

CRASHED SOFTWARE: ASSESSING PRODUCT LIABILITY FOR SOFTWARE DEFECTS IN AUTOMATED VEHICLES

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ABSTRACT

Automated vehicles will not only redefine the role of drivers, but also present new challenges in assessing product liability. In light of the increased risks of software defects in automated vehicles, this Note will review the current legal and regulatory framework related to product liability and assess the challenges in addressing on-board software defects and cybersecurity breaches from both the consumer and manufacturer perspective. While manufacturers are expected to assume more responsibility for accidents as vehicles become fully automated, it can be difficult to determine the scope of liability regarding unexpected software defects. On the other hand, consumers face new challenges in bringing product liability claims against manufacturers and developers.

INTRODUCTION

The automated car¹ is no longer a fiction. Tech companies, such as Google and Apple, as well as many traditional automakers, have begun investing in automated vehicle technologies.² Most recently, Dyson, a company most famous for its vacuum cleaners, announced plans to develop an electric vehicle equipped with basic self-driving features by

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¹ While there are varying terms referring to automated vehicles, such as self-driving vehicles, driverless vehicles, and autonomous vehicles, I will use the term “automated vehicles” as recognized by the National Highway Traffic Safety Administration (NHTSA). See *Automated Vehicles for Safety*, NAT’L HIGHWAY TRAFFIC SAFETY ASS’N, <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety> (last visited Apr. 19, 2018).

² Danielle Muoio, *19 Companies Racing to Put Self-Driving Cars on the Road By 2021*, BUS. INSIDER (Oct. 17, 2016, 1:12 PM), <http://www.businessinsider.com/companies-making-driverless-cars-by-2020-2016-10/#honda-is-aiming-to-produce-cars-that-are-completely-driverless-on-highways-by-2020-13>.

2020.³ In addition to transforming one's driving experience, automated vehicles also have great potential to improve road safety and reduce the risk of injury and death to passengers.⁴ Some of the benefits of automated vehicles listed in the National Highway Traffic Safety Administration's (NHTSA) latest guidance for automated driving systems include a decrease in accidents, reduced traffic congestion, and increased mobility options for those with disabilities.⁵

This Note will review the increasing importance, and potential risks, of software safety in automated vehicles, as well as the challenges in applying the existing product liability theories to accidents caused solely by software defects in fully automated vehicles. While this new market is still in its infancy, the fast pace of technological advances requires policymakers to closely monitor development and ensure that this new technology is safely introduced into the public sphere. The accident involving Tesla's Model S in May 2016, which resulted in the death of the driver, suggests that courts may soon be faced with cases analyzing the liability of accidents caused by fully automated vehicles.⁶ As cars become increasingly dependent on software and electronics, they will also become more susceptible to accidents caused by software defects. Unfortunately, it is unclear whether current product liability theories will effectively resolve disputes regarding defects of the rapidly developing automated vehicle technology. Therefore, an adequate framework for assessing vehicle products liability regarding these new technologies should be in place to incentivize manufacturers to enhance the safety of these vehicles,

³ James Titcomb, *Dyson Plans to Launch Electric Car in 2020*, TELEGRAPH (Sept. 26, 2017, 4:45 PM) <http://www.telegraph.co.uk/technology/2017/09/26/dyson-build-first-electric-car-uk-2020/>.

⁴ JAMES M. ANDERSON ET AL., AUTONOMOUS VEHICLE TECHNOLOGY: A GUIDE FOR POLICY MAKERS 135 (2016).

⁵ NAT'L HIGHWAY TRAFFIC SAFETY ASS'N, *supra* note 1.

⁶ *Preliminary Report, Highway HWY16FH018*, NAT'L TRANSP. SAFETY BOARD, <https://www.nts.gov/investigations/AccidentReports/Pages/HWY16FH018-preliminary.aspx> (last visited Dec. 1, 2017) (noting that the driver of the Tesla Model S was using Tesla's driver assistance feature when the car collided at 74 mph with a semitrailer); *see also* Sam Levin, *Uber crash shows 'catastrophic failure' of self-driving technology, experts say*, GUARDIAN (Mar. 22, 2018, 3:32 PM), <https://www.theguardian.com/technology/2018/mar/22/self-driving-car-uber-death-woman-failure-fatal-crash-arizona> (self-driving Uber SUV struck a pedestrian crossing a street at night); *see also* Sean O'Kane, *Tesla defends Autopilot after fatal Model X crash*, THE VERGE (Mar. 28, 2018, 11:46 AM), <https://www.theverge.com/2018/3/28/17172178/tesla-model-x-crash-autopilot-fire-investigation> (Tesla Model X crashed into the safety barrier and the driver died from injuries sustained in the crash).

provide drivers appropriate expectations when it comes to safety and liability, and promote the use of these vehicles.

