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AUTONOMOUS VEHICLES AND LIABILITY: WHAT WILL JURIES DO?

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ABSTRACT

Autonomous vehicles ("AVs") that can be operated without a human driver are now being tested on public roads across America and are soon expected to be commercialized and widely available. One of the greatest roadblocks holding up more rapid deployment of AVs is manufacturers' concerns about AV liability. This article provides a real-world assessment of AV liability risks, and concludes that manufacturers are indeed rightfully concerned about the extent and impacts of liability on AVs. The article first examines the application of product liability doctrine to AVs in various accident scenarios, drawing upon previous vehicle product liability cases. While AV manufacturers will likely and properly be held responsible for most accidents where the vehicle itself is responsible for the crash, the concern is that AV manufacturers may be sued and often held liable even when the AV was not the cause of the collision. This is because AVs have a much greater capability to avoid collisions than does a human-driven vehicle, and thus in almost any crash scenario it may be possible to argue that the AV should have detected and avoided the impending crash. Thus, even though the total number of vehicle accidents should decrease with AV deployment, the share and even net value of liability may go up for AV manufacturers. Next, the article considers jury tendencies and psychology, and concludes that jurors will be particularly harsh on AVs that draw on exotic artificial intelligence technology, and which may be involved in accidents that harm people notwithstanding their claims of improving overall vehicle safety. These factors are likely to result in more frequent and larger punitive damages than in past motor vehicle product liability. Given these finding, the article concludes by recognizing the need for some type of public policy intervention

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to prevent the tort system from having the contradictory effect of harming public safety.

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INTRODUCTION

Two recent incidents help to frame the issue of liability for accidents involving autonomous vehicles ("AVs"). First, on March 18, 2018, an Uber self-driving vehicle hit and killed a pedestrian in Tempe, Arizona.[2] The vehicle was being operated in autonomous mode with a human operator in the driver's seat when Elaine Herzberg, a 48-year old woman pushing a bicycle, stepped in front of the vehicle and was killed.[3] The victim was jaywalking in an unlighted stretch of road at night. A human-driven car would likely not have seen the victim in time, and also would have struck and killed her. However, the Uber car had a Lidar system that allowed it to see in the dark, well beyond the capability of a human driver, and that system reportedly detected Herzberg six seconds before the crash, enough time to have stopped.[4] However, Uber had disabled the automatic braking system, and the human operator was not paying proper attention and was instead watching a TV show on her cell phone.[5] Herzberg's relatives sued Uber for the accident, which Uber quickly settled for undisclosed terms.[6] Potential criminal charges against the driver for reckless manslaughter are still being considered by the Tempe police.[7]

The second incident occurred in San Francisco on December 7, 2017.[8] A motorcyclist named Oscar Nilsson crashed into a General Motors ("GM") Cruise Chevrolet Bolt driving in self-driving mode.[9] The Bolt had started to

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[2] Daisuke Wakabayashi, *Self-Driving Uber Car Kills Pedestrian in Arizona, Where Robots Roam*, N.Y. TIMES (Mar. 19, 2018), https://www.nytimes.com/2018/03/19/technology/uber-driverless-fatality.html [https://perma.cc/4377-TNEF].

[3] *Id.*

[4] *See* NAT'L TRANSP. SAFETY BD., PRELIMINARY REPORT HIGHWAY: HWY18MH010 (2018), https://www.ntsb.gov/investigations/AccidentReports/Pages/HWY18MH010-prelim.aspx [https://perma.cc/A4NY-NQSY].

[5] Chris Coppola & BrieAnna J Frank, *Report: Uber Driver was watching 'The Voice' moments before fatal Tempe Crash*, AZ CENTRAL (June 21, 2018, 9:10 PM), https://www.azcentral.com/story/news/local/tempe-breaking/2018/06/21/uber-self-driving-car-crash-tempe-police-elaine-herzberg/724344002/ [https://perma.cc/7FWD-5GW3].

[6] *See* Ryan Randazzo, *Uber reaches settlement with family of woman killed by self-driving car*, AZ CENTRAL (Mar. 29, 2018, 8:01 AM), https://www.azcentral.com/story/news/local/tempe/2018/03/29/uber-settlement-self-driving-car-death-arizona/469278002/ [https://perma.cc/BQ72-WYEC].

[7] Bree Burkitt, *Self-driving Uber fatal crash: Experts say prosecution would be precedent setting,* AZ CENTRAL (June 22, 2018, 7:43 PM), https://www.azcentral.com/story/news/local/tempe/2018/06/22/self-driving-uber-fatal-crash-prosecution-may-precedent-setting/726652002/ [https://perma.cc/EZ25-D7R2].

[8] Justin T. Westbrook, *Motorcyclist Sues GM Over Crash With Self-Driving Chevy Bolt*, JALOPNIK (Jan. 23, 2018, 7:45 PM), https://jalopnik.com/motorcyclist-sues-gm-over-crash-with-self-driving-chevy-1822358606#f1k6zh3sucwa2vdimgy7pcnhr.37oldc8ci8cqr [https://perma.cc/8N75-ATAS].

[9] *Id*.

make a lane change to the left, but then averted the maneuver and returned to the center lane, when Nilsson coming up from behind while straddling the two right-most lanes crashed into the Bolt. The driver in the GM car tried unsuccessfully to steer the car to avoid hitting Nilsson.[10] The motorcyclist walked away from the accident, but then later sued GM for some alleged injuries from the accident. The police report attributed the fault of the accident solely to Nilsson.[11] The case settled for undisclosed terms,[12] with Nilsson's attorney telling the media that "the case has been resolved to my client's satisfaction."[13]

These incidents raise difficult questions about liability for crashes involving AVs. The Uber case raises the issue about what standard of safety should apply to AVs. If a human-driven car would have also killed the pedestrian, wouldn't holding Uber liable impose a higher standard on self-driving cars than human-driven cars, potentially deterring deployment of AVs that are safer than existing human-driven cars? Wouldn't this have the effect of reducing overall public safety, exactly the opposite objective that tort law is intended to achieve of making society safer by reducing accidents?[14] Yet, if the objective of tort law is to incentivize product manufacturers to make their products as safe as reasonably possible, would that not suggest that Uber should be held liable, since it had deliberately disabled its automatic braking system, making the car less safe than it should be and perhaps less safe than competing AVs? Should the liability system push manufacturers to produce AV systems that, like other products, are as safe as reasonably feasible, even if it means that manufacturers could potentially be sued in most AV accidents, and may even be put out of business?

The GM case raises other questions. Would the motorcyclist who was injured in the accident have sued GM if it was a traditional human-driven GM vehicle rather than an AV that was involved in the accident? Given that the police report concluded that the motorcyclist was solely to blame, would a trial lawyer have taken and brought the case if it did not involve an AV? That is unlikely. Why then did GM settle the case on terms apparently favorable to the motorcyclist when the police report concluded that GM was not at fault? Was GM worried about bad publicity or the way a jury may treat an "exotic" technology like AVs?

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[10] *Id*.

[11] *Id*.

[12] *See* Joint Notice of Settlement at 2, Nilsson v. Gen. Motors LLC, No. 4:18-cv-00471-JSW (N.D. Cal. May 30, 2018).

[13] Ryan Felton, *GM Settles Lawsuit With Motorcyclist Over Crash With Self-Driving Chevy Bolt*, JALPONIK (June 1, 2018, 3:16 PM), https://jalopnik.com/gm-settles-lawsuit-with-motorcyclist-over-crash-with-se-1826492276 [https://perma.cc/SU6W-JL4T].

[14] *See* George L. Priest, *Modern Tort Law and its Reform*, 22 VAL. U.L. REV. 1, 8 (1987) ("Twin goals of modern tort law: accident reduction and compensation of the injured."); GUIDO CALABRESI, THE COSTS OF ACCIDENTS: A LEGAL AND ECONOMIC ANALYSIS 26 (1970) (A primary goal of tort law is to reduce "the number and severity of accidents").

How would a jury treat AVs and would it matter that they are safer overall than non-AVs?

These unanswered questions raise uncertainty about the liability implications of AVs. Two broad questions are presented. First, how will courts and juries likely treat AVs and their manufacturers under existing liability approaches in personal injury lawsuits arising from accidents involving such vehicles? Second, how should courts and juries treat such vehicles and their manufacturers in accident lawsuits, considering the impacts and incentives of such decisions for manufacturers as well as broader societal interests in safety? The first question is descriptive, whereas the second is normative.[15]

This paper focuses on the first question and explores how courts and juries are likely to treat AVs and their manufacturers in lawsuits that will arise from accidents involving AVs. There are many fears and concerns that real or perceived liability risks will impede or deter the development and deployment of AVs.[16] This article examines that question, and will consider the legal doctrines, evidence, factors and perceptions, that will influence court and jury decisions. The findings and conclusions from this analysis will help inform the second question as to how courts and juries *should* treat AVs, including whether changes or modifications are needed in product liability law to promote optimal societal outcomes. That will be the subject of future work.

Section I provides background on the technology, manufacturer plans, legislation, and safety of AVs. It also explains the paradoxical result that the number of lawsuits against vehicle and equipment manufacturers is likely to go up even though AVs will likely be safer than existing vehicles. Section II then examines doctrinal rules that will apply to AV accidents, and the arguments that plaintiffs and manufacturers are likely to make in applying those doctrines to AV accidents. Specifically, this section examines when and by what criteria an AV will be determined to be "defective" under product liability doctrine, and also examines the issue of who would be liable if an AV is held to be legally responsible for an accident.[17] Section III extends this analysis to examine liability outcomes in specific accident scenarios. Section IV then explores how jury perceptions, heuristics, and potential biases may play into liability and damages determinations in AV lawsuits, and the types of evidence that are likely to sway jury decisions about AVs.

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15 *See* Bryant Walker Smith, *Automated Driving and Product Liability*, 2017 MICH. ST. L. REV. 1, 2 (2017).

16 Stephen S. Wu, *Product Liability Issues in the U.S. And Associated Risk Management*, *in* AUTONOMOUS DRIVING 553, 553 (M. Maurer et al. eds., 2015); Mark A. Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 CAL. L. REV. 1611, 1616-17 (2017).

17 AV developers and manufacturers may also be held liable for defects that allow hackers to break into their system and cause accidents. That liability risk is not addressed in this article. *See* Geistfeld, *supra* note 16, at 1660-74.

I. BACKGROUND ON AVS AND LEGAL LANDSCAPE

A. AV Technologies

1. Levels of Autonomy

In January 2014, SAE International introduced a document now widely used to categorize AVs called Standard J3016 "Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems," which was further revised in 2016 and again in 2018.[18] The terminology used here is from the latest revision of the standard.[19] This standard is the most widely accepted standard as evidenced by the number of federal and state regulators that adopt its terminology. J3016 introduces a taxonomy with 6 levels of driving automation.[20] The levels are divided here into two groups.

1. Levels 0 through 2. The distinguishing feature of these levels is that the driver performs all or most of the dynamic driving task ("DDT").[21] In particular, the driver performs object and event detection and response ("OEDR") which includes monitoring and interpreting objects and events in the environment and preparing and executing responses.[22]
2. Levels 3 through 5. The distinguishing feature of these levels is that the Automated Driving System ("ADS") performs the whole dynamic driving task when it is engaged.[23] Level 3 qualitatively differs from levels 4 and 5 in that it requires a user for fallback, unlike levels 4 and 5 that have no such requirement.[24]

These six levels do not include active safety systems (such as automatic breaking) which are designed to be activated in case of emergency and are not involved in the DDT.[25]

Levels 0 through 2 do not generally raise novel liability issues because the driver is expected to be responsible for the DDT. One exception may be the Tesla auto-pilot system, which enables the car "to steer, accelerate and brake automatically within its lane," although "[c]urrent Autopilot features require active driver supervision and do not make the vehicle autonomous."[26] There

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[18] *See* SAE INT'L, TAXONOMY AND DEFINITIONS FOR TERMS RELATED TO DRIVING AUTOMATION SYSTEMS FOR ON-ROAD MOTOR VEHICLES 1 (2018).

[19] *See id.*

[20] *Id.* at 2.

[21] *Id.* at 21.

[22] *Id.* at 6-7.

[23] *Id.* at 19.

[24] *Id.* at 22-23.

[25] *Id.* at 2.

[26] TESLA, *Future of Driving*, https://www.tesla.com/autopilot [https://perma.cc/ZT77-J8AA].

have been at least four fatalities of Tesla drivers relying on the auto-pilot system that crashed into an object.[27] Litigation is currently pending on whether the manufacturer or driver is legally responsible for what appears to be over-reliance on the auto-pilot system.[28] These Level 2 Tesla vehicles are the vehicles with the highest level of autonomy currently commercially available for sale in the United States.[29]

Currently, there are no Level 3, 4 or 5 AVs available for sale to consumers.[30] However, such vehicles have been tested on public roads in a number of American cities for several years. Waymo, the AV division of Google's Alphabet, launched its Waymo One service in 2018 in a Phoenix suburb, partnering with Lyft for some vehicles, commercially offering consumers ride share trips for a fee.[31] Waymo currently keeps a human in the driver's seat in most vehicles, but has tested the vehicles with no human in the driver seat, and their goal is to expand the Waymo One service to other cities.[32]

As will be elaborated below, the level of autonomy of an AV will often be critical to liability determinations. A level 3 AV is capable of operating autonomously in specific situations and contexts, known as the Operational Design Domain ("ODD"), but a human driver remains in ultimate control of the vehicle and is purportedly prepared to take over operation of the vehicle on short notice if the ODD conditions are exceeded.[33] The issue in a crash of a Level 3 vehicle is therefore whether the vehicle or operator (or neither) is responsible for a crash. In a level 4 or 5 vehicle, the vehicle operates entirely autonomously in specified (level 4) or all (level 5) conditions (or ODDs), and therefore if a crash occurs with such a vehicle, the question is whether the vehicle is responsible for the accident, not the operator.

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[27] Alex Davies, *Tesla's Latest Autopilot Death Looks Just Like a Prior Crash*, WIRED (May 16, 2019), https://www.wired.com/story/teslas-latest-autopilot-death-looks-like-prior-crash/ [https://perma.cc/ERL6-U72V].

[28] Faiz Siddiqui, *Tesla sued by family of Apple engineer killed in Autopilot crash*, WASH. POST (May 1, 2019), https://www.washingtonpost.com/technology/2019/05/01/tesla-sued-by-family-man-killed-autopilot-crash/.

[29] Kyle Hyatt & Chris Paukert, *Self-driving cars: A level-by-level explainer of autonomous vehicles*, CNET (Mar. 29, 2018), https://www.cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/.

[30] *Id.*

[31] Matthew DeBord, *Waymo has launched its commercial self-driving service in Phoenix*, BUS. INSIDER (Dec. 5, 2018, 8:03 AM), https://www.businessinsider.com/waymo-one-driverless-car-service-launches-in-phoenix-arizona-2018-12 [https://perma.cc/88DS-KPP7]; *see* John Krafcik, *Waymo One: The Next Step on Our Self-driving Journey*, MEDIUM (Dec. 5, 2018), https://medium.com/waymo/waymo-one-the-next-step-on-our-self-driving-journey-6d0c075b0e9b [https://perma.cc/LD79-V5PP].

[32] *Id.*

[33] SAE INT'L, *supra* note 18, at 18-19.

2. Technologies That Make Autonomous Driving Possible

While AVs will incorporate a wide variety of technology improvements, we restrict the discussion here to the technologies that makes automatic driving possible. AVs need to (1) sense the environment in which they operate, and then (2) interpret the environment and plan their movement accordingly. We briefly discuss the technology behind each of these tasks, as the potential liability of an AV will often depend on the capabilities of these systems.

a. Sensors. The three main types of sensors used by AVs to sense their environment are Radar, Lidar, and cameras.[34] In addition, GPS data and detailed maps of the environment are used to supplement data obtained from sensors to get a more complete picture of the environment. AVs also use audio sensors to detect emergency sirens and other environmental sounds.[35]

i. Radar: Radar operates by emitting radio waves and collecting the reflected waves to form a picture of the environment.[36] It can be used to also measure the velocity of objects in the environment.[37] Radar can operate well in adverse weather conditions and at night, and can identify objects at a distance, but produces images of limited resolution.[38]

ii. Lidar: Lidar has an energy source that emits pulsed laser light and sensors that detect the reflected light and form a 3D representation of objects in the environment.[39] Lidar can produce higher resolution images than radar in general.[40] Lidar also has the advantage of being able to operate well at night as

[34] Katie Burke, *How Does a Self-Driving Car See?*, NVIDIA (Apr. 15, 2019), https://blogs.nvidia.com/blog/2019/04/15/how-does-a-self-driving-car-see/ [https://perma.cc/HY42-6VHJ]; *see* GRAHAM BROOKER, SENSORS FOR RANGING AND IMAGING 10 (2009).

[35] WAYMO, WAYMO SAFETY REPORT: ON THE ROAD TO FULLY SELF-DRIVING 14 (2018), https://storage.googleapis.com/sdc-prod/v1/safety-report/Safety%20Report%202018.pdf [https://perma.cc/77KA-QJFY]; *see, e.g.*, NURO, DELIVERING SAFETY: NURO'S APPROACH 12 (2018), https://static1.squarespace.com/static/57bcb0e02994ca36c2ee746c/t/5b9a00848a922d8eaecf65a2/1536819358607/delivering_safety_nuros_approach.pdf.

