehicle.

Here is the key to this proposed GTR: When the ADS is active, the DDT is always performed <u>in its entirety and in real time</u> by the ADS. This means the whole of the tactical and operational functions necessary to operate the vehicle are controlled by the ADS,

[24] SAI International, formerly known as the Society of Automotive Engineers, is a global professional association and standards organization with over 200,000 members.

not the Driver. When ADS is not active, the DDT is performed by a Driver (HUMAN). An ADS can be partially active, in which case the DDT task is shared between the ADS and the Driver.

In the introduction to the GTR the authors state that it is their intention "*to provide a harmonized methodology, incorporating high-level requirements that address the unique nature and safety challenges associated with ADS technology as well as a multi-pillar approach to ensure comprehensive, effective and efficient validation of ADS safety*". The RESULTS are being validated, and the regulation is intended to establish the validation requirements for the approval authorities, whether they are working under the Type Approval process or the self-certification process using requirements such as FMVSS. In addition to the requirements for ADS, there are requirements for the manufacturer of the vehicle and the sub-systems, a section on compliance assessments to be used by auditors to determine whether the requirements have been met, and a series of appendices/annexes. Validation of the ADS's safety compliance should be accomplished with a combination of virtual testing, track testing, and real-world testing on public roads, says the GTR, and completing the tests should be possible using both the Type Approval and the self-certification testing methods.

ADS must be at least as good as a competent and careful Driver

This is the lead sentence in the GTR's section on requirements. Human drivers are the benchmark, as they should be, but not just any human driver. Incompetent and careless drivers, the ones who misbehave, should stay at home. The second sentence states that the ADS "shall be free from unreasonable risk". This means no "Mad Max" settings. One of the first requirements for the ADS is that it "shall comply with traffic rules in accordance with the application of relevant law within the area of operation". Speeding and slowly moving through stop signs are not okay.

Under the headline, Rationale for requirements concerning performance of the dynamic driving task, the GTR "*establishes requirements for ADS driving behaviours under relevant traffic situations (nominal situations, critical situations, failure situations), at operational design domain boundaries, and in fallbacks to the Mitigated Risk Condition* (a stable and stopped state of the vehicle that reduces risk of a crash)". There is a statement that driving "*involves real-time risk management under prevailing traffic scenarios, which means a description of a sequence of driving situations that may occur during a given trip. Safe ADS performance of the DDT depends upon the situations presented under each individual scenario and each scenario is associated with one or more behavioural competencies*".

This is groundbreaking. By establishing requirements for driving behaviors, it is explicitly stating that the ADS must not simply react (*System 1*) but must also reflect (*System 2*).

Behavioural competencies and scenario identification

Annex 5 in the GTR provides an overview of an ODD-based approach that might be used to "*derive verifiable performance criteria for* *the approval or, as relevant, for self-certification of ADS, based on the manufacturer's description of the ODD of their ADS*". The idea is to track the three broad categories of driving situations: nominal, critical, and failure, but to do this within the confines of what the manufacturer defines as the vehicle's ODD. It gives an example of one manufacturer stating that its vehicle's ODD is limited to motorways or highways versus another manufacturer stating that its vehicles can operate on roads that have intersections without either stop signs or signals. The latter vehicle would have to be able to account for a jurisdiction's rules on which vehicle has the right of way when making turns at intersections.

Nominal driving situations are those in which the ADS or a Driver are operating according to defined traffic regulations, while critical driving situations are those in which the ADS or a Driver are violating traffic regulations, or in which road conditions suddenly change due to weather, and the ADS must quickly adapt to this changed behavior to avoid a collision or mitigate the effects of an unavoidable collision. Failure situations are those in which the ADS experiences a fault or failure which compromises the ability of the ADS to perform, such as a sensor failure.

NHTSA wants to make the ADS GTRs part of FMVSS

At the end of January 2026, NHTSA sent a Notice and Request for Comment (RFC) on the ADS GTR. "*NHTSA is seeking public comment on the draft GTR to help inform the U.S. government's position, including how that position could relate to any future domestic actions regarding the safety and performance of Automated Driving Systems.*" Comments were requested by the 23rd of February, but this was extended by fifteen days by NHTSA on the 26th of February. In the RFC, NHTSA explained that it is a Contracting Party to the 1998 Global Agreement on Wheeled Vehicles, Equipment and Parts, which in concerned with the establishment of Global Technical Regulations (GTRs), and serves at the U.S. government's Head of Delegation and Technical Lead on WP.29. It explained that if the GTR is approved by WP.29, the Contracting Parties will be expected to "*initiate processes to incorporate parts or all of the GTR into their individual national regulatory systems*," which is the Federal Motor Vehicle Safety Standards (FMVSS) for the U.S.

NHTSA asked that interested parties should provide comments on the draft GTR according to three criteria: a) technical merit; b) compatibility with U.S. safety standards and possible conflicts with FMVSS; and c) the GTRs' potential impacts on innovation, development, and deployment of ADS in the U.S.; and d) to provide any technical, scientific, or economic data that supports or challenges any of the GTR's requirements.

Many hours were invested in responding to NHTSA's RFC, including some of my own.[25] Waymo's response was ten pages, signed by Dan Smith, Waymo's Deputy General Counsel. Waymo

[25] https://www.regulations.gov/comment/NHTSA-2026-0034-0059

does not think the GTR is implementable within the current structure of FMVSS because "it was written primarily by experts who are most familiar with the application of the UN Regulations in type approval systems". It backs up this statement by pointing out that FMVSS does not use the Category 1 and Category 2 nomenclatures. Some provisions, it says, "would simply be incompatible with the nimble, self-certification framework that ensures safety in the design, construction, and performance of vehicles sold in the U.S." Nevertheless, it urges NHTSA to support adoption of the GTR.