I. BRIEF HISTORY OF AUTOMATED VEHICLE TECHNOLOGY

The idea of an autonomous vehicle was introduced to the public as early as 1939 at the World's Fair in New York, where the theme of the international exposition was the "World of Tomorrow" and an automaker envisioned highway traffic able to move at "unreduced rates of speed," achieved by maintaining a safe distance between cars through "automatic radio control."⁷ Later, General Motors and the Radio Corporation of America developed automated highway technology and demoed the 1958 Chevrolet Impala, equipped with technology that adjusted the steering wheel independent of any cues (steering) by the driver.⁸ In the 1980s, a German aerospace engineer, Ernst Dickmanns, tested a vehicle with cameras and microprocessors that drove 20 kilometers at 90 kilometers per hour.⁹ In 1995, roboticists at Carnegie Mellon University tested the NavLab 5, which drove almost 70 miles without human intervention.¹⁰

The Defense Advanced Research Projects Agency (DARPA) contributed to the significant development of automated vehicle technology by holding the first long distance competition for automated vehicles in 2004.¹¹ Although none of the cars managed to finish the course in 2004, five vehicles successfully completed a 132-mile course in the following year's Grand Challenge.¹² Sebastian Thrun, who led the development of Stanley, an automated vehicle which won the 2005 Grand Challenge, later started Google's self-driving car project in 2009.¹³ As of May 2017, Google's automated vehicle had driven without a pilot for three

⁷ See ANDERSON ET AL., *supra* note 4, at 1; Jeff Quitney, *Futurama 1939 New York World's Fair "To New Horizons" 1940 General Motors 23min*, YOUTUBE (Aug. 7, 2012), <https://www.youtube.com/watch?v=1cRoaPLvQx0>. See also Alan Taylor, *The 1939 New York World's Fair*, THE ATLANTIC (Nov. 1, 2013), <https://www.theatlantic.com/photo/2013/11/the-1939-new-york-worlds-fair/100620/>.

⁸ Tom Vanderbilt, *Autonomous Cars Through the Ages*, WIRED (Feb. 6, 2012, 6:30 AM), <https://www.wired.com/2012/02/autonomous-vehicle-history/>.

⁹ *Id.*

¹⁰ *Id.*

¹¹ Denise Chow, *DARPA and Drone Cars: How the US Military Spawned Self-Driving Car Revolution*, LIVE SCIENCE (Mar. 21, 2014, 2:27 PM) <https://www.livescience.com/44272-darpa-self-driving-car-revolution.html>.

¹² *Id.*

¹³ Danielle Muoio, *Here's Everything We Know About Google's Driverless Cars*, BUS. INSIDER (July 25, 2016, 2:50 PM), <http://www.businessinsider.com/google-driverless-car-facts-2016-7/>.

million miles.¹⁴ Google has tested the vehicles in five U.S. states.¹⁵ In 2016, National Highway Traffic Safety Administration acknowledged in one of its statements regarding automated vehicles that “partially and fully automated vehicles are nearing the point at which widespread deployment is feasible.”¹⁶

II. INCREASED IMPORTANCE OF SOFTWARE SAFETY IN VEHICLES

Software is becoming increasingly important in conventional vehicles. John Paul McDuffie, the Director of the Program on Vehicle and Mobility Innovation (PVMI) at the University of Pennsylvania, stated, “the average Ford auto by 2010 already had more lines of code than a Boeing Dreamliner aircraft.”¹⁷ According to a 2017 independent advisory firm report, vehicle defects related to integrated electronic components and software are the likely cause of the increased number of recalls in recent years.¹⁸ For example, the report noted that General Motors recalled 3.6 million vehicles in 2016 because the computers in the recalled vehicles could cause the airbags and seatbelts to malfunction.¹⁹

Inevitably, automated vehicles will involve more integration of complex technologies that might be vulnerable to internal software defects or a third party breach. Particularly, increased connectivity of modern vehicles poses a greater threat to software hacking than ever before. This concern was evidenced in a class action lawsuit filed against Toyota, Ford, and General Motors in 2015, alleging that the computer technology in their vehicles was susceptible to hacking.²⁰ Also, in an experiment conducted by two security engineers on an unaltered 2014 Jeep Cherokee, engineers found that they could remotely control the Jeep driving at low speeds,

¹⁴ *On the Road*, WAYMO, <https://waymo.com/ontheroad/> (last visited Dec. 1, 2017).

¹⁵ *Id.*

¹⁶ “DOT/NHTSA POLICY STATEMENT CONCERNING AUTOMATED VEHICLES” 2016 UPDATE TO “PRELIMINARY STATEMENT OF POLICY CONCERNING AUTOMATED VEHICLES,” AM. ASS’N MOTOR VEHICLE ADMINS. 1 (Jan 14, 2016).

¹⁷ *Connected Vehicles: How Soon Will They Hit the Road?*, WHARTON SCHOOL (Aug. 1, 2017), <https://pvmi.wharton.upenn.edu/news/driverless-connected-vehicles/>.

¹⁸ Neil Steinkamp, *2016 Automotive Warranty & Recall Report*, STOUT ADVISORY (May 1, 2016), <https://www.stoutadvisory.com/insights/report/2016-automotive-warranty-recall-report>.

¹⁹ *Id.*

²⁰ *Cahen v. Toyota Motor Corp.*, 147 F. Supp. 3d 955, 958 (N.D. Cal. 2015).

including its brakes and steering.²¹ Manufacturers can likely expect more product liability claims involving software vulnerability in the future.