[36] WAYMO*, supra* note 35, at 14. *See generally* Guilio Reina, David Johnson & James Underwood, *Radar Sensing for Intelligent Vehicles in Urban Environments*, 15 SENSORS 14661 (2015).

[37] NURO, *supra* note 35, at 19.

[38] Jelena Kocić, Nenad Jovičić & Vujo Drndarević, *Sensors and Sensor Fusion in Autonomous Vehicles* 1, 2 (26th Telecomms. Forum TELFOR 2018), https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8612054.

[39] Jeff Hecht, *Lidar for Self-Driving Cars*, 29 OPTICS & PHOTONICS NEWS 26, 41 (2018).

[40] *Id.* at 30.

it not dependent on an external source of light.[41] Lidar systems also have a wider field of view than radar systems.[42] However, Lidar does not operate well under adverse weather conditions,[43] and Lidar systems are vulnerable to hacking.[44] Most autonomous car manufacturers use Lidar with the notable exception of Tesla.[45]

iii. 2D Cameras: 2D-cameras capture visible light to obtain a 2D representation of the environment, which is further interpreted by algorithmic means to obtain a 3D representation of objects in the scene.[46] Cameras have the advantage of being cheap sensors, but they do not operate well in adverse lighting conditions.[47] Recent efforts have started looking at incorporating infrared thermal imaging spectrum to supplement existing cameras for added safety.[48]

b. Interpreting the environment. AVs combine data from all their sensor inputs to obtain an accurate understanding of their environment. Lidar images are combined with radar velocity information to form a model of objects and their trajectories in the environment. This information is further combined with camera information, GPS information and the stored map database to accurately determine the position of the vehicle and other objects in the environment. Interpreting the environment requires recognizing objects in the environment using computer vision[49] and machine learning techniques.[50] At a high-level, machine

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[41] *Id.* at 32.

[42] Phillip Lindner & Gerd Wanielik, *3D LIDAR Processing For Vehicle Safety and Environment Recognition,* 2019 IEEE WORKSHOP ON COMPUTATIONAL INTELLIGENCE IN VEHICLES AND VEHICULAR SYSTEMS 66, 66 (2019), https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4938725.

[43] Hecht, *supra* note 39, at 33.

[44] Mark Harris, *Researcher Hacks Self-driving Car Sensors*, IEEE SPECTRUM (Sept. 4, 2015), https://spectrum.ieee.org/cars-that-think/transportation/self-driving/researcher-hacks-selfdriving-car-sensor [https://perma.cc/KG2G-EPS8].

[45] Hecht, *supra* note 39*,* at 29.

[46] Mario Hirz & Bernhard Walzel, *Sensor and Object Recognition Technologies for Self-Driving Cars*, 15 COMPUTER-AIDED DESIGN AND APPLICATIONS 501, 504-05 (2018).

[47] *Id.* at 504.

[48] *Id.*

[49] Sayanan Sivaraman & Mohan Manubhai Trivedi, *Looking at Vehicles on the Road: A Survey of Vision-based Vehicle Detection, Tracking, and Behavior Analysis*, 14 IEEE TRANS. INTELLIGENT TRANSP. SYST. 1773, 1775 (2013).

[50] Andreas Geiger, Philip Lenz & Raquel Urtasun, *Are We Ready for Autonomous Driving? The KITTI Vision Benchmark Suite*, IEEE CONF. ON COMPUTER VISION AND PATTERN RECOGNITION (2012), https://ieeexplore.ieee.org/abstract/document/6248074 [https://perma.cc/S4XL-66E7].

> learning can be defined as "a set of methods that can automatically detect patterns in data, and then use the uncovered patterns to predict future data, or to perform other kinds of decision making under uncertainty."[51] The data used in learning is called the training data (or training set).[52] Machine learning algorithms are used for scene understanding,[53] as well as predicting the behavior of other vehicles.[54] While AVs have made impressive progress in understanding their surroundings, they still have difficulty in extreme conditions such as heavy snow, rain, fog or sandstorms.[55]

The exact algorithms used by autonomous vehicles companies are proprietary. The quality of systems based on machine learning is affected by the quality of the training data, which needs to be representative of the various settings in which the system will be used. Also, machine learning systems are susceptible to adversarial attacks. An adversarial attack on a machine learning system is a method to modify an input to the system in a way that is imperceptible to a human but that causes the system to have a completely erroneous understanding or prediction of the input.[56] The existence of adversarial attacks indicates that current machine learning systems are not sufficiently robust and makes the testing of systems based on machine learning especially challenging.[57]

3. Disengagement Reports

When a vehicle is operating in autonomous mode, it is possible that the autonomous control disengages due to an error or circumstances that cannot be handled by the system. California requires companies that are testing

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[51] Kevin P. Murphy, MACHINE LEARNING: A PROBABILISTIC PERSPECTIVE 1 (2012).

[52] *Id.* at 2.

[53] Markus Kuderer, Shilpa Gulati & Wolfram Burgard, *Learning Driving Styles For Autonomous Vehicles From Demonstration,* IEEE INT'L CONF. ON ROBOTICS AND AUTOMATION 2641, 2641-22 (2015); Moritz Menze & Andreas Geiger, *Object Scene Flow for Autonomous Vehicles,* IEEE CONF. ON COMPUTER VISION AND PATTERN RECOGNITION (2015), http://cvlibs.net/publications/Menze2015CVPR.pdf [https://perma.cc/V8N5-8FHG].

[54] Liangzhi Li, Kaoru Ota & Mianxiong Dong, *Humanlike Driving: Empirical Decision-Making System for Autonomous Vehicles*, 67 IEEE TRANS. VEHICULAR TECH. 6814, 6815-16 (2018).

[55] Tom Krisher, *5 Reasons Why Autonomous Cars Aren't Coming Anytime Soon*, ASSOC. PRESS (Feb. 4, 2019), https://www.apnews.com/b67a0d6b6413406fb4121553cdf0b95a [https://perma.cc/E8TC-RJB2].

[56] Alexy Kurakin, Ian Goodfellow & Samy Bengio, *Adversarial Examples in the Physical World* (Feb. 11, 2017), https://arxiv.org/pdf/1607.02533.pdf [https://perma.cc/XN85-BDAX]; Christian Szegedy et al., *Intriguing Properties of Neural Networks* (Feb. 14, 2014), https://arxiv.org/abs/1312.6199 [https://perma.cc/N7Y9-XKAM].

[57] Cumhur Erkan Tuncali et. al., *Simulation-based Adversarial Test Generation for Autonomous Vehicles with Machine Learning Components* (Jan. 7, 2018), https://arxiv.org/pdf/1804.06760.pdf [https://perma.cc/Y3ZA-Y46F].

autonomous technology in California to report any disengagements of the autonomous systems of the test vehicles. The following is a summary of the disengagements reports for 2017[58] and 2018.[59] The data shown is sorted from smaller to larger disengagement/mile numbers. The 2018 data only shows the top 12 entries with the smallest disengagement rates. The 2017 data is complete.

	2017 Data		**2018 Data**		
Company	**Miles (1000's)**	**Disengagement per 100 miles**	**Company**	**Miles (1000's)**	**Disengagement per 100 miles**
Waymo	353	0.0179	Waymo	1,272	0.00897
GM Cruise	125	0.0840	GM Cruise	448	0.0192
Nissan	5	0.479	Zoox	30.8	0.0520
Zoox	2.24	0.624	Nuro	24.7	0.0972
drive.ai	6.57	2.30	Pony.AI	16.4	0.0978
Baidu	1.97	2.43	Nissan	5.48	0.475
TeleNav	1.82	3.23	Baidu	18.1	0.486
Delphi	1.81	4.47	AIMotive	3.43	0.496
NVIDIA	0.505	21.6	AutoX	22.7	0.524
Valeo	0.574	37.4	Roadstar.AI	7.54	0.570
Bosch	1.43	41.5	WeRide/Jingchi	15.44	0.576
Mercedes	1.09	62	Aurora	32.86	1.00

It seems clear from these results that there is a wide variation between AV developers in the rate of disengagements, and that the better numbers are associated with companies with more extensive testing programs, but there are exceptions especially with many newcomers in 2018 (such as Nuro and Pony.AI).

Unfortunately, the various companies do not use the same format for their reports nor do they always specify the environment in which testing is done, which can greatly affect disengagement rates. Some interesting statistics include 45 out of the 105 disengagements for GM Cruise in 2017 are due to "other road

[58] CALIFORNIA DEPARTMENT OF MOTOR VEHICLES, REPORT ON AUTONOMOUS MODE DISENGAGEMENT FOR SELF-DRIVING VEHICLES IN CALIFORNIA (2017), https://dmvpublicaffairs.wetransfer.com/downloads/a64c8567218182cf88523a6c667c26f02 0190711160412/f2e212.

[59] CALIFORNIA DEPARTMENT OF MOTOR VEHICLES, REPORT ON AUTONOMOUS MODE DISENGAGEMENT FOR SELF-DRIVING VEHICLES IN CALIFORNIA (2018), https://dmvpublicaffairs.wetransfer.com/downloads/aa7273691c5e8dded0c34132a6ad6ae02 0190711163626/5e2bae.

users behaving poorly."[60] This is consistent with their testing which is done on the streets of San Francisco, which present a challenging driving environment. Waymo, on the other hand, has one of the sixty-three disengagements in 2017 reported due to "recklessly behaving road user."[61] It is not clear how many of the miles driven by Waymo are in a challenging urban environment, but its report states that most of the miles driven are on surface streets.[62] Of the sixty-three Waymo disengagements in 2017, fifty-seven are on streets and only six are on highways.[63] This discussion highlights the need for taking the testing environment into consideration when comparing disengagement rates.

Most of Waymo's disengagements in 2017 are due to hardware, software, or perception discrepancies.[64] The terminology used in the reports to describe the causes of disengagements are not specific which led the California MVD to ask for more details.[65] The supplementary information provided by the manufacturers gives more specific descriptions[66] and the issues listed are in general serious and could lead to accidents in the absence of a takeover by the backup driver. Examples of the issues include: "sensors not holistically capturing all data on vehicles approaching in opposite lanes" (Cruise), "AV planning on making a turn with oncoming traffic approaching quickly" (Cruise), "Other vehicles not yielding to AV" (Cruise), "component of the vehicle's perception system (e.g., camera, lidar, radar) fails to detect an object correctly" (Waymo), and "performing a driving behavior that was undesirable under the circumstances" (Waymo).[67] Again, this an area that can benefit from standardized terminology. The numbers for 2018 show a clear improvement with Waymo cutting their disengagement rate by half while more than tripling the miles driven.[68] GM Cruise also showed marked improvement.[69]

B. Manufacturers' AV Plans

Virtually all established motor vehicle manufacturers, as well as a number of upstarts focusing specifically on AVs, are actively pursuing the development of

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[60] CALIFORNIA DEPARTMENT OF MOTOR VEHICLES, REPORT ON AUTONOMOUS MODE DISENGAGEMENTS FOR WAYMO SELF-DRIVING VEHICLES IN CALIFORNIA (2017).

[61] *Id.*

[62] *Id.* at 1.

[63] *Id.* at 3.

[64] *Id.* at 4-6.

[65] Email from Ron Medford, Dir. of Safety, Waymo, to Dep't of Motor Vehicles Occupational Licensing Branch (Mar. 26, 2018).

[66] *Id.*

[67] *See* Report, CALIFORNIA DEPARTMENT OF MOTOR VEHICLES, *supra* note 58.

[68] Mario Herger, *Disengagement Report 2017—The Good, The Bad, The Ugly,* THE LAST DRIVER LICENSE HOLDER (Feb. 1, 2018), https://thelastdriverlicenseholder.com/2018/02/01/disengagement-report-2017-the-good-the-bad-the-ugly/ [https://perma.cc/2B22-3RRT].

[69] *Id.*

AVs. However, manufacturers differ on their strategy with respect to the level of AVs that should be deployed initially. Some manufacturers such as Google (Waymo) and Volvo are planning to go straight to Level 4 or 5 vehicles, concluding that reliance on a human operator at Level 3 is not effective.[70] Other manufacturers are planning a more gradual evolution of AVs from existing vehicles with some semi-autonomous safety features to Level 2 and 3 vehicles that increasingly incorporate autonomous functionality.[71]

Ford announced plans to launch a self-driving service in 2021.[72] Waymo already launched an "Early Rider Program" in the Phoenix area in April 2017 followed by its "Waymo One" ride-sharing service (limited to Phoenix initially) in December 2018.[73] In a press release in early 2017, General Motors announced that it "filed a Safety Petition with the Department of Transportation for its fourth-generation self-driving Cruise AV, the first production-ready vehicle built from the start to operate safely on its own, with no driver, steering wheel, pedals or manual controls."[74] In December 2018, Zoox received the first permit to transport passengers in their autonomous vehicles in California.[75] The permit requires backup drivers and forbids Zoox from getting paid by customers for their service.[76] A number of other manufacturers are also making plans to accelerate the deployment of self-driving services, with most manufacturers

[70] Kathleen Walch, *The Future With Level 5 Autonomous Cars*, FORBES (June 20, 2019), https://www.forbes.com/sites/cognitiveworld/2019/06/20/the-future-with-level-5-autonomous-cars/#6b698f9e4382 [https://perma.cc/5D3R-U7HK].

[71] *See id.*

[72] Sherif Marakby, *Here's What it Takes to Build a Self-Driving Business−And Where We Stand Today,* MEDIUM (Nov. 15, 2018), https://medium.com/self-driven/heres-what-it-takes-to-build-a-self-driving-business-and-where-we-stand-today-92609f4de69 [https://perma.cc/DCS5-792A].

[73] John Krafcik, *Apply To Be a Part of Waymo's Early Rider Program*, MEDIUM (Apr. 24, 2017), https://medium.com/waymo/apply-to-be-part-of-waymos-early-rider-program-5fd996c7a86f [https://perma.cc/D7QE-W6AS].

[74] Press Release, General Motors, Meet the Cruise AV: The First Production-Ready Car With No Steering Wheel or Pedals (Jan. 12, 2018), https://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2018/jan/0112-cruise-av.html [https://perma.cc/LF5C-Z7JG].

[75] Melina Druga, *Zoox First to Participate in California Autonomous-Vehicle Passenger Service*, TRANSP. TODAY (Dec. 27, 2018) https://transportationtodaynews.com/news/11529-zoox-first-to-participate-in-california-autonomous-vehicle-passenger-service/ [https://perma.cc/R3TT-3WBC].

[76] Permit, California Public Utilities Commission, Class P Charter-Party Permit Drivered Autonomous Vehicle Passenger Service Pilot Program (Dec. 21, 2018), https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/Licensing/autovehicle/Zoox%20AV%20Permit.pdf

planning to introduce such vehicles in ride-sharing programs rather than direct to consumer sales.[77]

In the past year or so, there have been several announcements by various manufacturers that they are slowing down their initially announced aggressive roll-out of AVs.[78] These delays are attributed to uncertainties about what level of safety should be expected from AVs, and how manufacturers should demonstrate such safety to the satisfaction of the public.[79] These delays are no doubt responding in part to surveys showing public fear of AVs,[80] and the underlying concern about how courts and juries would respond to accidents involving AVs.

C. AV Legislation

A number of states have launched efforts to study and regulate autonomous vehicles. Twenty-nine states have enacted legislation on AVs, and Governors in

[77] *See, e.g.*, *Why Driverless Cars Will Mostly Be Shared, Not Owned*, THE ECONOMIST (Mar. 5, 2018), https://www.economist.com/the-economist-explains/2018/03/05/why-driverless-cars-will-mostly-be-shared-not-owned.

[78] *See, e.g.*, Neal E. Boudette, *Despite High Hopes, Self-Driving Cars Are 'Way in the Future,'* N.Y. TIMES (July 17, 2019), https://www.nytimes.com/2019/07/17/business/self-driving-autonomous-cars.html [https://perma.cc/5RMT-YKPT]; Tom Krisher, *GM's Cruise Delays Autonomous Ride Service Beyond 2019*, KOMO NEWS (July 24, 2019), https://komonews.com/news/tech/gms-cruise-delays-autonomous-ride-service-beyond-2019-07-24-2019 [https://perma.cc/GZ8N-DASB]; Sam Mcearchan, *Auto Industry Re-Thinking Self Driving Approach, Says Major Supplier,* GM AUTHORITY (Aug. 12, 2019), http://gmauthority.com/blog/2019/08/auto-industry-re-thinking-self-driving-approach-says-major-supplier/ [https://perma.cc/T6CL-74YC].

[79] Boudette, *supra* note 78; Krisher, *supra* note 78; Cat Zakrzewski, *Self-Driving Car Companies Preach Safety First*, DAILY HERALD (Jan. 12, 2019), https://www.dailyherald.com/business/20190112/self-driving-car-companies-preach-safety-first [https://perma.cc/JL3T-QBF5].