As of this writing (2 March), there were two automobile companies that responded, Volvo Cars and Honda. Volvo Cars recommended, oddly, working outside of FMVSS in a parallel track just for ADS. Honda was supportive of the GTR inside FMVSS. The response from Consumer Reports (4 pages) lived up to the organization's reputation for level-headedness and consumer focus. It reminds NHTSA that 68% of U.S. adults think vehicle safety standards should be stricter for AVs than those for traditional passenger vehicles, and 52% think their local government should keep the power to decide whether and how autonomous vehicles (Why didn't they use ADS vehicles?) are allowed on the roads of their communities. Its main point is that self-certification without some form of third-party, independent verification and validation of safety cases, will not ensure adherence to the safety standards.

Mapping companies HERE and TomTom believe the GTR is a bit too light on the mention of map technology, and that location context can be more useful to the overall performance of any ADS, acknowledging at the same time that the GTR must be technology neutral. Alain Kornhauser reminded NHTSA that the GRT focuses on the safety side of the use of ADSs, not the benefits side. The safest transportation system is one that is never used.[26] But what good would that be, asks Alain. "How much risk is acceptable in order to capture for society the reward opportunities for ADS," he asks. Shouldn't there be a way of balancing the positive societal outcomes of ADS with the safety outcomes that come under NHTSA's purview?

The American Association of Motor Vehicle Administrators (AAMVA), a nonprofit organization that represents motor vehicle licensing and registration agencies in the U.S. and Canada, wrote an excellent set of comments, beginning with: "The draft GTR's framework for performance requirements represents the type of outcome-based regulation that should be incorporated into the U.S. standards. Rather than specifying sensor configurations or algorithmic approaches, the GTR establishes what the ADS must achieve: safe navigation, appropriate responses to dynamic conditions, and reliable performance within defined parameters." It

[26] It was actually a Swedish academic who seriously promoted this concept. His name escapes me, and, no, he has nothing to do with the Vision Zero quest, which is a serious Swedish invention first proposed by Claes Tingvall as Director of Traffic Safety for the Swedish National Road Administration (which preceded the Swedish Transport Administration.

closes with: "the development of this GTR represents a pivotal moment for ADS safety regulation." I completely agree.

I look forward to reading NHTSA's summary of the comments it has received. It might be a very good opportunity for NHTSA and the EU to have a deep think about their approach to testing and evaluating the safety of vehicles considering that more of the way the vehicles perform will be controlled by automated driving systems that are not monitored by human drivers. The GTR is the result of a conclusion by the ADS IWG that a prescriptive set of tests, like those currently included in FMVSS and Type Approval regulations, is not the way to determine if an ADS is roadworthy. The IWG opted for a safety case approach, putting the burden on ADS manufacturers and the automobile companies that incorporate those systems into their automobiles to prove the evidence their vehicles deliver safe performance in all of the places it will operate.

Looking ahead

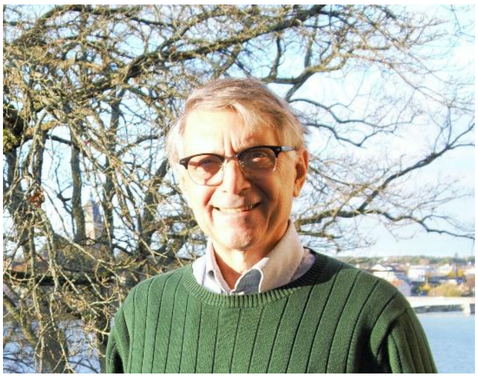
Driving is a game that almost anyone can play. Anyone who is able to pay more for the equipment than their parents paid for their first house, and more for owning the equipment each year than four years of college cost when they bought that house; anyone who can pass the test for a driver's license; anyone who accepts that breaking some rules will cost a month's salary or more or put you in jail; anyone who accepts that every time you play, if you mess up badly, you or your co-game player can end up in the hospital or dead. We accept these conditions because of the benefits we gain. And now we want to turn over the game to robots and become riders. As I have continued to say, those who will gain most are those who could not participate in the driving game. Anyone who wanted to play but who could not meet all the requirements to compete will be happy to be riders too—as long as the price of entry is affordable and the consequences of losing are not as calamitous.

All of us who have been engaged in this evolution of driving, moving driving from totally manual to mostly or totally automated, have slowly realized that the changes required to make that move are not only in the vehicle systems, but in the entire playing field along with the players. What I have written about in this MII is how the realization that automated driving systems cannot be tested like manually driven vehicles has manifested itself as a new results-based approach to vehicle testing. The systems have to be tested both as a machine and as a driver. Further, the developers of the ADS must now realize that their approach to building the robots doing the driving have to go far beyond "what you see is all there is". This is a pivotal moment as many of the commenters on the proposed UN Global Technical Regulation stated. We need to take the opportunity and make the pivot.

About Michael L. Sena

Through my writing, speaking and client work, I have attempted to bring clarity to an often-opaque world of highly automated and connected vehicles. I have not just studied the technologies and analyzed the services. I have developed and implemented them and have worked to shape visions and followed through to delivering them. What drives me—why do what I do—is my desire to move the industry forward: to see accident statistics fall because of safety improvements related to advanced driver assistance systems; to see congestion on all roads reduced because of better traffic information and improved route selection; to see global emissions from transport eliminated because of designing the most fuel-efficient vehicles; and to see everyone who needs a ride get one.

I try to put vehicles into their context. It is not just roads; it is communities, large and small. Vehicles are tools, and people use these tools to make their lives and the lives of their family members easier, more enjoyable, and safer. Businesses and services use these tools to deliver what people need. Transport is intertwined with the environment in which it operates, and the two must be developed in concert.



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