III. CURRENT PRODUCT LIABILITY TEST

In addition to a breach of warranty claim, under current tort liability theories, a plaintiff could claim that the seller or the manufacturer is liable for a vehicle defect under either strict product liability or negligence theory.²² While there may be variations across jurisdictions, the Restatement (Second) of Torts defines negligence as “conduct which falls below the standard established by law for the protection of others against unreasonable risk of harm.”²³ In the case of a fully automated vehicle, negligence theory may not be appealing for plaintiffs since manufacturers will likely exercise reasonable care, or at least make it difficult to prove otherwise, to avoid causing any unreasonable risk of injury. Unless manufacturers recklessly fail to protect against standard risks involved in driving a vehicle, plaintiffs would likely fail to prove that the manufacturers’ conduct fell below the necessary standard.

On the other hand, manufacturers may still be liable under strict product liability regardless of whether they exercised the duty of reasonable care.²⁴ The three categories of defects under the product liability theory are manufacturing defects, design defects, and warning defects.

A. Manufacturing Defect

Manufacturing defects can be found when the product does not meet the intended specification set by the manufacturer.²⁵ The idea of a manufacturing defect is based on the expectation that “a mass-produced product will not differ from its siblings in a manner that makes it more

²¹ CHRIS VALASEK & CHARLIE MILLER, REMOTE EXPLOITATION OF AN UNALTERED PASSENGER VEHICLE 87–88 (2015), *available at* https://ioactive.com/pdfs/IOActive_Remote_Car_Hacking.pdf.

²² RESTATEMENT (SECOND) OF TORTS §§ 402A, 281 (AM. LAW INST. 1979); RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(a) (AM. LAW INST. 1998).

²³ RESTATEMENT (SECOND) OF TORTS § 281 (AM. LAW INST. 1979)

²⁴ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmt. (a) (AM. LAW INST. 1998) (noting it “is no defense that [manufacturers] acted reasonably and did not discover a defect in the product”).

²⁵ *Id.* at § 2(a) (“A product (a) contains a manufacturing defect when the product departs from its intended design even though all possible care was exercised in the preparation and marketing of the product.”); RESTATEMENT (SECOND) OF TORTS § 402A (AM. LAW INST. 1965).

dangerous than the others.”²⁶ In the context of vehicle defects, the consumer would have to show that the vehicle, or the vehicle part, did not operate as the manufacturer warranted.

Plaintiffs might be able to use circumstantial evidence to prove that a product malfunctioned.²⁷ Under this approach, plaintiffs would only have to show that “(1) the product malfunctioned, (2) the malfunction occurred during proper use, and (3) the product had not been altered or misused in a manner that probably caused the malfunction.”²⁸ For example, a court found Toyota’s vehicle at fault by applying the principles of *res ipsa loquitur* regarding an alleged sudden acceleration claim against Toyota when there was no traceable record plaintiffs could find from the defective vehicle.²⁹ Courts might not always accept this theory, and they may disallow “plaintiffs or juries to rely on guess, conjecture, or speculation.”³⁰ But, manufacturers should be wary of the uncertainty and lack of clarity surrounding their potential liability.

B. Design Defect

A plaintiff can bring a design defect claim if the product is designed in an unreasonably dangerous manner. Under the Restatement (Second) of Torts, the consumer expectations test is used. The Restatement (Third) of Torts, however, rejects the consumer expectations test and instead adopts the risk-utility test to prove design defects.³¹

1. Consumer Expectations Test

While the Restatement (Third) of Torts rejects the consumer expectations test, some states may still use this test.³² The Restatement

²⁶ *Casey v. Toyota Motor Eng'g & Mfg. N. Am., Inc.*, 770 F. 3d 322, 329 (5th Cir. 2014) (quoting *Green v. R. J. Reynolds Tobacco Co.*, 274 F. 3d 263, 268 (5th Cir. 2001)).

²⁷ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(a) cmt. a (AM. LAW INST. 1998) (describing the method as “a function similar to the concept of *res ipsa loquitur*, allowing deserving plaintiffs to succeed notwithstanding what would otherwise be difficult or insuperable problems of proof”).

²⁸ David G. Owen, *Manufacturing Defects*, 53 S.C. L. REV. 851, 873 (2002); *see also* *White v. Mazda Motor of Am., Inc.*, 99 A.3d 1079, 1090 (Conn. 2014).

²⁹ *In re Toyota Motor Corp. Unintended Acceleration Mktg., Sales Practices, and Prods. Liab. Litig.*, 978 F. Supp. 2d 1053, 1096–97 (C.D. Cal. 2013).

³⁰ Owen, *supra* note 28, at 878.

³¹ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. g (AM. LAW INST. 1998) (noting that “consumer expectations do not constitute an independent standard for judging the defectiveness of product designs.”).

³² *See Crump v. Versa Prods., Inc.*, 400 F.3d 1104, 1108 (8th Cir. 2005) (“A product is ‘actionable if dangerous to an extent beyond that which would be contemplated by the ordinary consumer, who either purchases it or uses it, with

(Second) of Torts defines a design defect as a “condition not contemplated by the ultimate consumer, which will be unreasonably dangerous to him.”³³ To be “unreasonably dangerous,” the product “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.”³⁴

In *McCabe v. Am. Honda Motor Co.*, the court further discussed the applicability of this test in a product liability action regarding a failed airbag.³⁵ Accepting the application of the consumer expectations test, the court noted that an ordinary consumer’s expectations should not be assessed based on his knowledge of the product in isolation, but instead “in the context of the facts and circumstances of its failure” to see if he “can form minimum safety expectations.”³⁶ However, not all courts will adopt the consumer expectations test for product liability claims, especially for technically complex issues. For example, in a plaintiff’s design defect claim regarding her vehicle’s airbag deployment that caused her injury, the First Circuit Court of Appeals noted that “consumer expectations cannot be the basis of liability in a case involving complex technical matters.”³⁷