[80] *See, e.g.*, AAA: American Automobile Ass'n, *American Trust in Autonomous Vehicles Slips*, AAA (May 22, 2018), https://newsroom.aaa.com/2018/05/aaa-american-trust-autonomous-vehicles-slips/ [https://perma.cc/HL2J-YLRA]; C. Hewitt et al., *Assessing Public Perception Of Self-Driving Cars: The Autonomous Vehicle Acceptance Model*, MICROSOFT (Mar. 2019), https://www.microsoft.com/en-us/research/uploads/prod/2019/03/assessing-public-perception.pdf; Paul Lienert & Maria Caspani, *Americans Still Don't Trust Self-Driving Cars, Reuters/Ipsos Poll Finds,* REUTERS (Apr. 2, 2019), https://www.reuters.com/article/us-autos-selfdriving-poll/americans-still-dont-trust-self-driving-cars-reuters-ipsos-poll-finds-idUSKCN1RD2QS [https://perma.cc/3HUM-LN5P]; AAA: American Automobile Ass'n, *Three in Four Americans Remain Afraid of Fully Self-Driving Vehicles*, AAA (Mar. 14, 2019), https://newsroom.aaa.com/2019/03/americans-fear-self-driving-cars-survey [https://perma.cc/BDR2-HS6E].

twelve states have issued executive orders regulating AVs.[81] The efforts range from establishing study committees to legislation that allows the operation of fully autonomous vehicles with no human occupant.[82] While most of these state bills do not substantively provide or change liability standards, some of the provisions regarding responsibility for operating the AV may be relevant to liability. For example, some of the state bills that have been enacted require a human driver to be physically present in the vehicle with the ability to take over if the autonomous driving system is unable to function properly,[83] but this is not a universal requirement. For example, New York adopted some of the most restrictive legislation for testing AVs by requiring that a "natural person holding a valid license for the operation of the motor vehicle's class be present within such vehicle for the duration of the time it is operated on public highways."[84] In addition, the testing in New York must be conducted under the direct supervision of state police.[85] An example in the other extreme includes Colorado's Senate Bill 17-213 enacted in 2017 that states that levels 0-3 of SAE standard J3016 are already legal in Colorado and do not need new legislation. Instead, the bill defines "Automated Driving System" as levels 4 and 5 in SAE standard J3016 and makes it legal to operate an automated driving system if "the system is capable of complying with every state and federal law that applies to the function that the system is operating," but does not give guidelines on how to determine such compliance.[86] The bill states that "Liability for a crash involving an automated driving system driving a vehicle that is not under human control is determined according to state law, federal law, or common law."[87] Essentially, the bill makes levels 4 and 5 legal and leaves it to the courts to sort out liability.

Nevada, on the other hand, also allows the testing and operation of a fully autonomous vehicle, but only if it is capable of achieving a "minimal risk condition upon a failure of its automated driving system."[88] Nevada further defines the term "driver" for the purposes of the traffic laws of this State to include the "owner of a fully autonomous vehicle and the person who causes the automated driving system of any other autonomous vehicle to engage,"[89] which

[81] *Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation* (Oct. 9, 2019), http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx [https://perma.cc/4Z97-PZNA].

[82] Examples include Nevada Assembly Bill 69, approved June 2017, and Colorado Senate Bill 17-213 approved June 2017. *See, e.g.*, A.B. 69, 79th Sess. (Nev. 2017); S.B. 17-213 (Colo. 2017).

[83] Examples include Connecticut SB-260 and New York SB-2005. *See, e.g.*, S.B. No. 260 (Conn. 2019); S.B. S02005 (N.Y. 2017).

[84] A.B. 9508, Part H §1 (N.Y. 2018).

[85] *Id.*

[86] S.B. 17-213 §§ 2(7.7), 4(1) (Colo. 2017).

[87] *Id.* § 4(5).

[88] A.B. 69 § 9(2)(b), 79th Sess. (Nev. 2017).

[89] *Id.* §11.5.

will have implications on liability in the case of an accident. Texas considers the owner to be the operator of the vehicle "for the purpose of assessing compliance with applicable traffic or motor vehicle laws,"[90] even if the owner is not physically present in the vehicle and considers the automated driving system to be licensed to operate the vehicle. Nebraska takes a somewhat similar approach.[91] It allows an autonomous vehicle to "operate on the public roads of this state without a conventional human driver physically present in the vehicle," as long as the vehicle is capable of achieving a minimal risk condition and "capable of operating in compliance with the applicable traffic and motor vehicle safety laws and regulations of this state that govern the performance of the dynamic driving task."[92] An interesting aspect of Nebraska's bill is the explicit statement not requiring "a conventional human driver to operate a driverless-capable vehicle that is being operated by an automated driving system" and further stating that "the automated driving system of such vehicle, when engaged, shall be deemed to fulfill any physical acts required of a conventional human driver to perform the dynamic driving task."[93]

The requirement that an automated driving system be able to achieve a minimal risk condition has already been noted for Nevada and Nebraska. Other states that explicitly require the ability to achieve a "minimal risk condition" include Georgia, Louisiana, Michigan, North Carolina, and Tennessee.[94]

At the federal level, no legislation has passed yet. A bill passed the House in 2018 and was introduced in the Senate,[95] but failed to pass over safety, cybersecurity, forced arbitration, and preemption concerns.[96] Media reports indicated that despite concessions by automakers, the bill could not overcome objections from some House Democrats who argued it did not do enough to resolve safety concerns.[97] In July 2019, committee staff from the House and Senate jointly sent a letter to various stakeholders seeking input on a new

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[90] S.B. 2205 § 545.453, (Tex. 2017).

[91] L.B. 989 (Neb. 2018).

[92] *Id.* § 2.

[93] *Id.* § 6.

[94] S.B. 995, 2016 Leg. (Mich. 2016); Nev. A.B. 69; Neb. L.B. 989; S.B. 219 (Ga. 2019); H.B. 1143, Reg. Sess. (La. 2016), H.B. 469, 166th Gen. Assemb. (N.C. 2017); S.B. 151, 110th Reg. Sess. (Tenn. 2018).

[95] S. 1885, 115th Cong. (2017).

[96] *See* David Shepardson, *Self-Driving Vehicle Regulation Bill Gets Late Push in Senate*, INS. J. (Dec. 4, 2018), https://www.insurancejournal.com/news/national/2018/12/04/510909.htm [https://perma.cc/U5MT-YSBQ].

[97] *See* David Shepardson, *U.S. Congress will not pass self-driving car bill in 2018: senators,* REUTERS (Dec. 19, 2018), https://www.reuters.com/article/us-autos-selfdriving/u-s-congress-will-not-pass-self-driving-car-bill-in-2018-senators-idUSKCN1OI2CV [https://perma.cc/2DPB-7PCC].

bipartisan bill on AVs.[98] It is not clear whether such a bill will address liability issues.

With respect to federal regulatory oversight, the National Highway Traffic Safety Administration ("NHTSA") has regulatory jurisdiction over new vehicle safety. NHTSA produced a series of four annual reports that describe the agency's approach and activities on AVs. The most recent (fourth) report published in January 2020 emphasized the central importance of AV safety, recognizing both that AVs have the potential for major safety benefits for society by reducing accidents, but also that AVs have the potential to introduce their own novel safety risks.[99] NHTSA is not intending to adopt any new regulations for AV safety in the near term, in order to provide AV manufacturers flexibility to explore different approaches to AV development, but instead supports the development of consensus private standards that can establish appropriate methodologies and metrics for demonstrating AV safety.[100]

D. Safety Projections of AVs

Motor vehicle accident fatality and injury rates have been going up in recent years, although the rates declined again over the past two years.[101] In 2017, motor vehicle accidents took the lives of an estimated 40,100 people, a significant increase over the 35,398 fatalities in 2014.[102] Most of these accidents are caused by human faults, such as impaired driving, distracted driving, drowsiness and speeding.[103] Moreover, pedestrian deaths reached a thirty-year high of 6227 fatalities in 2018, with the increase attributed to the growing

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[98] Makena Kelly, *Congress Wants the Self-Driving Car Industry's Help to Draft a New AV Bill*, THE VERGE (July 30, 2019), https://www.theverge.com/2019/7/31/20748582/congress-self-driving-cars-bill-energy-commerce-senate-regulation [https://perma.cc/U532-ZLMV].

[99] NATIONAL SCIENCE & TECH. COUNCIL, ENSURING AMERICAN LEADERSHIP IN AUTOMATED VEHICLE TECHNOLOGIES: AUTOMATED VEHICLES 4.0, 8, 8-9 (2020), https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/360956/ensuringamericanleadershipav4.pdf.

[100] *Id.* at 29-30.

[101] NHTSA, TRAFFIC SAFETY FACTS: EARLY ESTIMATE OF MOTOR VEHICLE TRAFFIC FATALITIES IN 2018 (June 2019), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812749; NHTSA, *Press Release: U.S. DOT Announces 2017 Roadway Fatalities Down* (Oct. 3 2018), https://www.nhtsa.gov/press-releases/us-dot-announces-2017-roadway-fatalities-down.

[102] NATIONAL SAFETY COUNCIL, NSC MOTOR VEHICLE FATALITY ESTIMATES (2018), https://www.nsc.org/Portals/0/Documents/NewsDocuments/2018/December_2017.pdf. The National Safety Council (NSC) statistics are not directly comparable to the NHTSA statistics, as the NSC counts both traffic and nontraffic deaths that occur within a year of the accident, while NHTSA counts only traffic deaths that occur within 30 days. *Id.* For example, NHTSA counted 37,461 deaths in 2016 while the NSC estimated 40,327 fatalities. NHTSA, USDOT RELEASES 2016 FATAL TRAFFIC CRASH DATA, (Oct. 6, 2017), https://www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data [https://perma.cc/32ZL-UKQF].

[103] NHTSA, *supra* note 102.

prevalence of SUVs and distractions from cell phones by both drivers and pedestrians.[104] A NHTSA survey found that ninety-four percent of motor vehicle crashes were due to human choice or error.[105] Because AVs avoid these human errors, which account for the vast majority of vehicle accidents, AVs have the potential to be significantly safer overall than human-driven conventional vehicles.[106] However, AVs may create new accident scenarios when the machine learning systems controlling AV performance encounter unusual circumstances they have not seen before – in such situations AVs may perform worse than human operated vehicles because AI systems generally lack the common sense humans employ in such novel situations.[107] It is fair to say that safer performance will almost certainly be a social if not legal expectation for AVs – since improved safety is a primary objective of such vehicles, no manufacturer should or would produce an AV that is more dangerous than existing vehicles.[108]

The actual safety benefits of AVs remain to be determined – they will depend in large part on when and how fast AVs are deployed, and how advanced and tested the technology is when it is put onto public roads and into commercial use. NHTSA has estimated that a fully developed vehicle-to-vehicle communications system could potentially eliminate eighty-one percent of unimpaired light vehicle crashes.[109] The consulting firm KPMG convened a group of insurance experts who estimated an eighty percent decrease in collisions by 2040 with full deployment of AVs.[110] These and other expert estimates lead to the conclusion that "[a]utonomous vehicles will save lives and prevent many more injuries, making a compelling safety case for policies that foster the widespread deployment of this technology."[111]

However, quantitatively demonstrating that AVs are safer than conventional vehicles in any given accident type will be a daunting task given the almost infinite range of potential accident scenarios that motor vehicles may

[104] Scott Calvert, *Pedestrian Deaths Reach Highest Level in Nearly 30 Years*, WALL ST. J. (Feb. 28, 2019), https://www.wsj.com/articles/pedestrians-deaths-reach-highest-level-in-nearly-30-years-11551330060 [https://perma.cc/KUU5-YWLY].

[105] SANTOKH SINGH, NHTSA, CRITICAL REASONS FOR CRASHES INVESTIGATED IN THE NATIONAL MOTOR VEHICLE CRASH CAUSATION SURVEY, Report No. DOT HS 812 115 (Feb. 2015).

[106] Gary E. Marchant & Rachel A. Lindor, *The Coming Collision Between Autonomous Vehicles and the Liability System*, 52 SANTA CLARA L. REV. 1321, 1330 (2012).

[107] Wu, *supra* note 16, at 586.

[108] Peng Liu, Run Yang & Zhigang Xu, *How Safe Is Safe Enough for Self-Driving Vehicles?*, 39 RISK ANALYSIS 315, 316 (2019).

[109] J. HARDING, ET AL., NHTSA, VEHICLE-TO-VEHICLE COMMUNICATIONS: READINESS OF V2V TECHNOLOGY FOR APPLICATION, Report No. DOT HS 812 014 (Aug. 2014).

[110] KPMG, MARKETPLACE OF CHANGE: AUTOMOBILE INSURANCE IN THE ERA OF AUTONOMOUS VEHICLES 26 (2015), *available at* https://assets.kpmg.com/content/dam/kpmg/pdf/2016/06/id-market-place-of-change-automobile-insurance-in-the-era-of-autonomous-vehicles.pdf.

[111] Geistfeld, *supra* note 16, at 1615.

encounter.[112] A Rand Institute analysis estimated that an autonomous vehicle must be test driven for at least 275 million miles, which could take a decade or more to achieve with a fleet of 100 test vehicles, in order to demonstrate that the AV is as safe or safer than a human-driven car.[113] Also, it is possible that tasks that are relatively easy for humans will not be fully mastered by AVs, resulting in new accident scenarios.[114] One such scenario involves communicating with other cars or pedestrians with facial expressions and gestures (yielding the way with a hand gesture for example) that humans are proficient at but are particularly challenging for AVs.[115] The bottom line is that there is currently no agreed criteria or method by which an AV can demonstrate satisfactory AV safety, which both deters the introduction of such vehicles into commerce and creates open-ended potential liability risks if such vehicles are operated on public roads, notwithstanding the enormous potential of this technology to increase overall traffic safety.[116]

II. PRODUCT LIABILITY DOCTRINE

Although AVs are likely to provide significant safety benefits, they will inevitably be involved in some accidents.[117] It is likely that in many of those cases an injured victim will try to bring a lawsuit against the AV manufacturer, alleging that the AV should have had the capacity to avoid the accident, even if another (usually human driven) vehicle broke a traffic rule and was the initial cause of the accident.[118] Even if AVs improve overall public safety, they will not be immune from lawsuits and liability from specific accidents in which the vehicle malfunctioned – there are many technologies that improve public safety that have nonetheless been subject to extensive liability, such as vaccines, as well as air bags and antilock brakes.[119] If AVs are safer than human-driven vehicles, but accidents continue to occur, AV manufacturers[120] will likely "bear a bigger slice of a smaller pie of total crash costs."[121]

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[112] Smith, *supra* note 15, at 31.

[113] Nidhi Kalra & Susan M. Paddock, *Driving to Safety: How Many Miles of Driving Would it Take to Demonstrate Autonomous Vehicle Reliability?,* 94 TRANSP. RES. PART A 94, 191 (2016).

[114] Nick Chater et al., *Negotiating the Traffic: Can Cognitive Science Help Make Autonomous Vehicles a Reality?,* 22 TRENDS IN COGNITIVE SCI. 93, 95 (2018).

[115] *Id*.

[116] As discussed at *infra* notes 258-262 and accompanying text, important progress is being made in developing a consensus standard or approach for evaluating AV safety.

[117] Smith, *supra* note 15, at 1.

[118] *Id.* at 2.

[119] Marchant & Lindor, *supra* note 106, at 1331.

[120] There are issues in who is included within the definition of AV manufacturer, and vehicle and component manufacturers often attempt to shift responsibility to other parties, as discussed *infra* in section III.

[121] Smith, *supra* note 15, at 2.

Prior to the launch of AVs, human drivers caused most car accident, and negligence was the relevant legal doctrine for litigating such liability. Drivers were covered by insurance, so relatively few vehicle accidents resulted in actual litigation.[122] With conventional vehicles, where allegations of negligence were the primary claims brought against individual drivers, between 5,000 and 12,000 auto negligence claims have been resolved each year since 2000 (with the number of cases per year generally declining over time).[123] In contrast, fewer than 200 vehicle product liability cases per year were resolved against vehicle manufacturers, with the number of such cases dropping below 50 per year in recent years.[124] However, with AVs, the manufacturer is the most likely target of a lawsuit, and such lawsuits will generally be brought as product liability claims.[125] Thus, AVs will bring about a "shift from a compensation regime for conventional driving that is largely premised on vehicular negligence to a compensation regime for automated driving that increasingly implicates product liability."[126]

Product liability has two primary purposes – (i) to incentivize product manufacturers to make their products safer, and (ii) to compensate victims harmed by products.[127] While product liability has achieved success in promoting both of these objectives in the past,[128] there have been concerns that excessive liability may be imposed due to unachievable expectations of perfect safety as well as runaway juries that deliver verdicts that harm public health and safety.[129]

A product manufacturer is held liable under products liability law if its product contains a "defect" that causes injury. The Restatement (Third) of Torts: Product Liability provides that "[o]ne engaged in the business of selling or

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122 *Id*. at 33.

123 *Id*. at 34.

124 *Id*. at 35.

125 Marchant & Lindor, *supra* note 106, at 1327; Smith, *supra* note 15, at 44-45. *But see* J.D. POWER & MILLER CANFIELD, AUTOMATED VEHICLES: LIABILITY CRASH COURSE 18 (Mar. 2018), https://www.millercanfield.com/assets/htmldocuments/JDP_Miller%20Canfield%20MCity%20White%20Paper_2018_Final.pdf [https://perma.cc/SQ2R-TBXR] ("It is important to note that under [the] current liability framework, a 'manufacturer' is not limited to the manufacturer of the complete automobile – everyone in the supply chain is potentially liable.").

126 Smith, *supra* note 15, at 4 (footnotes omitted).

127 Priest, *supra* note 14, at 8.

128 For example, it has been claimed that product liability litigation involving motor vehicle accidents has been responsible for many improvements in vehicle safety, including shielding gas tanks, strengthening frames, requiring installation of airbags, and improving tire tread. Aaron Ezroj, *Product Liability After Unintended Acceleration: How Automotive Litigation Has Evolved*, 26 LOY. CONSUMER L. REV. 470, 490 (2014).