Since automated vehicle technologies are still in their infancy, consumer expectations for “reasonable safety” are likely to change dramatically over time. Although the public might be hesitant to believe in the safety of current automated vehicle technology, consumers will likely expect fully automated vehicles to operate in a reasonably safe manner once they become more readily available.³⁸ The NHTSA ranks vehicles based on their level of automated technology.³⁹ If the highest NHTSA level of automated vehicle technology is in fact achieved and

the ordinary knowledge common to the community as to its characteristics”); *Griffin v. Suzuki Motor Corp.*, 124 P.3d 57, 63 (Kan. 2005) (noting that “the final test is one of consumer expectations” for a design defect claim).

³³ RESTATEMENT (SECOND) OF TORTS § 402A cmt. g (AM. LAW INST. 1979).

³⁴ *Id.* at cmt. i.

³⁵ *McCabe v. Am. Honda Motor Co.*, 123 Cal. Rptr. 2d 303, 313 (Cal. Ct. App. 2002).

³⁶ *Id.*

³⁷ *Quintana-Ruiz v. Hyundai Motor Corp.*, 303 F.3d 62, 77 (1st Cir. 2002).

³⁸ See Jack Barkenbus, *To Get the Most Out of Self-Driving Cars, Tap the Brakes on Their Rollout*, CONVERSATION (Jan. 3, 2018, 6:25 AM), <https://theconversation.com/to-get-the-most-out-of-self-driving-cars-tap-the-brakes-on-their-rollout-88444>.

³⁹ See *Automated Vehicles for Safety*, NAT’L HIGHWAY TRAFFIC SAFETY ASS’N, <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety> (last visited Apr. 19, 2018).

becomes available, ordinary consumers, as well as courts, might find it reasonable to expect a very high level of safety from automated vehicles.⁴⁰

2. Risk-Utility Test

While rejecting the consumer expectations test, the Restatement (Third) of Torts endorses the risk-utility test for design defects.⁴¹ The risk-utility test finds a product to be defective when that product's foreseeable risk of harm "could have been reduced or avoided" by adopting "a reasonable alternative design . . ." and not doing so "renders the product not reasonably safe . . ."⁴² The Restatement (Third) further explains the balance between risks and benefits by adding that "excessively safe" products would not be any more beneficial than "products that are too risky."⁴³

Courts might evaluate a number of factors to assess whether the level of danger outweighs the utility of a product. For example, the New York Court of Appeals has identified seven factors to consider in a risk-utility test:⁴⁴

- (1) the utility of the product to the public as a whole and to the individual user;
- (2) the likelihood that it will cause injury (also known as the nature of the product);
- (3) the availability of a safer design;
- (4) the potential for designing and manufacturing the product so that it is safer but remains functional and reasonably priced;
- (5) the ability of the plaintiff to avoid injury by careful use of the product;
- (6) the degree of awareness of the potential danger of the product which can reasonably be attributed to the plaintiff; and
- (7) the manufacturer's ability to spread any cost related to improving the safety of the design.⁴⁵

The key to prevailing on a risk-utility test is to show a reasonable alternative design that would have reduced the risk of harm as noted in

⁴⁰ See *id.* (noting the highest level of automation is when "the vehicle is capable of performing all functions under all conditions" and "the driver may have the option to control the vehicle.").

⁴¹ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. g. (AM. LAW INST. 1998). Compare *Branham v. Ford Motor Co.*, 701 S.E.2d 5, 16–17 (S.C. 2010) (remanding case for retrial using "risk-utility test and not the consumer expectations test"), with *Aubin v. Union Carbide Corp.*, 177 So. 3d 489, 520 (Fla. 2015) (adhering to the Restatement (Second) of Torts and adopting the consumer expectation test in a design defect case).

⁴² RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(b) (AM. LAW INST. 1998).

⁴³ *Id.* at § 2 cmt. a.

⁴⁴ See *Voss v. Black & Decker Mfg. Co.*, 450 N.E.2d 204, 208–09 (N.Y. 1983)

⁴⁵ *Id.*

element (3) and (4) above from the New York Court of Appeals.⁴⁶ For example, under Texas law, to prevail on a design defect claim, “a plaintiff must prove that (1) the product was defectively designed so as to render it unreasonably dangerous; (2) a safer alternative design existed; and (3) the defect was a producing cause of the injury for which the plaintiff seeks recovery.”⁴⁷ In some jurisdictions, the burden of providing the risk benefit analysis shifts to the defendant if the plaintiff proves that product design is the proximate cause of the damage.⁴⁸ For example, in *McCabe*, the court held that once the injured plaintiff showed that the alleged design defect caused his injury, “the burden shifts to the defendant to prove the benefits of the design outweigh its inherent risks.”⁴⁹

In the context of software defects for vehicles, plaintiffs might be able to use subsequent updates in the software as evidence of a reasonable alternative design. However, this would not be permitted in federal courts unless such updates were made prior to the accident due to Federal Rules of Evidence 407.⁵⁰ In contrast, state courts might allow subsequent measures by manufacturers as evidence for strict product liability claims. For example, the Supreme Court of California held that California Evidence Code § 1151, which bars the admission of subsequent remedial measures as evidence, applies to prove negligence or culpability but not strict liability.⁵¹ Similarly, the Supreme Court of Wisconsin held that evidence of subsequent remedial measures regarding the suspension system of the vehicle at issue is admissible.⁵²

C. Warning Defect

Plaintiffs can also bring a product liability claim for a warning defect if “foreseeable risks of harm posed by the product could have been reduced or avoided by the provision of reasonable instructions or warnings”⁵³ In other words, manufacturers have a duty to provide adequate warning of danger and to provide reasonable instructions to use the

⁴⁶ 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, 260 (2017).

⁴⁷ *Goodner v. Hyundai Motor Co., Ltd.*, 650 F.3d 1034, 1040 (5th Cir. 2011).

⁴⁸ See, e.g., *Barker v. Lull Eng'g Co.*, 573 P.2d 443, 455 (Cal. 1978); *Collazo-Santiago v. Toyota Motor Corp.*, 149 F.3d 23, 25–26 (1st Cir. 1998).

⁴⁹ *McCabe v. Am. Honda Motor Co.*, 123 Cal. Rptr. 2d 303, 315 (Cal. Ct. App. 2002).

⁵⁰ FED. R. EVID. 407 (“When measures are taken that would have made an earlier injury or harm less likely to occur, evidence of the subsequent measures is not admissible to prove . . . a defect . . . or . . . a need for a warning”).

⁵¹ *Ault v. Int'l Harvester Co.*, 528 P.2d 1148, 1150 (Cal. 1974).

⁵² *Chart v. Gen. Motors Corp.*, 258 N.W.2d 680, 683 (Wis. 1977).

⁵³ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(c) (AM. LAW INST. 1998).

product safely. Even without a manufacturing or design defect, a court might still find the manufacturer liable for failure to attach an adequate warning to a product.⁵⁴ An adequate warning does not absolve the manufacturer of a liability for other defect claims.⁵⁵ However, risks that are obvious to an ordinary consumer, or the public, do not fall under the category of risks that manufacturers have a duty to warn their consumers about.⁵⁶

Furthermore, depending on the subject matter regarding the alleged warning defect, expert testimony might be required. For example, the court in *Ruggiero v. Yamaha Motor Corp.*, finding no need for expert testimony regarding a product defect claim for a personal watercraft, still noted that “expert testimony is required in a warning defect case where the subject matter ‘falls outside of the common knowledge of the factfinder and depends on scientific, technical, or other specialized knowledge.’”⁵⁷ For software defects of automated vehicles, courts are likely to find that the technical issues fall outside of consumers’ common knowledge.

IV. APPLICATION/LIMITATIONS

A. How Much Control Is Attributable to the Manufacturer or the Software Designer?

One of the most important considerations in the shift of focus on product liability assessment from regular vehicles to automated vehicles is: with the shift of control over the vehicle, which parties will assume new liability? As vehicles become more fully automated, accidents are less likely to be caused by driver error but more likely to be caused by product defects, and manufacturers may assume increased liability for accidents related to these mechanical errors.⁵⁸ The challenge lies in determining to

⁵⁴ See *Battersby v. Boyer*, 526 S.E.2d 159, 162 (Ga. Ct. App. 1999) (“[A] duty to warn can arise even if a product is not defective.”).

⁵⁵ See *Uloth v. City Tank Corp.*, 384 N.E.2d 1188, 1192 (Mass. 1978) (“Whether or not adequate warnings are given is a factor to be considered on the issue of negligence, but warnings cannot absolve the manufacturer or designer of all responsibility for the safety of the product.”).

⁵⁶ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. j (AM. LAW INST. 1998) (explaining that typically “no duty is owed to warn of obvious and generally known dangers”).

⁵⁷ *Ruggiero v. Yamaha Motor Corp.*, No. 15-49 (JBS/KMW), 2017 U.S. Dist. LEXIS 48908, at *24–25 (D.N.J. Mar. 31, 2017) (quoting *Jerista v. Murray*, 883 A.2d 350, 364 (N.J. 2005)).

⁵⁸ See GILLIAN YEOMANS, LLOYD’S EXPOSURE MANAGEMENT, AUTONOMOUS VEHICLES HANDING OVER CONTROL: OPPORTUNITIES AND RISKS FOR INSURANCE 18–19 (2014) (discussing the potential for increased liability to manufacturers of automated vehicles).

what extent the automated vehicle's software or algorithm defect is attributable to the manufacturer.

One may argue that software is only as good as its designers and programmers, and those who design the software should be liable for any on-board software defect, including defects that may result from the designer's failure to predict a particular problem. The accident of a 2005 Toyota Camry that accelerated suddenly, injured the driver, and took the life of the passenger illustrates the difficulty of detecting a software defect before it is too late.⁵⁹ The plaintiffs argued that the electronic throttle system of the vehicle had a design defect and caused the sudden acceleration.⁶⁰ One of the plaintiff's expert's testimony during the trial illustrates the three problems that engineers face with preventing software defects.