129 *See, e.g.*, Priest, *supra* note 14 ("[M]odern tort law as currently defined largely thwarts the accident reduction and compensation objectives."); Marchant & Lindor, *supra* note 106.

otherwise distributing products who sells or distributes a defective product is subject to liability for harm to persons or property caused by the defect."[130] A product can be defective in three ways – by a manufacturing defect, by a design defect, or by a failure to warn.[131] Of these three types of defects, design defects are usually the most relevant with respect to the liability of AVs involved in accidents.[132]

Product liability generally applies a standard of strict liability, which, in its most pure form, involves no consideration of fault or reasonableness.[133] However, in response to concerns that a pure strict liability standard is too harsh and unfair to defendants, states have gradually incorporated a "reasonableness" element into strict liability determinations.[134] Thus, under the most recent Restatement of Torts, a product has a design defect "when the foreseeable risks of harm posed by the product could have been reduced or avoided by the adoption of a *reasonable alternative design* by the seller or other distributor, or a predecessor in the commercial chain of distribution, and the omission of the alternative design renders the product not reasonably safe."[135] The key question in a lawsuit against an AV for an accident in most states will therefore be whether there is a "reasonable alternative design" that if it had been adopted, would have avoided the accident.

An alternative test for a design defect, called the "consumer expectation" test, requires that the product provides the level of safety that a reasonable consumer

[130] RESTATEMENT (THIRD) OF TORTS: PRODUCT LIABILITY § 1 (AM. LAW INST. 1998).

[131] *Id.* § 2.

[132] J.D. POWER & MILLER CANFIELD, *supra* note 125, at 14 (design defects is the liability theory most often relied upon by plaintiff's counsel when suing auto manufacturers). A manufacturing defect occurs when an error occurs in the manufacturing process such that one or more units of the product is produced off-spec. These tend to be relatively rare and straightforward cases if a flaw is demonstrated which caused the injury, and do not present any unique issues for AVs compared to other vehicles, manufacturing defects will not be discussed further here. *See* Marchant & Lindor, *supra* note 106, at 1323; Geistfeld, *supra* note 16, at 1633. Failure to warn defects are discussed i*nfra* at section III.C.

[133] *See* Marchant & Lindor, *supra* note 106, at 1323. A product liability lawsuit can also include a negligence claim, but since the standard for strict liability is usually easier to satisfy for an injured plaintiff, strict liability defects will be the primary cause of action against an AV developer or manufacturer.

[134] *Id.*

[135] *Id.*; The Restatement's "reasonable alternative" standard grew out of the older risk-utility test, which some states still apply, which considers additional factors in addition to the availability of a reasonable alternative. RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2(b); "Under the risk-utility test, the plaintiff is required to show that the product is unreasonably dangerous in the sense that the incremental risk associated with the defendant's chosen design far exceeds the incremental utility when compared to an alternative safer design." KEITH N. HYLTON, TORT LAW: A MODERN PERSPECTIVE 340 (2016) (internal citation omitted).

would expect.[136] Following the Restatement of Torts, many states have now adopted the "reasonable alternative design" test.[137] Moreover, the consumer expectation test has been held to be particularly inapplicable for complex technologies that the typical consumer does not understand.[138] Nevertheless, some states still apply the consumer expectation test, and thus its applicability must also be considered when looking at AV liability risks for the nation as a whole.[139]

A failure to warn defect may arguably also apply to some AV situations, such as in the case of a partially autonomous vehicle where the manufacturer failed to provide a sufficient warning to the user to stay engaged in the driving process. Such a defect exists "when the foreseeable risks of harm posed by the product could have been reduced or avoided by the provision of reasonable instructions or warnings . . . and the omission of the instructions or warnings renders the product not reasonably safe."[140] This duty to warn is generally limited to risks that could "reasonably" be known at the time of sale. The adequacy and effectiveness of such warnings may become an issue in future AV accident litigation.

III. PROVING DEFECT AND LIABILITY IN AN AV CASE

In most automobile accidents, the vehicle (or vehicles) responsible for the crash is usually easily identified. One or more cars will have violated a traffic law and, for example, ignored a stop sign or stop light, crossed a median, drove off the side of the road and hit something or someone, or failed to stop and hit another vehicle or object from behind. The responsible vehicle will usually be identified in such accidents in the police report of the accident and the evidence collected by police at the accident scene. This will be even more the case with AVs because the cameras and other sensors on the AV will usually provide a clear record of how the accident occurred. While this information will be influential in determining whether a lawsuit will be filed and the outcome of any lawsuit, that evidence will not be determinative of liability because other factors, defenses and claims may expand or contract the liability of the at-fault vehicle and its responsible party depending on the specifics of the accident.

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[136] RESTATEMENT (SECOND) OF TORTS § 402A, cmt. i (1965) ("The article sold must be dangerous to an extent beyond that which would be contemplated by the ordinary consumer who purchases it, with the ordinary knowledge common to the community as to its characteristics.").

[137] Branham v. Ford Motor Co., 701 S.E.2d 5, 14-15 (S.C. 2010) ("Some form of a risk-utility test is employed by an overwhelming majority of jurisdictions in this country."); *see also* J.D. POWER & MILLER CANFIELD, *supra* note 125, at 16-17 (showing which states apply risk utility test and consumer expectation test for defining design defects).

[138] *See* Montag v. Honda Motor Co., Ltd., 75 F.3d 1414, 1419-20 (10th Cir. 1996).

[139] *See* Geistfeld, *supra* note 16, at 1635-36.

[140] RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2(c).

In a product liability lawsuit involving AVs, the initial focus will be on whether the design and operation of the AV was defective. In exploring AV design defects, we will first examine accident scenarios where an autonomous vehicle broke a traffic rule and caused the crash. The autonomous vehicle will be presumptively defective and hence liable in such accidents, with the exception of possible defenses for excuse and foreseeability. In addition, there may be an issue whether the vehicle manufacturer or the operator of the vehicle was the responsible party. In the second set of scenarios, we will examine situations where another vehicle or person violated a traffic law and was the primary cause of the crash. While this may protect the AV manufacturer from liability in many such accidents, it will not provide a complete defense against liability depending on whether or not the AV could have nevertheless avoided or mitigated the collision. This will involve an inquiry into the definition of a defect for an AV, and the standard of care that will be imposed on AVs. Finally, this section will examine potential failure to warn defects, and whether an AV warning can help to overcome design defect liability for an AV.

A. Design Defects: Accidents Where AV Was Presumptive Cause of Crash

In an accident where the AV was the ostensible cause of the crash, it will likely be fully or partially liable for the crash and the resulting injuries. It is quite likely that even though AVs will perform better than human-driven vehicles overall, they will occasionally misperceive a situation and make an error that results in a crash, especially given the almost infinite number of scenarios such vehicles will encounter. The nature of machine learning systems is that they may behave unexpectedly when they encounter a new situation they have not encountered in their previous learning or training. For example, when encountering a novel situation, the AV may cross a median or lane divider, fail to stop at a red light or stop sign, or crash into another vehicle or object from behind. While AV fleets will learn from such mistakes and their frequency will decline even further with each unfortunate experience, the AV manufacturer is likely to be held liable for most such incidents, unless one of the following defenses or mitigation factors exist.

1. Failure to Prove Defect

The plaintiff has the burden of proof in a product liability lawsuit to demonstrate that a manufacturer's product is defective.[141] In an accident involving an AV, it may be difficult to ascertain the exact technological or programming flaw in the AV that may have caused the crash and hence be defective.[142] Most machine learning systems are a "black box" in which the

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[141] RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2 cmt. D.

[142] Smith, *supra* note 15, at 51 ("requiring the plaintiff to specifically demonstrate how and why an automated driving system performed poorly and should have performed better could impose technical and financial barriers to many claims, especially those involving comparatively minor injuries"). A design defect does not only concern the technical design

decision-making process of the machine is usually impermeable to human understanding, although AI developers are devoting substantial resources to trying to make their systems more transparent.[143] However, when the accident was caused by the AV violating a traffic rule, the plaintiffs will likely contend that the fact that the AV violated the traffic rule is *res ipsa loquitor* – the traffic violation speaks for itself that the AV had a defect. The Restatement provides that product performance is a sufficient substitute for direct proof of defect when it "was of a kind that ordinarily occurs as a result of product defect . . . ."[144] The failure of the AV to comply with traffic laws would likely be seen by judges and juries as sufficient evidence of faulty performance that would ordinarily indicate a defect. This argument would be particularly effective in jurisdictions still applying the consumer expectation test, as most jurors would not expect a properly functioning AV to violate a traffic rule and cause an accident.[145]

A manufacturer may still try to insist that the plaintiff nevertheless has to identify a specific defect that caused the violation. The manufacturer may also argue that its system complied with the "state of art" at the time of manufacture, and thus could not have been reasonably expected to perform better[146] However, even if a court is receptive to such an argument, a plaintiff's expert will almost certainly be able to identify (with the benefit of hindsight) that some aspect of the AV's technology or performance could have performed better to not violate the traffic law and cause the accident and was therefore defective.[147]

Another argument the manufacturer may make is that even if the AV acted in a risky and perhaps non-optimal manner in the specific scenario in which the accident occurred, it still performs better overall than a comparable product (e.g., a human-driven vehicle) in the entire range of vehicle operating contexts, and therefore is arguably *per se* not "defective."[148] Yet product liability does not

but extends to specification. Proving bad specification as exhibited by AV behavior might not be as costly as proving that implementation does not satisfy that specification.

[143] Will Knight, *The Dark Secret at the Heart of AI,* MIT TECH. REV. (Apr. 11, 2017), https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/ [https://perma.cc/3QJH-MT3J]; Andreas Holzinger, Holzinger Grp., Keynote Talk at IEEE DISA 2018 Conf.: From Machine Learning to Explainable AI (Aug. 23, 2018); David Gunning, Med. Univ. of Graz, Speech for the Def. Advanced Research Projects Agency (DARPA): Explainable Artificial Intelligence (XAI) (Nov. 2017); Pat Langley et al*.*, Dep't of Comput. Sci., Univ. of Auckland, Twenty-Ninth AAAI Conf. on Innovative Applications: Explainable Agency For Intelligent Autonomous Sys. (2017).

[144] RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 3.

[145] Smith, *supra* note 15, at 51-52.

[146] Wu, *supra* note 16, at 587. The "state of art" defense is only available in some states and not others. *Id.*

[147] Marchant & Lindor, *supra* note 106, at 1333; *see also* J.D. POWER & MILLER CANFIELD, *supra* note 125, at 13 (describing how plaintiffs' experts were able to claim a design defect in the algorithm of Toyota electronic throttle control system, and suggesting similar complexities may apply to AV algorithms).

[148] Geistfeld, *supra* note 16, at 1650.

work this way. GM attempted to defend its "side saddle" GM pickups by arguing that even if the placement of the gas tanks on the side of the vehicle made the trucks slightly more at risk in side impacts, it was safer in rear end hits and overall safety than the comparator vehicles that place the gas tanks in the rear of the vehicle.[149] This argument fell on deaf ears for both judges and juries, which made the defect determination based narrowly on the specific type of crash involved in the case before them.[150] The same result applies in other areas of product liability – for example, if a vaccine is proven to have harmed a specific plaintiff, the vaccine manufacturer will not be able to protect itself from liability by arguing that the same vaccine protects most people from ill effects and thus has an overall positive net impact on public health.[151] From an economic perspective, this makes sense to impose liability on the manufacturer when harm is caused so that the costs of compensation can be spread over all users of the product, even when the product has a net beneficial safety or health impact. But from a practical perspective, the imposition of such liability, especially when punitive damages may be involved, may have the effect of driving the beneficial product off the market, which was happening to vaccines before Congress intervened,[152] and may happen again with AVs.

2. Lack of Foreseeability

An AV will encounter an almost unlimited variety of situations over time, and it is impossible for that AV manufacturer to anticipate every such situation.[153] Product liability law, even for strict liability, requires foreseeable harm from the use of the product.[154] Therefore, an extremely unlikely event, sometimes referred to in the AV world as a "corner event," may not meet this foreseeability requirement.[155] Yet, it is unlikely that a lack of foreseeability defense would provide much protection for an AV developer or manufacturer. Consider a hypothetical in which an AV drives through a red light because there was a green balloon flying in the background which the AV mistook for a green light. The

[149] Marchant & Lindor, *supra* note 106, at 1332 (referencing GM v. Moseley, 447 S.E.2d 302 (Ga. App. Ct. 1994) (jury awarded $101 million in punitive damages against GM)).

[150] *Id.*

[151] An exception to this rule, the controversial nature of which demonstrates the general rule, is the Restatement (Third) of Torts for pharmaceutical design defects, which provides that there is no design defect if the benefits of the drug outweigh the risks for any subset of the patients. George W. Conk, *Is There a Design Defect in the Restatement (Third) of Torts: Products Liability?*, 109 YALE L.J. 1087, 1120-21 (2000).

[152] National Childhood Vaccine Injury Act of 1986, H.R. 5546, 99th Cong. (1986); *see* Victor E. Schwartz & Liberty Mahshigian, *National Childhood Vaccine Injury Act of 1986: An Ad Hoc Remedy or a Window for the Future*, 48 OHIO ST. L.J. 387, 388-89 (1987).

[153] Marchant & Lindor, *supra* note 106, at 1334.

[154] Geistfeld, *supra* note 16, at 1632 n.64.

[155] Shai Shalev-Shwartz et al., SAFE, MULTI-AGENT, REINFORCEMENT LEARNING FOR AUTONOMOUS DRIVING 6 (2016), https://arxiv.org/pdf/1610.03295.pdf.

manufacturer might legitimately argue that it did not foresee such an expected set of circumstances, and thus the accident was not foreseeable. Yet a jury would likely decide that the AV developer or manufacturer should bear the cost of this unfortunate (and unforeseen) accident because it took the action of deploying a product that it knew may behave differently and perhaps dangerously in unanticipated situations.[156] Thus, in a sense, the lack of foreseeability was foreseeable.

3. Excuse

Much has been written about the so-called "trolley car" problem for AVs, in which an AV may be required to make a tragic choice between two alternative actions that would harm or kill different numbers or types of people.[157] The likelihood and frequency of such situations is likely to be quite rare, as the more usual situation is that the AV will avoid an accident altogether or have an accident with a particular vehicle that was not avoidable given the technology, programming and circumstances at the time.[158] However, in those rare situations where an AV may have deliberately crashed into one object or vehicle to avoid a more devastating crash with another vehicle or group of persons, the AV manufacturer may be able to rely on a defense of excuse to avoid liability. This inquiry will often focus on what priorities and trade-offs the manufacturer programmed into the vehicles, and what were the ethical principles used to make such decisions, all of which are ill-defined and subject to second-guessing by plaintiffs' counsel and legal fact finders.

4. Shifting Responsibility to Another Party

When an AV manufacturer's vehicle breaks a traffic law and causes an accident, the most likely defense is that some other party was to blame. This could be a component manufacturer, outside programmer, or data provider who may be ultimately responsible for the miscalculation that resulted in the traffic violation and accident.[159] The manufacturer of a component integrated into a complex product such as an AV will generally be protected from failure to warn liability.[160] A component manufacturer will also not be held liable for a design

[156] *See, e.g.*, Larsen v. Gen. Motors Corp., 391 F.2d 495, 502 (8th Cir. 1968) ("We do agree that under the present state of the art an automobile manufacturer is under no duty to design an accident-proof or fool-proof vehicle or even one that floats on water, but such manufacturer is under a duty to use reasonable care in the design of its vehicle to avoid subjecting the user to an unreasonable risk of injury in the event of a collision. Collisions with or without fault of the user are clearly foreseeable by the manufacturer and are statistically inevitable.").

[157] *See, e.g.*, Jean-François Bonnefon et al., *The Social Dilemma of Autonomous Vehicles*, 352 SCI. MAG. 1573, 1573-74 (2016).

[158] *Id*. at 1573.

[159] Marchant & Lindor, *supra* note 106, at 1328; Smith, *supra* note 15, at 45.

[160] RESTATEMENT (THIRD) OF TORTS: PRODUCT LIABILITY § 5 cmt. b (AM. LAW INST. 1998) ("The component seller is required to provide instructions and warnings regarding risks

defect when it establishes that its component was not defective.[161] However, in many cases, that will be difficult to prove, and it will also be difficult for the plaintiff or the court to determine what was the technology specification or component that was responsible for the error that lead to the accident.[162]

In some cases, the vehicle manufacturer and component manufacturer may have an indemnification agreement between them that allocates liability if an accident occurs as a result of specified failure modes.[163] Moreover, some manufacturers, such as Volvo, have committed that they "will accept full liability whenever one of its cars is in autonomous mode."[164] If none of these solutions apply, it is possible that the vehicle manufacturer and component manufacturer will battle out responsibility in court, because as a practical matter plaintiffs' attorneys will likely sue both the vehicle manufacturer and the component manufacturer/AI developer (especially if the latter is also a large company with deep pockets) and leave it the defendants to allocate responsibility between themselves.[165]

Another issue is whether the AV manufacturer or AV operator is responsible for the crash. This argument may depend on the level of AV that was involved. If the vehicle is a Level 4 or 5 AV, then it is operating mostly autonomously, and the manufacturer will be less likely to be able to shift responsibility to the operator, with the only possible claim being that the operator should not have been operating such a vehicle in autonomous mode if there were extreme conditions present and the vehicle was capable of operating in non-autonomous

associated with the use of the component product . . . . However, when a sophisticated buyer integrates a component into another product, the component seller owes no duty to warn either the immediate buyer or ultimate consumers of dangers arising because the component is unsuited for the special purpose to which the buyer puts it.").