[J]ust because a company and its engineers think up 100 possible things that can go wrong, or a thousand possible things that can go wrong and implement a set of failsafes that they think will defend against them, there is two problems with that. The first is the failure of imagination possibility, which is it didn't get on their list. They forgot that it was possible that tasks could die, for example. Another possibility is that failsafe itself has a bug in it, a hole in it, a gap . . . So a third thing that can go wrong is that one of those gaps is exposed in the safety architecture. And sometimes it takes all three of those happening at once in order for your car to malfunction or to malfunction in a dangerous way that you report. For example, it might begin with a hardware . . . and that might cause a bug and that might escape detection because they didn't think of that possibility.⁶¹

Because a fully automated vehicle is expected to make decisions on its own based on its algorithm, manufacturers might argue that it would be impossible to enable such autonomous decision-making capability while still being liable for the vehicle's decisions.⁶² Regardless of how the liability gets allocated between software designers and vehicle

⁵⁹ See Brief for Petitioner at ¶ 11, *Bookout v. Toyota Motor Corp.*, No. CJ-2008-7969, 2013 WL 5596096 (Okla. Dist. Ct. Sept. 13, 2013), (No. CJ-2008-7969), 2009 WL 9155882 (Okla. Dist. Ct. Sept. 16, 2009) [hereinafter *Toyota*].

⁶⁰ See *id.*; *Toyota Sudden Unintended Acceleration Lawsuit Ends in Landmark Verdict*, BEASLEY ALLEN LAW FIRM (Oct. 28, 2013), <http://www.beasleyallen.com/news/toyota-sudden-unintended-acceleration-lawsuit-ends-in-landmark-verdict/>.

⁶¹ Transcript of Record at 60–61, *Bookout v. Toyota Motor Corp.*, No. CJ-2008-7969 (Okla. Dist. Ct. Oct. 14, 2013) [hereinafter *Transcript*].

⁶² See John W. Zipp, *The Road Will Never Be the Same: A Reexamination of Tort Liability for Autonomous Vehicles*, 43 *TRANSP. L.J.* 137, 163 (2016) (“It will be virtually impossible for an autonomous vehicle manufacturer to conceive of every possible situation that may arise while driving.”).

manufacturers, both will argue that most if not all software defects should be treated as unforeseeable risks of harm. Also, it would be difficult for plaintiffs to argue that manufacturers should be fully liable for software defects caused by unusual external causes, such as hacking.

B. Is Software a Manufactured Product?

Whether tort law regards software as a product, rather than a service, will also play a role in determining the application of product liability to software defects. A “product” is defined under the Restatement (Third) of Torts: Products Liability as a “tangible personal property distributed commercially for use or consumption.”⁶³ However, the Restatement does not consider services to be products.⁶⁴ Unlike other component parts of a vehicle, because software is not a tangible “manufactured product,” a court might find that manufacturing defect theory is not applicable for software or algorithmic errors in automated vehicles.⁶⁵ While many courts have applied contract law in software related cases under the Uniform Commercial Code, software manufacturers have not been found strictly liable for software defects based on tort product liability theories.⁶⁶

From the perspective of consumers, adopting strict liability would encourage manufacturers to perform enough tests to find and prevent

⁶³ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 19(a) (AM. LAW INST. 1998).

⁶⁴ *Id.* at § 19(b); *see id.* at § 19 cmt. a (“Apart from statutes that define ‘product’ for purposes of determining products liability, in every instance it is for the court to determine as a matter of law whether something is, or is not, a product.”).

⁶⁵ Roy Alan Cohen, *Self-Driving Technology and Autonomous Vehicles: A Whole New World for Potential Product Liability Discussion*, IADC PROD. LIAB. COMMITTEE NEWSLETTER (Int’l Ass’n Def. Counsel), May 2015, at 332, available at <http://pbnlaw.com/media/540169/Cohen-IADC-Product-Liability-May-2015.pdf>; *see also* Jeffrey K. Gurney, Article, *Sue My Car Not Me: Products Liability and Accidents Involving Autonomous Vehicles*, 13 U. ILL. J. L. TECH. & POL’Y 247, 259 (2013).

⁶⁶ *See* Joseph L. Reutiman, *Defective Information: Should Information be a “Product” Subject to Products Liability Claims?*, 22 CORNELL J. L. & PUB. POL’Y 181, 195 (2012) (“Those courts that have determined whether computer software is a ‘good’ under the Uniform Commercial Code have struggled to apply a tangible–intangible distinction and have reached conflicting conclusions. Such courts have tended to focus on the service-like aspects of a software sale as compared to the tangible aspects of the software medium.”); Robert D. Sprague, *Software Products Liability: Has Its Time Arrived?*, 19 W. ST. U. L. REV. 137, 140 (1991). *But see* Frances E. Zollers et al., *No More Soft Landings for Software: Liability for Defects in an Industry That Has Come of Age*, 21 SANTA CLARA COMPUTER & HIGH TECH. L. J. 745, 774 (2005) (contending that “software should be considered a ‘product’ for product liability purposes.”).

software defects before the software is released into the market instead of rushing to the market “in the hope that users will find the bugs and report them.”⁶⁷ Some scholars note that software industry is “no longer in its infancy” and that limiting the application of strict liability to software “that foreseeably causes physical harm when defective” could minimize the concern over other software designers whose software are less likely to cause physical harm.⁶⁸ On the other hand, strict liability could significantly stifle innovation, especially since it could hinder software developers’ use of software written by other companies or software components that were freely available.⁶⁹ Likewise, manufacturers and software designers might argue that the automated vehicle industry is not mature enough to absorb all unforeseeable risks since spreading the cost among very few buyers will not be economically feasible.⁷⁰ However, as automated vehicle technology matures, the argument that strict liability stifles innovation will likely lose its force.

How much direct control consumers have over vehicles’ software might also determine the applicability of strict liability.⁷¹ For example, when assessing liability for defects related to “extrinsic software” that consumers purchase and interact with directly consumers’ negligent behavior such as not keeping antivirus software up-to-date should be considered.⁷² However, software embedded in automated vehicles would likely be treated as “intrinsic software” since drivers might not be fully aware of the myriad list of software embedded in a vehicle, and prescribing strict liability might be appropriate.⁷³ Considering the increasing risk of physical injury due to software defects, courts and federal agencies overseeing vehicle safety standards will soon have to determine whether or to what extent strict liability can be extended to software to ensure adequate consumer protection without deterring technological progress.

⁶⁷ Zollers et al., *supra* note 66, at 769.

⁶⁸ *Id.* at 771.

⁶⁹ Seldon J. Childers, *Don’t Stop the Music: No Strict Products Liability for Embedded Software*, 19 U. FLA. J. L. & PUB. POL’Y 125, 153 (2008).

⁷⁰ *Id.* at 173.

⁷¹ T. Randolph Beard et al., *Tort Liability for Software Developers: A Law & Economics Perspective*, 27 J. MARSHALL J. COMPUTER & INFO. L. 199, 200–01 (2009).

⁷² *Id.* at 230.

⁷³ *Id.* at 230. *But see* Sean O’Kane & Lauren Goode, *George Hotz is Giving Away the Code Behind His Self-Driving Car Project*, VERGE (Nov. 30, 2016, 2:12 PM), <https://www.theverge.com/2016/11/30/13779336/comma-ai-autopilot-canceled-autonomous-car-software-free> (noting that open source software for automated vehicles might become a reality, and lie outside existing rules promulgated by the National Highway Traffic Safety Administration).

C. What Is the Impact on the Cost of Litigation?

Although records of vehicle operation and software error will be more readily available thanks to advancements in technology, this might not be good news for consumers, as they will not be able to prevail based on circumstantial evidence. The plaintiff who sought a software defect claim stemming from Camry's sudden acceleration problem in 2013 would not have enjoyed the same decision by the court without admissible evidence specifying the defect if Toyota had tracked its vehicle's software operation.⁷⁴ For example, if the recorded data of an automated vehicle in an accident indicates that driver was warned by the system to take manual control, a court might find it difficult to hold the manufacturer fully liable for the accident.

Also, courts have hesitated to accept circumstantial evidence based on the malfunction doctrine if the vehicle has been used extensively⁷⁵ or if it had been repaired.⁷⁶ Therefore, if automated vehicles have been used for an extended period or shared among multiple drivers, courts might be reluctant to attribute liability to the manufacturer or the software designer simply based on circumstantial evidence. Furthermore, due to the complex nature of automated vehicle technology, finding an expert witness to testify will be difficult and expensive.⁷⁷ Some plaintiffs might be turned away from bringing a claim because the cost of litigation would be too high and would not be covered by award.⁷⁸

On the other hand, the cost of product liability litigation as well as the impact of litigation will be also be a concern for manufacturers of automated vehicles, which might lead them to mitigate product liability claims.⁷⁹ By avoiding a product liability claim, manufacturers could

⁷⁴ *In re Toyota Motor Corp. Unintended Acceleration Mktg., Sales Practices & Prods. Liab. Litig.*, 978 F. Supp. 2d 1053, 1102 (C.D. Cal. 2013). *See also Toyota*, *supra* note 59.

⁷⁵ *See Corcoran v. Gen. Motors Corp.*, 81 F. Supp. 2d 55, 69 (D.D.C. 2000) (rejecting an inference of product defect for a vehicle used for over seven years).

⁷⁶ *See Parsons v. Ford Motor Co.*, 85 S.W.3d 323, 326 (Tex. App. 2002) (holding that "the dealer's intervening repair and replacement of the allegedly defective" ignition switch precludes application of the malfunction doctrine).

⁷⁷ Gurney, *supra* note 65, at 265–66 (noting that multiple expert witnesses will be needed to assess the highly complex algorithm of an automated vehicle).

⁷⁸ Joseph Sanders, *Adversarial Legalism & Civil Litigation: Prospects for Change*, 28 L. & SOC. INQUIRY 719, 723 (2003).

⁷⁹ François J. Castaing, *The Effects of Product Liability on Automotive Engineering Practice*, in *PRODUCT LIABILITY AND INNOVATION: MANAGING RISK IN AN UNCERTAIN ENVIRONMENT*, 77, 79 (1994) (noting that "threat of product liability" can impede manufacturers drive to implement "new or improved designs" in vehicles).

protect the reputation of their products, consumer loyalty, and corporate goodwill, which will be especially crucial for the success of this new technology.⁸⁰ Therefore, to control product liability exposure regarding their automated vehicles, manufacturers might be advised by their counsels to take preventive measures to avoid product liability exposure, including: proper warning, specifying policies regarding insurance and indemnification, and retaining experts.⁸¹ Additionally, courts often order the prevailing plaintiffs to recover attorneys' fees from defendants in product liability claims based on the terms of the contract or statute.⁸² Consequently, plaintiff-oriented attorneys might be willing to represent victims of automated vehicle related accidents on a contingency fee arrangement. This would lower consumers' financial barrier to bringing a claim.⁸³