161 Jones v. W+M Automation, Inc., 818 N.Y.S.2d 396, 398 (N.Y. App. Div. 2006) (Claims against manufacturers of components of workplace robotic system that injured worker dismissed when manufacturers "established as a matter of law that they manufactured only non-defective component parts, and plaintiffs failed to raise an issue of fact to defeat their motions").

162 Marchant & Lindor, *supra* note 106, at 1328.

163 Daniel A. Crane et al., *A Survey of Legal Issues Arising from the Deployment of Autonomous and Connected Vehicles*, 23 MICH. TELECOMM. & TECH. L. REV. 191, 267 (2017).

164 Press Release, Volvo Car Group, US Urged to Establish Nationwide Federal Guidelines for Autonomous Driving (Oct. 7, 2015), https://www.media.volvocars.com/global/en-gb/media/pressreleases/167975/us-urged-to-establishnationwide-federal-guidelines-for-autonomous-driving [https://perma.cc/M4JS-4P2P]. Presumably, Volvo will need to clarify this statement to indicate they will only be responsible when their vehicle is in some way at fault – otherwise anyone with a dented bumper can get it fixed courtesy of Volvo by bumping into a Volvo autonomous car.

165 Marchant & Lindor, *supra* note 106, at 1328-29.

mode (i.e., level 4).[166] But if the vehicle is a level 2 or 3 vehicle, where the vehicle only operates in partial autonomous mode and under the active supervision of a human driver, the manufacturer could argue that the operator still had primary responsibility for the vehicle, and was responsible for the vehicle violating a traffic law and causing an accident.

There is some legal precedent to support such an allocation of responsibility to the operator.[167] For example, in a case from the 1940s where a plane operating on auto-pilot caused a crash, the court attributed responsibility to the human pilot rather than the manufacturer of the plane with the autopilot system because "[t]he obligation of those in charge of a plane under robot control to keep a proper and constant lookout is unavoidable."[168]

The American Association for Justice ("AAJ"), the professional association of plaintiffs' attorneys, has argued that Level 2 and 3 AVs are inherently unsafe because of the "handover problem."[169] Studies show that humans tend to become complacent and distracted when asked to monitor a situation where nothing significant usually happens, bringing into question whether it is feasible to expect a human operator to assume control of an AV operating in autonomous mode on very short notice if something unusual happened.[170] The AAJ claims that the attempt to shift responsibility to the driver is a "moral crumple zone" that legislatures, regulators, and courts should reject.[171] The AAJ have called on legislatures and courts to apply truly strict liability to AVs involved in accidents.[172]

In response to concerns about inattentive or overly complacent drivers, manufacturers of AVs with a human operator have already announced plans to include various types of active alerts to monitor operators and provide alerts if the operator fails to maintain adequate attention, even pulling the vehicle safely off the road if the operator is non-responsive.[173] As the initial Tesla crashes

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[166] Even then, the AV should have the capability to itself detect that the environmental conditions are not appropriate. Existing legislation requires that the vehicle be able to enter a safe state if the AV system malfunctions or is unable to function properly.

[167] Kyle Colonna, *Autonomous Cars and Tort Liability*, 4 J. L. TECH. & INTERNET 81, 91-102 (2012).

[168] Brouse v. United States, 83 F.Supp. 373, 374 (N.D. Ohio 1949).

[169] AMERICAN ASSOCIATION FOR JUSTICE, DRIVEN TO SAFETY: ROBOT CARS AND THE FUTURE OF LIABILITY 14 (Feb. 2017).

[170] Robert E. Llaneras, Jeremy Salinger & Charles A. Green, *Human Factors Issues Associated with Limited Ability Autonomous Driving Systems: Drivers' Allocation of Visual Attention to the Forward Roadway*, PROCEEDINGS OF THE SEVENTH INT'L DRIVING SYMP. ON HUMAN FACTORS IN DRIVER ASSESSMENT, TRAINING AND VEHICLE DESIGN, 92, 92-98 (2013); Tracy Hresko Pearl, *Hands on the Wheel: A Call for Greater Regulation of Semi-Autonomous Cars,* 93 IND. L.J. 713, 731-37 (2018).

[171] AMERICAN ASSOCIATION FOR JUSTICE, *supra* note 169, at 14.

[172] *Id.* at 31.

[173] *See* Christopher D.D. Cabrall, et al*., How to Keep Drivers Engaged While Supervising Driving Automation? A Literature Survey and Categorisation of Six Solution Areas*, 20

involving cars operating on "autopilot" have demonstrated, further investigation is needed to determine if the vehicle operator is primarily or fully legally responsible for crashes when they are notified in advance and alerted in real-time of their responsibility to control the vehicle.[174] Of course, some vehicle manufacturers may be reluctant for marketing reasons to suggest that the drivers of the vehicles they sell may be liable for any accidents that result, which explains why some manufacturers (e.g., Volvo) have stated they would assume liability for any accidents involving their AVs.[175] Moreover, as the artificial intelligence system in a Level 2 or 3 vehicle gets more sophisticated and its failure rates decrease, the challenge of effective human supervision of such a complex system increases.[176]

If a plaintiff argues that a Level 2 or 3 vehicle is defective because it is not as safe as a Level 4 or Level 5 AV, the manufacturer could respond that a Level 4 or 5 AV would be even more dangerous because such vehicles did not have a human over-ride option.[177] Or put another way, a reasonable (and perhaps safer) alternative to the completely self-driving vehicle would be some machine-human combination.[178] In addition, the manufacturer could argue that this is a claim of categorical liability, in which the plaintiff is arguing that the consumer should have purchased a different category of vehicle, rather than a safer version of the same vehicle.[179] Courts have generally rejected such claims of categorical liability in recognition of the importance of respecting consumer choice.[180]

B. Design Defects: Accidents Where AV Was Not Initial Cause of Crash

If the AV is not primarily responsible for a crash caused in the first instance by another vehicle or bystander breaking a traffic law and causing the accident, the other at-fault party would at least be partially responsible for the resulting

THEORETICAL ISSUES IN ERGONOMICS SCI. 332, 334 (2019) (listing driver alert technologies in various automated driving systems); Geistfeld, *supra* note 16, at 1626-27 (citing Tesla vehicles slowing down if driver has not passed checks to ensure attention); *id.* at 1628 (stating GM developing active alert system for semi-autonomous vehicles).

174 *See* NAT'L TRANS. SAFETY BOARD, PRELIMINARY REPORT HIGHWAY HWY19FH008 (2019).

175 *See* Volvo Cars Press Release, *supra* note 164 and accompanying text.

176 Philip Koopman & Beth Osyk, *Safety Argument Considerations for Public Road Testing for Autonomous Vehicles*, SAE WCX 1, 11 (forthcoming in 2019) ("[A]s the autonomy capabilities start to mature, safe road testing will actually *increase* the performance demands placed upon human supervisors to remain vigilant and effective.").

177 In the Toyota unintended acceleration litigation, plaintiffs relied heavily on a claim that the Toyota vehicles were defective because they lacked a "brake override system" that would allow the human driver to override the automated electronic control system and manually stop or slow the engine. *See* Ezroj, *supra* note 128, at 505.

178 Smith, *supra* note 15, at 46.

179 Geistfeld, *supra* note 16, at 1628.

180 *Id.* at 1628-29.

harm.[181] The AV could be partially responsible, however, if a plaintiff made a colorable claim that the advanced sensor and avoidance capabilities of the AV should have avoided the accident by taking evasive actions.[182] Here, jurors are likely to expect the AV to be better able to avoid such an accident than a human-driven vehicle.[183] This is analogous to "crashworthiness" claims, where vehicle manufacturers are held responsible for avoiding preventable injury in the case of an accident, even though the vehicle was not responsible for the crash.[184]

A plaintiff that seeks under product liability law to hold an AV developer or manufacturer partially responsible for a crash must demonstrate that the AV was "defective."[185] Compliance with federal standards and industry standards and custom can provide some evidence on whether there is a defect, but such compliance or non-compliance is not determinative.[186] Design defects are often demonstrated in auto cases by comparative performance analysis.[187] For example, in the Toyota unintended acceleration product liability litigation, which ultimately settled for $1.5 billion, plaintiffs argued that Toyota's vehicles were defective because they lacked brake override systems that other manufacturers had installed in their vehicles.[188]

In conducting such comparative analyses, the focus is on the specific failure mode or performance factor involved in the specific accident at issue in the case, rather than the overall safety performance of the vehicle relative to competing models.[189] In the General Motors ("GM") C/K pickup litigation, where GM was held liable for substantial compensatory and punitive damages,[190] GM attempted to defend its vehicles by showing that even if it was slightly more prone to fire fatalities from side-collisions, it was safer overall in all collisions and all fire

[181] Smith, *supra* note 15, at 49.

[182] *Id.*

[183] *Id.*

[184] *See, e.g.*, Haberkorn v. Chrysler Corp., 533 N.W.2d 373, 379-80 (Mich. Ct. App. 1995) (finding that a vehicle manufacturer has duty to design its vehicle to prevent unreasonable risk of foreseeable injury from a vehicle crash); Mary Anne Mellow, Timothy C. Sansone & Jesse Rochman, *The Legal Landscape: Crashworthiness Claims and Comparative Fault,* 50 No. 12 FOR THE DEF. 38, 38 (Dec. 2008).

[185] *See* Kim v. Toyota Motor Corp., 424 P.3d 290, 295 (Cal. 2018).

[186] Kim v. Toyota Motor Corp. 424 P.3d 290, 298 (Cal. 2018). For more discussion of the role of standards in assigning liability and punitive damages, *see* discussion *infra* Section IV.A.2.

[187] This comparative analysis has limitations. For example, in discussing the caveats of a comparative analysis in an automobile crash case, one court opined that every bicycle is not defective without a light or bell just because some bicycles have those safety features. Branham v. Ford Motor Co., 701 S.E.2d 5, 16 (S.C. 2010).

[188] Ezroj, *supra* note 128, at 505-06.

[189] *See, e.g.,* Honda of America Mfg Inc. v. Norman, 104 S.W.3d 600, 605 (Tex. App. 2003) (focusing analysis on the risk of death in the accident at issue).

[190] Terence Moran, *GM Burns Itself*, AM. LAW., Apr. 1993, at 69.

fatality accidents.[191] This in part was due to the fact that while the gas tank in the GM trucks was on the side of the vehicle, other manufacturers positioned their gas tanks in the rear of the vehicle, making them more at risk from rear hits.[192] Given the inherent trade-offs in placing the gas tank in one position or the other, GM argued that the overall safety of the vehicle (measured as either all accidents or only accidents that result in a fire fatality of an occupant) was the most reasonable comparator.[193] Yet, juries largely ignored this evidence, and focused only on side-hit accidents, and imposing substantial damage verdicts on GM that sometimes were in nine figures.[194]

Not only does the comparative analysis tend to focus on the specific failure mode that occurred in the accident at issue, but a defendant cannot defend by comparing their product to a different category of product. For example, Honda tried to defend the safety of its all-terrain vehicles with a comparative analysis of the safety of other recreational vehicles such as snowmobiles and motorcycles, but such comparisons were excluded by the court.[195] Thus, just as a manufacturer of a large sedan vehicle could not defend the crashworthiness of its vehicle by comparing its accident performance to a small compact vehicle, an AV manufacturer likely could not defend the safety of its vehicle by comparing it to a non-AV.[196] Moreover, the comparative products must have had their safety features at the time the manufacturer in the present case designed its products – it is not appropriate to compare the product in the accident to safer products developed at a later time.[197] This line of precedent suggests that the safety and "defectiveness" of an AV would be based primarily on comparison to other AVs, rather than to human-driven vehicles.[198]

[191] Marchant & Lindor, *supra* note 106, at 1332.

[192] Walter Olson, *The Most Dangerous Vehicle on the Road*, WALL ST. J., Feb. 9, 1993, at A16 ("Any possible placement of the fuel tank 'causes' some accidents and averts others. Respectable designers have tried every gas-tank location at one time or another . . . All have been rejected at other times as unsafe.").

[193] Marchant & Lindor, *supra* note 106, at 1332.

[194] GM v. Moseley, 447 S.E.2d 302, 305 (Ga. App. Ct. 1994) (stating jury awarded $101 million in punitive damages against GM); Moran, *supra* note 190; Marchant & Lindor, *supra* note 106, at 1332.

[195] Bittner v. Am. Honda Motor Co., 533 N.W.2d 476, 488-489 (Wis. 1995) (overturning verdict for defense based on improper admission of comparative risk evidence); Kava v. Am. Honda Motor Co., 48 P.3d 1170, 1172 (Alaska 2002) (upholding exclusion of comparative risk evidence); *see* Marchant & Lindor, *supra* note 106, at 1332-33.

[196] *See* discussion *infra* Section V (noting this liability could have the effect of deterring AV development and deployment, to the detriment of overall public safety, a result inconsistent with the purported objectives of tort law).

[197] *See* Branham v. Ford Motor Co., 701 S.E.2d 5, 19 (S.C. 2010).

[198] *But see* discussion *infra* Section IV.A.1 (noting the relative safety of an AV compared to a human-driven vehicle will likely have salience in AV product liability cases, particularly in the determination for whether to award punitive damages).

A design defect can also be evidenced by internal reports in the possession of a vehicle manufacturer detailing concerns or complaints from vehicle owners and dealers about the same or substantially similar problem that allegedly caused or contributed to the accident.[199] A design defect can also be demonstrated by showing that the same product was involved in many other substantially similar accidents, thus demonstrating a pattern of apparently unsafe performance.[200] For AVs, where an apparent problem can be "fixed" by an instantaneous "over the air" fleet-wide software download, this pattern of repeat accidents should generally be avoidable, helping to protect AVs from this risk factor for liability.[201]

Because of the complexity of AVs, it will be challenging and expensive for many plaintiffs to meet their burden of proving that the AV was defective, especially when the AV was not the initial cause of the crash.[202] Nonetheless, in almost any AV accident, a capable plaintiffs' expert, with the benefit of hindsight, will be able to hypothesize some possible change that the manufacturer could have made to prevent or minimize the accident.[203] The AV will produce an unprecedentedly large set of data, which, through discovery, the plaintiff's expert may be able to mine for clues as to a possible defect.[204]

Here, a fundamental disconnect and unfairness arises between the prospective design decisions of a manufacturer designing a product such as an AV and the retrospective critique of the product by the plaintiff's attorney in the context of a specific accident. In the product design stage, there is an almost unlimited number of additions or alterations the manufacturer could make that would make the vehicle safer. Of course, it would be impractical for the manufacturer to

[199] Gen. Motors Corp. v. Johnston, 592 So. 2d 1054, 1058-59 (Ala. 1992); Ezroj, *supra* note 128, at 505 (plaintiffs relied in part on internal Toyota reports of problems with its electronic control system to argue Toyota cars had a defect causing unintended acceleration).

[200] Branham, 701 S.E.2d 5 at 17 (allowing evidence of other similar accidents with the same product to help demonstrate defect, but the accidents must be "substantially similar" to be probative and hence admissible).

[201] *See, e.g.*, *Cadillac to Increase Super Cruise Compatible Highway Network*, CADILLAC PRESS ROOM, (June 5, 2019), https://media.cadillac.com/media/us/en/cadillac/home.detail.html/content/Pages/news/us/en/2019/jun/0605-supercruise.html [https://perma.cc/3RYG-VJ4H]. Such over-the-air updates may increase AVs to cyberattacks, so it is not clear that all manufacturers will utilize such updates. There are also interesting liability issues about when a problem is adequately confirmed to justify such an update and whether the updated software does not create its own new risks due to software bugs or unanticipated effects.

[202] Smith, *supra* note 15, at 38, 51.

[203] Marchant & Lindor, *supra* note 106, at 1333-34; *see, e.g.*, J.D. POWER & MILLER CANFIELD, *supra* note 125, at 10-13.

[204] Smith, *supra* note 15, at 52. Of course, analyzing these data would likely be expensive, so a plaintiff's attorney would likely only attempt such an approach in an accident involving serious injury or death where the potential damages would be large enough to cover such costs.

implement every one of these almost unlimited safety enhancements. Therefore, manufacturers must prioritize ex ante and make only the most cost-effective and beneficial safety enhancements.[205] In the case of AVs, the *ex ante* safety planning will consist of training the machine learning operating system to become familiar and respond safely in as many situations as possible.[206] But without any standards or guideposts to determine what is safe enough, AV manufacturers will face a quandary of when to make their vehicles available to the public and yet be protected from excessive liability.

Ex post, after an accident has occurred and victims have been killed or seriously injured, the plaintiffs' expert will focus on the specific changes that could have prevented or mitigated that specific accident.[207] Here, in hindsight, the calculations look very different, and often a small change costing only a few dollars, or in the case of AV the almost negligible costs of adding just a few lines of code to the AV operating system, could have prevented the deaths or injuries in that case.[208] Thus, in the case of an AV, the plaintiff's case may seem even more compelling, because a reasonable alternative design would likely just consist of changing a few lines of code, which may have a negligible marginal cost.[209] Such arguments put product manufacturers in a very difficult position with regard to potential liability for accidents.

C. Failure to Warn Defects

The other major category of product liability that AVs may be subject to is failure to warn liability. Whether or not the legal factfinder determines there is a design defect with the AV, a plaintiff injured by an AV crash could separately claim that the manufacturer's failure to provide an adequate warning about the AV's limitations and risks of crashing also contributed to the crash and resulting injuries.[210] To succeed on this failure to warn claim, the plaintiff would have to establish that the warning given was not adequate and thus a more specific or prominent warning might have prevented the accident from occurring.[211] One way to warn is for the manufacturer of a Level II or III semi-autonomous vehicle to require that the driver stay engaged and at attention. Indeed, AV manufacturers are already building active alert systems that warn the driver to take control, actively monitor the driver's response, and execute a fail-safe maneuver to pull the car off the road and stop it if the human driver does not take appropriate measures to stabilize the vehicle.[212] If an AV manufacturer

[205] Marchant & Lindor, *supra* note 106, at 1334 n.50.

[206] Geistfeld, *supra* note 16, at 1646 ("[W]hether the fully functioning operating system is defectively designed wholly depends on the adequacy of prior testing.").

[207] Marchant & Lindor, *supra* note 106, at 1334.

[208] Smith, *supra* note 15, at 47.

[209] *Id*.

[210] RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. i (AM. LAW INST. 1998).

[211] *Id.*

[212] *See* Geistfeld, *supra* note 16, at 1628.

implements these types of active warning and fail-safe systems, it is difficult to envision how the AV manufacturer could be held liable for failing to warn the driver to take control in appropriate circumstances, assuming the active warning system worked as intended.

However, under the Restatement, "instructions and warnings may be ineffective because users of the product may not be adequately reached, may be likely to be inattentive, or may be insufficiently motivated to follow the instructions or heed the warnings."[213] In such a situation, a manufacturer must consider whether "a safer design can reasonably be implemented and risks can reasonably be designed out of a product," in which case "adoption of the safer design is required over a warning that leaves a significant residuum of such risks."[214]

It is unlikely that an AV manufacturer would be able to anticipate most of the specific accident scenarios in which its vehicles will be involved.[215] Indeed, such accidents are likely to occur in unanticipated situations that the AV operating system had never encountered in its training program.[216] If a vehicle manufacturer carefully monitors and promptly corrects for such accident scenarios, there again seems no room for failure to warn liability. There may be some limited general driving situations such as poor weather conditions, unusual road configurations, or highway construction zones that present more foreseeable AV accident risks. However, if the AV manufacturer warns about such unusual conditions, there seems little opening for failure to warn lawsuits and liability.

Not only are failure to warn claims unlikely to prevail in most AV accident lawsuits, but manufacturer warnings may arguably provide some liability protection to AV manufacturers on design defect liability claims. Some product liability experts have suggested that AV manufacturers could protect themselves from design defect liability (particularly under the consumer expectation test) by providing a warning about the inherent potential of AVs to crash.[217] While this advice may have some value, there are also limitations as to the effect of a warning on limiting or eliminating manufacturer liability. First, a warning would only apply to the operator of the AV (who receives the warning when purchasing the vehicle), and so would not insulate the AV manufacturer from liability towards other parties such as occupants of another vehicle hit by the AV, a bystander struck by the AV, or even guests riding in the AV.[218] None of those parties would have received the warning.

[213] RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. l (AM. LAW INST. 1998).

[214] *Id.*

[215] Marchant & Lindor, *supra* note 106, at 1334.

[216] *See id.*

[217] Geistfeld, *supra* note 16, at 1641 ("An adequate warning about the safe use and inherent risks of a safely designed autonomous vehicle will absolve the manufacturer from liability for crashes caused by the fully functioning operating system.").

[218] RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. i (AM. LAW INST. 1998).

Second, an AV manufacturer cannot possibly anticipate and hence warn about all the potential failure modes and specific accident scenarios that the AV may encounter.[219] Thus, the most the AV manufacturer could offer is a general warning that there is an inherent risk of an unanticipated failure.[220] As a result, a plaintiff's expert will argue (with the benefit of hindsight) that the manufacturer should have provided a warning about the failure mode for the specific accident being litigated.[221] Products liability has struggled to define the requisite level of specificity that product warnings must convey given the impossibility of trying to predict every accident scenario.[222] A third problem for manufacturers in relying on general warnings is that it is well-established under the Restatement that a warning will not suffice to eliminate liability if a design change could have eliminated or reduced the risk warned about.[223] As discussed above, a savvy plaintiff's expert will usually be able to identify a design change to the AV, even if it was just a few different lines of code in the operating system that could have prevented the accident.[224]

Finally, a strong warning about inherent risks of AVs is inconsistent with both the fact and the necessary public perception that AVs will be safer than human-driven vehicles. This public perception of safety is critical to both the commercial success of AVs and juror benevolence towards AVs.[225] Harsh warnings that AVs are inherently dangerous would contravene and undermine those safety messages to both consumers and jurors. For example, one of the tort experts who recommends use of warnings to immunize AV manufacturers from tort liability relies on the precedent from cigarettes, where package labels warning that tobacco is carcinogenic and very dangerous helped to protect the manufacturers from liability.[226] In the case of tobacco warnings, "[o]nce the ordinary consumer has been adequately warned that smoking causes cancer, his or her minimum safety expectations would not be violated if that product use causes cancer."[227] However, unlike cigarettes, AVs will not harm public safety overall, and so the warning strategy used by cigarette manufacturers to protect from liability would likely backfire for AV manufacturers, as elaborated in the following discussion of punitive damages.

219 *See* Geistfeld, *supra* note 16, at 1655.

220 *Id.*

221 *Id.*

222 RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. i (AM. LAW INST. 1998) ("It is impossible to identify anything approaching a perfect level of detail that should be communicated in product disclosures . . . No easy guideline exists for courts to adopt in assessing the adequacy of product warnings and instructions.").

223 *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. l (AM. LAW INST. 1998).

224 *See* Marchant & Lindor, *supra* note 106, at 1334.

225 *See id.*

226 Geistfeld, *supra* note 16, at 1640.

227 *Id.*

IV. JUROR DECISION-MAKING AND PUNITIVE DAMAGES

The analysis of liability exposure for AV manufacturers and developers does not end with the doctrinal analysis of product liability law, but must also consider the issue of jury psychology, which can play a significant role in liability determinations and punitive damages awards. Punitive damages can be awarded when a jury finds there was reckless disregard for public safety in product design cases, which frequently occurs in motor vehicle accident cases.[228] Punitive damages should only be awarded for "flagrant" actions by a manufacturer, which implies that such damages should be limited to extreme departures from accepted and acceptable safety practices and engineering choices.[229] Otherwise, customers could always view a manufacturer's unavoidable trade-offs between safety, costs, and inevitable uncertainties as intentional wrongs to injured consumers.[230]

In examining the potential exposure to punitive damages, it is important to note that juries are not machine-like entities that apply governing law in an objective and neutral manner. Rather, a jury is a collection of individual humans who act on a variety of group and individual psychologies, emotions, heuristics, and biases. To many, this is the essence of the jury, and represents the reason the jury is an important enforcer of democratic and societal norms.[231] On the other hand, these subjective factors can make the outcome of litigation, and the amounts of damages awarded when there is liability, unpredictable, or unfair.[232] There is growing body of empirical evidence and academic studies on jury decision-making that can help inform a descriptive analysis of how juries are likely to treat AVs, both in applying the liability doctrines discussed above and in deciding whether to impose punitive damages. Some key factors are discussed below.

In discussing how these factors affect how jurors might respond in cases involving AVs, it is important to keep one point in mind. Unlike in a public opinion poll or casual discussion, the jurors here evaluate AVs after a horrible accident in which one or more human beings were seriously harmed or killed.[233] In the courtroom, the victim or their family provide a vivid message about "gruesome disfigurements and stories of out-of-control cars and tragic, frightful accidents."[234] This will no doubt tilt jurors' perceptions in a negative

[228] Wangen v. Ford Motor Co., 294 N.W.2d 437, 440, 442 (Wis. 1980).

[229] David G. Owen, *Problems in Assessing Punitive Damages Against Manufacturers of Defective Products*, 49 U. CHI. L. REV. 1, 24 (1982).

[230] *Id.* at 26.

[231] *See id*. at 917.

[232] *See* Reid Hastie & W. Kip Viscusi, *What Juries Can't Do Well: The Jury's Performance as a Risk Manager*, 40 ARIZ. L. REV. 901, 917 (1998) ("The primary conclusion from our empirical study is that juries perform poorly when making the decisions required to assess liability for punitive damages.").

[233] Marchant & Lindor, *supra* note 106, at 1334.

[234] Wu, *supra* note 16, at 578.

direction.[235] The resulting juror outrage could subject AV manufacturers to punitive damages.[236]

This section looks first at factors that can make a jury more sympathetic to a product manufacturer and less likely to award punitive damages, and then examines factors that may increase jury antipathy toward a company and make them more likely to award punitive damages.

A. Factors Making Jurors More Sympathetic to Manufacturers

1. Relative Risk and Affect

A key psychological factor that is likely to influence jurors is the overall safety benefit of AVs. People, including jurors, often perceive risks and their acceptability in relative, rather than absolute, terms. Thus, if AVs can be demonstrated to significantly reduce overall crashes, deaths, and injuries, jurors will generally be less inclined to punish AV developers and manufacturers for occasional mishaps where the vehicle causes or contributes to an accident. One tort scholar claims that if testing data demonstrates that AVs are at least twice as safe as human-driven vehicles, they will be found to be "reasonably safe and not defectively designed" by courts and juries.[237] A study of citizens in China found that the public would "tolerate" AVs that are four to five times safer than human-driven vehicles, but would only "broadly accept" AVs that provide a "two order of magnitude improvement" over existing traffic risks.[238]

Moreover, when an AV is in an accident, the vehicle will learn from the events and the whole fleet's operating system may be updated to prevent similar future accidents.[239] Thus, unlike traditional vehicle defects where a certain model or piece of equipment may be responsible for a large number of accidents, many accidents caused by an AV's specific shortcomings should only occur one or a few times, which is an important mitigating factor against punitive damages.[240]

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[235] Owen, *supra* note 229, at 49 ("In a products liability case against a corporate manufacturer, the inherent juror bias, the complexities of the factual questions, and the vagueness of the legal standards create an atmosphere especially ripe for an effective plaintiff's advocate to stir the hearts and inflame the passions of any jury.").

[236] Smith, *supra* note 15, at 47; Wu, *supra* note 16, at 579.

[237] Geistfeld, *supra* note 16, at 1653.

[238] Liu et al., *supra* note 108, at 323.

[239] Pearl, *supra* note 170, at 745-46. As discussed previously, the actual implementation of over-the-air updates is fraught with complications about when such updates are warranted and with potential new risks associated with software fixes. *See* Caleb Kennedy, Note, *New Threats to Vehicle Safety: How Cybersecurity Policy Will Shape The Future Of Autonomous Vehicles*, 23 MICH. TELECOMM. TECH. L. REV. 343, 344 (2017).

[240] Owen, *supra* note 229, at 28-29 (finding many prior complaints and lawsuits to be an important aggravating factor for punitive damages because they prove "the existence of a hazard, its seriousness, and the manufacturer's probable knowledge of its existence"); *id.* at 36 (finding that a "low number of prior complaints tends to support a manufacturer's claim of ignorance of a problem in need of attention").

In addition, an idiosyncrasy of juror risk perception and decision-making that may benefit AV manufacturers is something called "the denominator blindness effect."[241] In determining the risk of an accident from a product and whether punitive damages should be awarded against the product manufacturer, jurors tend to look at only the absolute number of accidents (the numerator), while ignoring the level of activity (the denominator) that would be used to calculate the frequency or rate of accidents.[242] For example, in an empirical study where jury-eligible adults were asked to compare the recklessness of two chemical companies, one that had two accidents in 10,000 trips and the other that had two accidents in 50,000 trips, the jurors perceived the relative risk, and hence recklessness, of the two companies as the same, even though the former was five times more dangerous than the latter.[243] If AV operating systems are safer than human-driven cars and can avoid repeat accidents via self-correcting, [244] the numerator should be a relatively low number, and such cases may be treated less harshly by jurors.

2. Compliance with Standards

Compliance with standards can help protect a product manufacturer from liability and punitive damages. Such standards, if perceived as credible and objective by the jury, provide a benchmark against which the company's performance is judged.[245] Thus, the manufacturer can tell a story to the jury that it did the best it reasonably could, given the many uncertainties and lack of federal standards that apply to this technology.[246] If the company has complied with the standard, it will be seen as evidence of responsible and reasonable behavior, and help shield against liability, although rarely providing a complete shield against liability.[247] Alternatively, if a manufacturer fails to comply with an applicable standard, this would provide evidence of corporate irresponsibility

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[241] *See generally* W. Kip Viscusi & Richard J. Zeckhauser, *The Denominator Blindness Effect: Accident Frequencies and the Misjudgment of Recklessness*, 6 AM. LAW AND ECON. REV. 72 (2004).

[242] *Id.* at 72.

[243] *Id.* at 83-85.

[244] *See id.* at 72. As discussed *supra* Part III, Section B, it is the repeated involvement of an alleged vehicle defect in hundreds of accidents (e.g., Toyota acceleration cases, GM C/K pick-up cases, Firestone tire cases) that usually triggers a litigation wave and calls for punitive damages.

[245] Wu, *supra* note 16, at 588-89.

[246] *Id.* at 588.

[247] *Id.* The exception is where a federal government standard has preempted state law, including product liability tort law. *Id.* at 587 n.16.

and indifference, enhance liability and damages (including punitive damages), and perhaps even demonstrate negligence per se.[248]

Government standards are the most authoritative standards to provide a standard of care in product liability litigation. However, federal standards, such as the Federal Motor Vehicle Safety Standards ("FMVSS"), do not provide a complete shield of liability, and a motor vehicle is still defective in most states even if it complies with such federal standards.[249] A manufacturer's compliance with federal standards helps protect it against the imposition of punitive damages.[250] If, after all, a manufacturer complies with the requirements imposed by the government for a product, it is generally not reckless or wanton with respect to the behavior regulated by such standards.[251] Some states, such as Arizona, prohibit punitive damages for a manufacturer that complies with applicable regulatory standards.[252] While other states do not prohibit punitive damages in such situations, the compliance defense should argue strongly against punitive damages.[253] Tort experts have suggested that the adoption of federal safety standards for AVs could go a long way in protecting AV manufacturers from tort liability (including punitive damages).[254]

In the absence of government standards, private industry standards can play an important role in product liability as both a shield for complying companies and a sword against non-complying companies.[255] The nature of the standards and how the standards are set are important in determining the level of deference

[248] *See* Kim v. Toyota Motor Corp., 424 P.3d 290, 298-299 (Cal. 2018) (holding that a jury can consider a manufacturer's non-compliance with industry standards as a relevant factor in determining liability and damages).

[249] *See* Gen. Motors Corp. v. Moseley, 213 Ga. App. 875, 884-85 (1994) (holding that the compliance of General Motor's pickup truck with NHTSA's FMSVV for side impact collisions did not preclude an award of punitive damages where there was other evidence of culpable behavior), *abrogated on other grounds by* Webster v. Boyett, 269 Ga. 191 (1998); *see also* Owen, *supra* note 229, at 41.

[250] Owen, *supra* note 229, at 41-42.

[251] *See id.* (explaining that violations of government safety statutes or regulations undercut claims of good faith).

[252] ARIZ. REV. STAT. ANN. § 12-689(a)(1) (2012) ("A manufacturer, service provider or seller is not liable for exemplary or punitive damages if . . . [t]he product alleged to have caused the harm was designed, manufactured, packaged, labeled, sold or represented in relevant and material respects according to the terms of an approval, conditional approval, clearance, license or similar determination of a government agency.").

[253] Owen, *supra* note 229, at 41-42.

[254] *See* Geistfeld, *supra* note 16, at 1674-75, 1677.

[255] Kim v. Toyota Motor Corp., 197 424 P.3d 290, 298-99 (Cal. 2018) (finding that evidence of industry standards can explain the reasonableness of a manufacturer's conduct in designing a product and the adequacy of the design); *cf.* Gary E. Marchant, *'Soft Law' mechanisms for nanotechnology: liability and insurance drivers,* 17 J. RISK RES. 709, 714 (2014) (discussing compliance with private industry standards in the context of nanotechnology).

courts and juries will give to such private standards, but if the standards are adopted in a credible and objective manner, they provide an important guidepost, especially in emerging technology fields without government standards or other guidelines to anchor jurors' expectations.[256] The potential role of private AV safety standards is revisited in the final section of this paper.[257]

B. Factors Making Jurors Less Sympathetic to Manufacturers

1. Dread Risks

The general public, and juries in particular, are prone to misunderstanding and misuse of probabilistic and statistical evidence.[258] Many lay people, including jurors, overestimate the risk and danger from unfamiliar, exotic technologies.[259] Unlike scientists and engineers that make risk evaluations based on probability *x* consequences, a number of more subjective factors influence risk judgments by the public.[260] In particular, the public tends to overreact to risks that exhibit so called "dread risk" characteristics such as unfamiliarity, uncertainty, novelty, uncontrollability, and involuntariness.[261]

Not surprisingly, these characteristic of public risk perceptions apply to jurors.[262] Studies show that juries tend to overreact to risks "associated with new technologies; to risks that represent increases from accustomed, status quo risk levels; to risks outside of their personal control; and to risks associated with highly publicized events."[263] Juries are particularly harsh towards ambiguous and uncertain risks:

> [I]f a party is unfortunate enough to experience an adverse outcome, then juries will tend to be especially unforgiving when the ex ante risk was ambiguous. There is a bias against uncertain risks; people respond as if they were greater than they are. Given this bias, juries are likely to be excessively demanding when judging situations of uncertainty; they will view the risks incurred by a defendant as being greater, and hence judge behavior as more likely to have been reckless, because risks were uncertain.[264]

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[256] Marchant, *supra* note 255, at 714.

[257] *See infra* parts IV. B. and V.

[258] Reid Hastie & W. Kip Viscusi, *What Juries Can't Do Well: The Jury's Performance as a Risk Manager*, 40 ARIZ. L. REV. 901, 909-10 (1998).

[259] *Id.* at 912.

[260] Yuval Rottenstreich & Ran Kivetz, *On decision making without likelihood judgment*, 101 ORG. BEHAV. & HUM. DECISION PROCESSES 74, 74-75 (2006).

[261] *Id.* at 85; Paul Slovic & Ellen Peters, *Risk Perception and Affect*, 15 CURRENT DIRECTIONS IN PSYCHOL. SCI. 322, 322-23 (2006).

[262] Hastie & Viscusi, *supra* note 258, at 909.

[263] *Id.* at 912.

[264] *Id.* at 913.

AVs, operated by artificial intelligence and machine learning, will appear as a new and exotic technology with ambiguous risks to many jurors.[265] They therefore will appear as dread risks to the public and jurors, who will hold AVs to a higher safety standard than human-driven vehicles.[266] Public opinion polls are indeed showing that public opinion is currently leery of AVs, with a slight majority or plenary of surveyed citizens expressing fear and reluctance of AVs, likely due to their novel and mysterious properties.[267] If such public anxieties continue, this unease will be easily leveraged by plaintiffs' attorneys in arguing for liability and in many cases punitive damages.

2. Hindsight Bias

Hindsight bias has always been a problem with tort litigation.[268] A manufacturer designs its products and decides what to warn about *ex ante*, before the product is in widespread use.[269] Tort litigation occurs after a specific harm has occurred – and the judge, jury members, and experts know that there was a bad result and how it occurred.[270] It is human nature to use what we know now to frame the manufacturer's earlier decision and to assume the manufacturer should have known what was unknowable at the time the manufacturer made its design and warning determinations.[271] This results in *ex poste* overestimates of foreseeability that "can produce unjustified feelings of outrage and punitiveness."[272] No doubt a natural result of how our brains work, jurors view a risk situation after an accident has occurred as being more preventable than it was *ex ante*.[273] As Judge Frank Easterbrook has noted, "the *ex post* perspective of litigation exerts a hydraulic force that distorts judgment."[274]

However, this hindsight bias significantly biases and distorts the purpose and effect of product liability law, because it produces a disjunction between the manufacturer's decision and the jury's judgment.[275] As Hastie and Viscusi explain:

> If a juror uses the post-accident reference point as the basis to determine how defendants should select their safety levels, a higher level of

[265] *See* Jerry Kaplan, *Why We Find Self-Driving Cars So Scary,* WALL ST. J. (May 31, 2018, 12:38 PM), https://www.wsj.com/articles/why-we-find-self-driving-cars-so-scary-1527784724 [https://perma.cc/SN47-ZSW5].

[266] Liu et al., *supra* note 108, at 316.

[267] *See supra* note 80 and accompanying text.

[268] *See* Jeffrey J. Rachlinski, *A Positive Psychological Theory of Judging in Hindsight*, 65 U. CHI. L. REV. 571, 571-73 (1998).

[269] *See Id.* at 572.

[270] *Id.*

[271] *Id.* at 573.

[272] Hastie & Viscusi, *supra* note 258, at 903-04.

[273] Viscusi & Zeckhauser, *supra* note 241, at 74.

[274] Carroll v. Otis Elevator Co., 896 F.2d 210, 215 (7th Cir. 1990).

[275] Hastie & Viscusi, *supra* note 258, at 911.

> precaution will seem optimal than one based on the actual imperfect pre-accident state of knowledge. The ex post perspective in the courtroom will consequently overestimate the magnitude of the punitive damages necessary to align the incentives for the defendant with levels of punishment that are needed to produce efficient degrees of care.[276]

Even when a judge specifically admonishes a jury not to use hindsight to affect their judgment, juries continue to apply hindsight bias.[277] Thus hindsight bias will tend to bias product liability law in an anti-manufacturer and overly-precautionary direction. Hindsight bias is likely to be particularly salient in AV litigation because accidents will usually involve unusual situations that were not anticipated *ex ante* by the manufacturer, but after the fact may seem quite obvious.

3. Manufacturer Cost-Benefit Analysis

In making design decisions about a motor vehicle or any other complex product, there is an almost infinite number of design choices or alternatives the product manufacturer could consider, many of which may affect safety. Of course, if a vehicle manufacturer made every design decision and added every safety device possible, motor vehicles would cost millions of dollars per vehicle, and few if any people could afford them. Manufacturers therefore must make choices under the constraint of keeping the price of the product accessible, which often means weighing the safety benefit that can be achieved versus the cost of the design change.[278] A rational way to make such decisions is using cost-benefit analysis or cost-effectiveness analysis.[279]

However, juries often respond harshly to evidence that manufacturers may have explicitly weighed costs and benefits in making judgments that affect safety.[280] For example, General Motors was hit with a $4.9 billion verdict in 1999 (of which $4.8 billion was for punitive damages) for an accident in which the GM vehicle occupants were severely burned after the vehicle was hit from behind by a drunken driver speeding at fifty to seventy miles per hour.[281] The

[276] *Id.* at 914.

[277] *Id.* at 915-16.

[278] *Id.* at 913.

[279] Cost-benefit analysis compares the marginal cost of a change against its marginal benefits, and generally approves changes where the benefits exceed the cost. Cost-effectiveness calculates the number of dollars a change costs per life saved, and rather than providing an answer of whether a specific change is justified when considered in isolation, but rather facilitates a comparative analysis of different design choices to allow the manufacturer to spend its limited resources to obtain the greatest benefits per dollar spent on safety.

[280] Hastie & Viscusi, *supra* note 258, at 913.

[281] Andrew Pollack, *$4.9 Billion Jury Verdict in G.M. Fuel Tank Case*, N.Y. TIMES (July 10, 1999), https://www.nytimes.com/1999/07/10/us/4.9-billion-jury-verdict-in-gm-fuel-tank-case.html [https://perma.cc/9S4A-Q3GY].

extraordinary large punitive damages award was because GM had rejected a safer design for the fuel tank that would have cost an additional $8.59 per vehicle.[282] The jury was shown an internal GM memo written twenty-six years earlier in 1973 by a young GM engineer that argued that cost-benefit analysis supported not making the safety improvements to the gas tank, although there is no evidence that the memo was ever used in GM's internal decision making.[283] In awarding $4.9 billion damages, "[t]he jurors wanted to send a message to General Motors that human life is more important than profits," according to the plaintiffs' attorney in the case.[284]

The very act of explicitly making such tradeoffs in contexts where people's safety or lives may be at risk is viewed by many jurors as a form of reckless disregard for individual life or limb.[285] In empirical simulations with mock jurors, punitive damages were more likely to be imposed and were higher in value when a manufacturer performed a cost-benefit analysis than when it did not.[286] Ironically, punitive damage levels were higher when companies used a correct analysis model that had a higher value of human life, than an erroneous analysis based on compensatory damages with a lower amount.[287]

The fact that a company performed a cost-benefit analysis on a specific possible safety improvement demonstrated to the jury that the company was aware of the linkage between that potential improvement and the risk to the public; thus a decision to forego the improvement suggests that the manufacturer "place[d] a dollar value on human life" and based on economic trade-offs "deliberately intended to injure the plaintiff."[288] This puts product manufacturers in an untenable position, requiring them to either (i) make every possible safety improvement it identifies and analyzes, which would likely quickly make the product unaffordable; (ii) avoid analyzing possible safety improvements altogether, which would make the product less safe; or (iii) choose to forgo safety improvements that the company hopes will never be significant in any accident litigation.

This dilemma is again pronounced and unique in the AV context. There is an almost infinite range of situations an AV could encounter, most of which are highly unlikely. Thus, an AV developer or manufacturer could marginally improve the safety of its vehicle by doing yet more testing in both real-world and simulation modes. On the other hand, if the AV is already safer than human-

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[282] *Id.*

[283] Milo Geyelin, *How a Memo Written 26 Years Ago is Costing General Motors Dearly*, WALL ST. J. (Sept. 29, 1999, 8:49 AM), https://www.wsj.com/articles/SB9385366607816889 [https://perma.cc/BUT9-45PD].

[284] Pollack, *supra* note 281.

[285] Viscusi & Zeckhauser, *supra* note 241, at 72-73.

[286] W. Kip Viscusi, *Corporate Risk Analysis: A Reckless Act?*, 52 STAN. L. REV. 547, 552 (2000).

[287] *Id.* at 558.

[288] Wu, *supra* note 16, at 579; Viscusi, *supra* note 286, at 566.

driven vehicles, the company will feel strong pressure to deploy the vehicles commercially to start getting returns on the substantial financial and resource investment it has made in its AV technology. Cost-benefit analysis may help to clarify such trade-offs, but again could expose the company to juror wrath if and when accidents and associated injuries occur.

4. Over-Statements of Safety

In a number of examples, product manufacturers were punished by large punitive damage awards by juries who perceive that the manufacturer over-promised the safety of its products. In the Toyota unintended acceleration litigation, the plaintiffs repeatedly focused, with much success, on Toyota's marketing claims that its vehicles were "safe" and that safety was one of the manufacturer's highest priorities.[289] In the GM "exploding gas tank" litigation discussed above, the company was subjected to repeated punitive damage awards for its alleged indifference to the risks of its vehicle design.[290] In recent cases against non-vehicle technologies such as Johnson & Johnson's Baby Powder and Monsanto's Round-Up herbicide, juries have found liability and repeatedly awarded large punitive damages awards, with verdicts already in the range of hundreds of millions to billions of dollars per case and many more cases remaining.[291] Juror behavior in these cases suggests that the large punitive damage awards were due in large part to the company's continuing denial of any cancer risk from its products, even though the weight of scientific evidence available to date may support the company's position.[292]

Many autonomous vehicle and component manufacturers may be over-stating the safety of AVs. A number of such companies have launched marketing statements that state or imply that AVs may be able to achieve zero or an extremely low level of fatalities and injuries.[293] While designed to instill confidence in consumers, such over-statements of safety could backfire if an accident does occur and goes before a jury. "If consumers believe zero accidents will occur with an automated vehicle and one does happen, the fragile trust that

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[289] *See* Ezroj, *supra* note 128, at 507.

[290] *See supra* notes 281-284.

[291] Richard Smith et al., *Key Takeaways from Roundup Verdicts So Far*, LAW360 (May 17, 2019, 1:56 PM), https://www.law360.com/articles/1160798/key-takeaways-from-roundup-verdicts-so-far.

[292] *See* Daniel Fisher, *Massive Roundup Verdict, in Wake of EPA Ruling, Shows How Uncertainty and Embarrassing Emails Can Trump Science*, LEGAL NEWSLINE (May 14, 2019), https://legalnewsline.com/stories/512490386-massive-roundup-verdict-in-wake-of-epa-ruling-shows-how-uncertainty-and-embarrassing-emails-can-trump-science [https://perma.cc/J4UQ-VZXS]; Daniel Siegal, *J&J Hid Asbestos in Talc for Years, Latest Jury Told in SC,* LAW360 (May 13, 2019, 10:19 PM), https://www.law360.com/articles/1159287/j-j-hid-asbestos-in-talc-for-years-latest-jury-told-in-sc.

[293] J.D. POWER & MILLER CANFIELD, *supra* note 125, at 56.

was present will be shattered. Consumer emotions are elevated in such a hypothetical situation . . . ."[294]

An important psychological effect which may apply to AVs is known as "betrayal aversion," which is when people have a stronger than might be expected or appropriate negative reaction to a product that promises increased safety but actually ends up harming people.[295] Thus, jurors apply higher damage awards (often including punitive damages) to defective products that are intended to protect people from risks than to people injured from the original risk. Even when two products create similar risks or injuries, juries punish those that are perceived as betraying a promise of protection or safety than more those that make no such explicit or implicit promise.[296] Examples may include faulty respirators, air bags, and other products that claim to protect the safety of users. In such cases of safety betrayal, the punitive damages awarded by mock juries did not depend on the harm caused, but on the jury outrage associated with the betrayal.[297] An empirical study found that "betrayal risks appear to be so psychologically intolerable that people are willing to double their risk of death from automobile crashes, fires, and diseases to avoid a small possibility of death by safety device betrayal."[298]

This presents a catch-22 for AV manufacturers. On the one hand, the greatest benefit of AVs will be their expected safety improvements over human-driven cars. This safety benefit will be a key message for manufacturers to deliver to the general public and to jurors to enhance public acceptance. At the same time, when an accident does occur that an AV caused or should have been able to avoid, the safety claim by the manufacturer may now backfire and cause the jury to express this phenomenon of betrayal aversion. As one tort expert stated in the context of AVs, "[p]aradoxically, the safe performance promised by the technology could generate demanding expectations of safety that subject the manufacturer to liability in the event of a crash."[299]

5. Manufacturer Secrecy and Deception

Perhaps the number one risk factor for punitive damages is where the jury perceives that the product manufacturer concealed or failed to take action to redress previous information or complaints about problems related to the defect

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[294] *Id.*

[295] Jonathan J. Koehler & Andrew D. Gershoff, *Betrayal Aversion: When Agents of Protection Become Agents of Harm*, 90 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 244, 245 (2003); *see also* Marchant & Lindor, *supra* note 106, at 1335 (applying Koehler and Gershoff's findings to AVs).

[296] Jim Norman, *Name the Harm: Betrayal Aversion and Jury Damage Awards in Safety Product Liability Cases*, 32 REV. LIT. 525, 529-30 (2013).

[297] *Id.* at 547-548; *see also* Daniel Kahneman et al., *Shared Outrage and Erratic Awards: The Psychology of Punitive Damages*, 16 J. RISK UNCERTAINTY 49, 72-73 (1998).

[298] Koehler & Gershoff, *supra* note 295, at 255.

[299] Geistfeld, *supra* note 16, at 1639.

at issue in the case.[300] Specifically, where a vehicle manufacturer purportedly had knowledge of a vehicle safety problem or risk and failed to disclose or fix the problem, juries will often award significant punitive damages.[301]

A recent non-auto example is the herbicide glyphosate (commercial name Roundup) produced by Monsanto (now owned by Bayer). Even though the herbicide is known to be one of the least toxic herbicides on the market, and its safety has been reaffirmed by multiple government agencies in the United States and elsewhere,[302] a jury recently awarded a former groundskeeper who had developed cancer a verdict of $289 million, of which $250 million was punitive damages.[303] A subsequent case awarded a couple with cancer allegedly caused by Roundup with a $2 billion verdict, most of which was punitive damages.[304] These large punitive damages awards resulted from jury acceptance and outrage over arguments from the plaintiff's attorney and expert witness that Monsanto had denied and hidden evidence of risk from its product.[305] In the months after these initial cases were decided, the number of product liability suits against Monsanto for glyphosate jumped from 5,000 to over 13,000 cases.[306]

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[300] *See* Gen. Motors Corp. v. Johnston, 592 So. 2d 1054, 1060-62 (Ala. 1992) (upholding jury award of large punitive damages on the grounds that "General Motors concealed this [defect] from the public and did not notify any of its purchasers, or prospective purchasers, of the problems related to these vehicles. Accordingly, the Court finds . . . the degree of reprehensibility of Defendant General Motors in this case to be great and that the damages should be high."); Ezroj, *supra* note 128, at 506 (plaintiffs' primary argument for punitive damages in the Toyota unintended acceleration litigation was that Toyota was aware of the problems but chose to mask those dangers rather than fix them).

[301] *See, eg.*, *In re* GM LLC Ignition Switch Litig., 257 F. Supp. 3d 372, 457-58 (S.D.N.Y. 2017) (upholding lower court's decision by relying on GM's awareness of alleged defects).

[302] Gabriella Andreotti et al., *Glyphosate Use and Cancer Incidence in the Agricultural Health Study,* 110 J. NAT'L CANCER INST. 509, 510, 513 (2017).

[303] Reuters, *Monsanto Ordered to Pay $289 Million in Roundup Cancer Trial*, N.Y. TIMES (Aug. 10, 2018), https://www.nytimes.com/2018/08/10/business/monsanto-roundup-cancer-trial.html [https://perma.cc/5EDM-GEME].

[304] Richard Smith et al., *Key Takeaways from Roundup Verdicts So Far*, LAW360 (May 17, 2019); Patricia Cohen, *$2 Billion Verdict Against Monsanto Is Third to Find Roundup Caused Cancer*, N.Y. TIMES (May 13, 2019), https://www.nytimes.com/2019/05/13/business/monsanto-roundup-cancer-verdict.html [https://perma.cc/CES8-JXDD] (verdict was later lowered by the trial judge to $86 Million); Tina Bellon, *In Roundup Case, U.S. Judge cuts $2 Billion Verdict against Bayer to $86 Million*, REUTERS (July 25, 2019), https://www.reuters.com/article/us-bayer-glyphosate-lawsuit/in-roundup-case-u-s-judge-cuts-2-billion-verdict-against-bayer-to-86-million-idUSKCN1UL03G [https://perma.cc/YK6B-STQM].

[305] *See* Sam Levin, *Monsanto 'Bullied Scientists' and Hid Weedkiller Cancer Risk, Lawyer Tells Court*, THE GUARDIAN (July 9, 2018), https://www.theguardian.com/business/2018/jul/09/monsanto-trial-roundup-weedkiller-cancer-dewayne-johnson [https://perma.cc/CDV6-Q4N2].

[306] Smith et al., *supra* note 304; Phil McCausland, *Monsanto Parent Company Bayer Faces Thousands of Roundup-Cancer Cases After $2 Billion Verdict*, NBC NEWS (May 20, 2019),

According to one analysis of punitive damage awards, the three most common actions by manufacturers that result in punitive damages are: (i) failing to acquire sufficient product safety information through tests, inspections, or post-marketing safety monitoring, (ii) failing to remedy an excessively dangerous condition known to exist in a product by altering its design, adding warning or instructions, or recalling the product for repair, and (iii) knowingly misleading the public concerning the product's safety.[307] Courts will scrutinize marketing communications particularly carefully when considering a punitive damages request.[308] A product manufacturer that can document that it does not engage in any of these abuses will usually be safe from punitive damage awards.[309] Given the other risk factors for AVs discussed above that might predispose jurors to award punitive damages, AV manufacturers and developers must take the utmost care to ensure transparency, rigor, and diligence in addressing potential safety issues.

V. ANALYSIS AND CONCLUSIONS

A product liability lawsuit could conceivably be brought against AV developers and manufacturers in almost every accident involving an AV.[310] However, there is enormous uncertainty concerning how many cases will be brought and how they will be resolved by courts and juries.[311] Two key factors will affect the number of cases brought. The first factor is the overall safety of the AVs. The assumed lower rate of accidents involving AVs compared to human-driven vehicles should presumably reduce the number of possible lawsuits brought. As discussed above, AVs are expected to significantly decrease the number of motor vehicle accidents.[312] Although product liability lawsuits against manufacturers are expected to represent a larger slice of the total number of accidents involving AVs,[313] the smaller the pie, the smaller the absolute number of product liability lawsuits. This decrease in accident rate will not only result from the greater sensing and reaction capabilities of AVs and the lack of any distractions that affect human drivers, but also from the unique potential of AVs to learn from a single accident and update fleet operating systems to prevent recurrence of such accidents. This latter capability is a key

https://www.nbcnews.com/news/us-news/monsanto-parent-company-bayer-faces-thousands-roundup-cancer-cases-after-n1007246 [https://perma.cc/3ZST-6BC3].

307 Fred W. Morgan, *Punitive Damages Awards for Flagrant Mismarketing of Products*, 3 J. PUB. POL'Y & MARKETING 113, 113 (1984).

308 *Id*. at 118.

309 *See id.* at 113.

310 Geistfeld, *supra* note 16, at 1639 ([T]the [AV] manufacturer could be liable for all crashes, creating costs that could plausibly impede the widespread deployment of this crash-reducing technology.").

311 *Id*.

312 *See* KPMG *supra* note 110, at 26.

313 Smith, *supra* note 15, at 2.

advantage of AVs because many mass motor vehicle lawsuits arise after the same vehicle model or component is involved in a significant number of cases, building both the evidentiary case for a defect and the attention and investment of plaintiffs' attorneys prepared to litigate such cases.[314]

The second key variable affecting the number of lawsuits brought are plaintiffs' attorneys.[315] Because most motor vehicle product liability suits are brought on a contingency fee basis, where the plaintiffs' counsel must invest their own resources to prepare and litigate the case, plaintiffs' attorneys are a critical gatekeeper for litigation.[316] Thus, the plaintiffs' attorney's cost-benefit analysis will often determine whether a case will be brought.[317] Further, some factors will deter an attorney from taking such a case.[318] These cases are often quite expensive to litigate, and usually require costly expert witnesses who understand and can interrogate the AV system involved in the crash.[319] The substantial uncertainties about how judges and juries will receive such cases will also deter plaintiffs' counsel, who tend to dislike cases where the chances of recovering his or her substantial investments in the case are highly uncertain and unpredictable.[320]

On the other hand, several factors would encourage plaintiffs' lawyers to pursue these lawsuits. First, if the public is concerned about the "dread risks" associated with the exotic artificial intelligence technology controlling an AV, plaintiffs' attorneys may be attracted to such cases because of the potential for a substantial punitive damages payout. The recent GM case in San Francisco where a plaintiff's attorney brought a lawsuit against GM, despite the fact that his client was to blame for the accident, is an indicator of this dynamic[321] because it is unlikely that the attorney would have brought a lawsuit against a human-driven vehicle that was not at fault for the accident. Additionally, plaintiffs' attorneys are aware that AV manufacturers and developers often want to settle AV lawsuits quickly to minimize bad publicity or to avoid the risk of large punitive damages awards. Again, the recent decision of GM to settle the San Francisco case, even though the manufacturer was not at fault, signals that AV companies may be prone to quick settlements. This in turn encourages plaintiffs' attorneys to bring similar suits.[322]

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[314] *See, e.g.,* Branham v. Ford Motor Co., 701 S.E.2d 5, 19 (S.C. 2010) (allowing in evidence of other similar accidents as long as they are "substantially similar" to the present case).

[315] *See* Smith, *supra* note 15, at 38.

[316] *See id*.

[317] *See id*.

[318] *See id*.

[319] *See id*.

[320] *See* Smith, *supra* note 15, at 38.

[321] *See* Westbrook, *supra* note 8 and accompanying text.

[322] *Id.*

The final, and perhaps the most powerful, driver of lawsuits is early success in other similar suits. Plaintiffs' attorney behavior follows a group swarming dynamic – once there have been one or more breakthrough cases with substantial verdicts, more attorneys will jump on the bandwagon and use the successful cases as roadmaps for their own litigation strategy.[323] At that point, runaway litigation can swamp even the largest corporate defendant with the sheer costs of litigating hundreds of complex cases across the country.

In addition to the number of lawsuits that are brought, the second major factor that affects litigation risk exposure for AV developers and manufacturers is the expected outcome of such lawsuits. Of course, these two factors are interrelated, because the more successful the outcomes are for plaintiffs, the more lawsuits that will be brought. As noted above, there is substantial uncertainty about the outcome of AV product liability lawsuits.[324] The specific facts of each accident are important. If the AV broke a traffic law by deviating from its lane, failing to stop or yield when required to do so, or leaving the roadway, the manufacturer of such a vehicle will usually be liable for the resulting accident.[325] This will not be an unreasonable outcome in most cases, however, there are some exceptions to this liability. The most common exceptions are (1) when the AV caused the accident to avoid a more harmful crash that was not its fault, in which case the crash may be excused, and (2) when the operator of a semi-autonomous vehicle was negligent or inattentive and failed to take proper control of the vehicle under circumstances that the reasonable operator could have done so, in which case some or all the liability may shift to the human operator under negligence claims.[326]

The more difficult and uncertain cases occur when another vehicle or bystander was the immediate cause of the crash. In such cases, the other blameworthy party is at least partially responsible, but the AV could also share responsibility if the judge or jury determines that the AV was defective and should have avoided the crash but did not. As in many previous motor vehicle product liability cases, this determination of defect will often be based on a comparative analysis with the products of other manufacturers.[327] Thus, the strongest cases for plaintiffs are those where they use expert testimony to show that a competitor's AV had features that would have avoided the crash, or alternatively, that the expert can identify a reasonable modification of the AV's sensors or operating system that would have avoided the crash.

Two important factors are critical in determining the outcome of many such cases. First, can the manufacturer demonstrate that it has complied with applicable standards for the safety performance of AVs? These standards, set by

[323] *See, e.g.*, Priest, *supra* note 14 and accompanying text.

[324] Geistfeld, *supra* note 16, at 1639.

[325] *See* Marchant & Lindor, *supra* note 106, at 1333.

[326] *See* Smith, *supra* note 15, at 2, 4, 33-35, 44-45; Marchant & Lindor, *supra* note 106, at 1327, 1331 and accompanying text.

[327] *See Branham*, 701 S.E.2d at 17; *supra* note 187 and accompanying text.

a government body or by a credible private standard-setting organization, will anchor the jury and provide a predictable measuring stick to evaluate both the AV's and the company's performance.[328] As further explained below, important progress is being made to develop consensus standards to provide an objective baseline for evaluating AV safety. Although there is an existing ISO standard 26262 that defines component failure, the ISO is developing a new standard, ISO 21448, described as "Safety of the Intended Functionality ("SOTIF")," that will define unreasonable risks for autonomous driving systems in the absence of software or hardware malfunctions, which are covered by ISO 26262.[329]

In July 2019, Intel and ten autonomous vehicles companies published "Safety First for Automated Driving," a 157-page framework for the design, development, verification and validation of safe automated passenger vehicles.[330] This guide builds on Intel's model for safer AV decision-making known as Responsibility-Sensitive Safety ("RSS").[331] The National Institute of Standards and Technology ("NIST") held a workshop on AV safety approaches in June 2019,[332] which lead to a published report that concluded that:

> [T]here was a clear consensus amongst the workshop attendees that the ADS-equipped vehicle community would benefit greatly from a community-wide effort to establish a coherent, widely-supported, comprehensive safety methodology framework that would help focus the efforts of the various ADS-equipped vehicle stakeholders to advance the introduction of ADS-equipped vehicle technology.[333]

The report noted there was still significant disagreement about the details of any such framework.[334] While these developments indicate significant progress towards the development of consensus standards for AV safety, widespread

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328 Geistfeld, *supra* note 16, at 1685; Wu, *supra* note 16, at 588-89; *see also* Jae Kim v. Toyota Motor Corp. 424 P.3d 290, 297-98 (Cal. 2018).

329 Junko Yoshida, *AV Safety Ventures Beyond ISO 26262*, EETIMES (Mar. 15, 2019), https://www.eetimes.com/document.asp?doc_id=1334397#.

330 *Intel and Auto Industry Leaders Publish New Automated Driving Safety Framework*, INTEL: NEWSROOM (July 2, 2019), https://newsroom.intel.com/news/intel-auto-industry-leaders-publish-new-automated-driving-safety-framework/#gs.7opqxa [https://perma.cc/BS4K-RYVR]; Matthew Wood et al., *Safety First For Automated Driving* INTEL: NEWSROOM (2019), https://newsroom.intel.com/wp-content/uploads/sites/11/2019/07/Intel-Safety-First-for-Automated-Driving.pdf [https://perma.cc/9SXK-RLRX].

331 Shai Shalev-Shwartz et al., *On a Formal Model of Safe and Scalable Self-driving Cars*, MOBILEYE 1, 1-2 (2017), https://arxiv.org/pdf/1708.06374.pdf [https://perma.cc/FAW5-FGQ8].

332 Christopher Greer et al., *Workshop Report: Consensus Safety Measurement Methodologies for ADS-Equipped Vehicles*, NIST: U.S. DEPT. OF COMMERCE, 1 (2019), https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1900-320.pdf [https://perma.cc/T4EY-7T5A].

333 *Id.* at 23.

334 *Id.*

commercial release of AVs before conclusive safety demonstration standards are established pose a risk to public safety as well as manufactures, who may face heightened liability exposure.

The second important factor affecting the outcome of cases in which another vehicle or bystander was the immediate cause of the crash is jury perceptions of AV safety. These perceptions will affect how jurors apply product liability doctrine in making the initial determination of liability and damages, and even more importantly, in deciding whether punitive damages are warranted.

On one hand, if jurors understand that AVs represent a significant safety improvement over human-driven cars, and that some residual accidents are inevitable, they may be more forgiving of AV developers and manufacturers. While such jurors may still hold AV companies responsible for the harms they do cause, they will be less inclined to impose liability when another party was primarily responsible for the accident, therefore less inclined to impose punitive damages.

On the other hand, certain attributes of AVs avail themselves to significant punitive damages exposure. First, AVs powered by artificial intelligence represent an unfamiliar risk with which jurors may be uncomfortable, thereby identifying as the type of "dread" risk that are particularly susceptible to distrust and large punitive advantages awards.[335] Second, the safety claims that AV manufacturers will and should make may present a double-edged sword. Studies and prior precedents show that jurors are particularly harsh towards products that claim to improve safety but end up harming some individuals, or where a product manufacturer makes unrestricted claims of safety.[336] In making accurate and supportable claims about the relative safety of AVs, companies might shield themselves from exposure to punitive damages by clearly warning that, although they may be safer than other vehicles overall, AVs will be subject to occasional errors and mishaps, assuring that the company will carefully monitor for and immediately fix fleet-wide any such errors. Conversely, in making unsupported or overly broad claims of AV safety, such manufacturers are setting themselves up for punitive damage awards in the events where AVs are involved in injury-producing accidents, which will inevitably occur.

Despite product liability's aim to improve public safety, excessive liability for AVs may diminish public safety. If liability costs result in higher consumer prices for AVs, fewer AVs will replace human drivers, resulting in more accidents and decreased safety.[337] Moreover, uncertainty about liability exposure for AVs may cause manufacturers and their suppliers to slow development and deter introduction of AVs into the market, again leading to lower public safety.[338]

[335] *See* discussion *supra* Section IV.B.1.

[336] *See supra* text accompanying notes 291-292.

[337] *See* Smith, *supra* note 15, at 6.

[338] Marchant et al., *supra* note 106, at 1322; Smith, *supra* note 15, at 6.

There remain many uncertainties in trying to quantify the increased liability risk for AV developers and manufacturers. A recent estimate, which relied on a series of assumptions that were admittedly rough guesses, approximated that liability for AV manufacturers from crashes would, if passed on to vehicle purchasers, range from five to thirty-four percent of annual vehicle ownership costs, depending on the assumptions used.[339] However, this analysis did not consider the potential increased costs from higher punitive damages awards, discussed above, which are likely to be the greatest liability risk for AV developers and manufacturers. The monetary amounts of punitive damage awards are difficult to predict. Although factors such as outrage can be used to predict with some reliability the punitive intent of jurors, the actual amount awarded in a given case or set of cases remains uncertain and cannot be accurately predicted.[340]

The deterrent effect that liability may have on AV development and deployment is contrary to public safety, and therefore the purported goals of product liability doctrine. This is not the first time such an effect has occurred – large liability awards also deterred new vaccines, again harming public safety.[341]

If the analysis in this article is correct, that the real or perceived impacts of product liability may deter or slow the implementation of AVs that can potentially safe thousands of lives per year in the United States alone, then some degree of policy intervention may be necessary. An AV company may be able to partially mitigate its risk of punitive damages by showing conformity to industry or government safety standards, if and when they exist, thereby demonstrating a commitment to meeting expert safety expectations. Several initiatives are currently underway to develop consensus private safety standards for AVs that would give guidance to AV manufacturers and provide a baseline to judges and juries for evaluating appropriate levels and evidence of AV safety prior to deployment.[342]

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[339] *Id.* at 62.

[340] *See* Kahneman et al., *supra* note 297, at 78.

[341] *See* NAT'L RESEARCH COUNCIL, *Vaccine Supply and Innovation: Chapter 6, Liability for the Production and Sale of Vaccines*, 1, 85 (1985).

[342] *See, e.g.,* Shalev-Shwartz, *supra* note 331 (proposing a Responsibility-Sensitive Safety (RSS) standard for demonstrating safety of AVs); Sam Abuelsamid, *SAE International Ready to Tackle Automated Vehicle Safety Testing Standards*, FORBES (Aug. 1, 2018, 7:27 AM), https://www.forbes.com/sites/samabuelsamid/2018/08/01/sae-international-ready-to-tackle-automated-vehicle-safety-testing-standards/#712ed52f733c [https://perma.cc/2B6K-58W4]; *Automotive and Mobility Industry Leaders Publish First-of-its-Kind Framework for Safe Automated Driving Systems*, BUS. WIRE (July 2, 2019, 9:58 AM), https://www.businesswire.com/news/home/20190702005370/en/Automotive-Mobility-Industry-Leaders-Publish-First-of-its-Kind-Framework [https://perma.cc/CBH7-EVZE] (describing release of Safety First for Automated driving (SaFAD) white paper by eleven AV industry leaders that provides a "non-binding organized framework for the development, testing and validation of automated passenger vehicles").

While consensus safety standards likely present the best route for making AV liability more principled and predictable, other more radical interventions are available if standards fail to provide adequate assurance against AV liability with socially non-optimal consequences. One option would be to preempt all product liability claims against AVs.[343] However, this remedy would likely be too radical, as it would completely obliterate both the deterrence and compensation functions of tort law. Another option would be to create an alternative compensation system for AV injuries, as Congress did for childhood vaccines, to prevent products that have a positive net public impact on public health or safety from being pushed out of market due to mounting liability.[344] Yet other legislative limits or requirements for AV liability lawsuits are also possible.[345]

If, as this article posits, AV liability has a socially detrimental net effect on public safety, it appears likely that federal and state legislatures will work to enact statutory and regulatory measures to counteract such risks. The means and mechanisms for how such bodies react warrants additional scholarly and public policy research and debate.

[343] *See* Mark Geistfeld, *The Regulatory Sweet Spot for Autonomous Vehicles*, 53 WAKE FOREST L. REV. 337, 341 (2018).

[344] *See* Tracy Hresko Pearl, *Compensation at the Crossroads: Autonomous Vehicles & Alternative Victim Compensation Schemes,* 60 WM. & MARY L. REV. 1827, 1850 (2019).

[345] *See generally,* Brett A. Ross, *Automated Vehicle Lawsuits: How Will We Litigate the Auto Crash of the Future*, 47 THE BRIEF (ABA), 42, 46-48 (2018).