D. What Should Consumers Expect?

As discussed in section B, the Restatement (Third) of Torts rejects the consumer expectations test for design defect claims.⁸⁴ Moreover, even if a court were to accept the consumer expectations test, consumers might not be able to argue that ordinary users' expectations regarding automated vehicles should be the basis of assessing liability since it involves a complicated, developing technology. Also, software developers might not be able to predict every possible software error deviation from a vehicle's expected operation.⁸⁵ For example, an unexpected error not traceable or attributable to the software designer is certainly plausible if the vehicle is given the capacity to truly "think independently."⁸⁶

If it is unreasonable for manufacturers to expect automated vehicles to be foolproof, courts might find that consumers should also not expect automated vehicles to be entirely free of software defects. Also,

⁸⁰ JEFFREY A. SOBLE, FOLEY & LARDNER LLP, PREEMPTING AND MITIGATING PRODUCT LIABILITY CLAIMS 2.

⁸¹ *Id.* at 4–5.

⁸² *Bylsma v. Willey*, No. 20140484, 2017 WL 5998937, at *22 (Utah Dec. 1, 2017) (noting that a court may award attorney fees "through the reciprocal attorney fee provision of the Utah Code"); *Cashio v. Kojis & Sons Signs*, 568 So. 2d 1388, 1389 (La. Ct. App. 1990) (noting that attorney fee may be awarded to the purchaser of the product in a product liability action).

⁸³ *Id.*

⁸⁴ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. g (AM. LAW INST. 1998) (noting that "consumer expectations do not constitute an independent standard for judging the defectiveness of product designs").

⁸⁵ *See Transcript, supra* note 61, at 60–61.

⁸⁶ David C. Vladeck, *Artificial Intelligence & the Law: Essay: Machines Without Principals: Liability Rules & Artificial Intelligence*, 89 WASH. L. REV. 117, 123, 126 (2014).

while the risk-utility test requires a showing of “a reasonable alternative design,” one of the major challenges for consumers in prevailing over the risk utility test might be that the technology of the vehicle in dispute might be the safest available.⁸⁷ The lack of a safer alternative design in the market would make the task of finding a reasonable alternative design almost impossible.⁸⁸

As to warning defect liability, manufacturers of automated vehicles should be very cautious, trying to temper consumer expectations through their warnings. While manufacturers competing against each other will highlight the overall safety of their vehicles, they should also try to caution consumers against unreasonable expectations regarding their vehicles’ automated driving technology.⁸⁹ Manufacturers might also need to provide real-time warnings through consumers’ vehicles once the vehicle detects that the driver is inattentive or is driving on harsh road conditions.⁹⁰

E. Is There a Solution?

Scholars have proposed a number of ideas to properly assign liability regarding accidents related to software defects in automated vehicles that are not clearly traceable to software designers or manufacturers. Despite the challenges reviewed above, liability for software defects caused by design or manufacturing error can be assessed in a similar manner as other product defects based on settled product liability theories. Therefore, finding solutions for rare software defects that are at odds with the software designer’s direction and cannot be traced to a human error will be most difficult.⁹¹

Conferring personhood on the vehicle has been one of the possible suggested solutions.⁹² By treating each automated vehicle as a separate business entity, victims of vehicle defects can bring claims against the vehicle without deterring manufacturers from producing more automated

⁸⁷ RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(b) (AM. LAW INST. 1998).

⁸⁸ Gurney, *supra* note 65, at 265.

⁸⁹ See K.C. Webb, *Products Liability & Autonomous Vehicles: Who’s Driving Whom?*, 23 RICH. J.L. & TECH. 9, 40 (2016). (noting that manufacturers would seek to manage consumer expectations, and provide adequate warnings for safe use of AVs, while simultaneously encouraging use and advertising the overall increased safety of the product).

⁹⁰ Gurney, *supra* note 65, at 269–70.

⁹¹ See Vladeck, *supra* note 86, at 126 (discussing that assigning liability for errors caused by human would not be difficult and that automated vehicles should be held at the same or even higher standard errors traceable to manufacturers).

⁹² *Id.* at 129.

vehicles. In fact, NHTSA has recently indicated to Google that the artificial intelligence system in the autonomous vehicle could be interpreted as the driver.⁹³ To do so, devising an insurance program for each automated vehicle that would enable the vehicle to be treated as the “driver” and compensate the victim would be necessary.⁹⁴ For example, insurance costs might have to be factored into the purchase price of an automated vehicle.⁹⁵

Also, manufacturers should be discouraged from setting unreasonable expectations for consumers during advertising and sales that their automated vehicles will be error free.⁹⁶ While customers buying vehicles today would not expect current automated vehicle technology to be completely reliable, the high expectations of modern day consumers of electronics would likely transfer to automated vehicle industry.⁹⁷ Although manufacturers do not have to warn of obvious risks involved in driving, they should not set unreasonable expectations for the safety of automated vehicles and should be warned of potential risks.⁹⁸ If the software in automated vehicles require updates, manufacturers should alert end-users in a timely manner.⁹⁹ Also, to prevent security breach, manufacturers should communicate critical security information to the end-users of automated vehicles in a timely manner.¹⁰⁰

Manufacturers should also specify the allocation of liability with software vendors for potential software defects in automated vehicles.¹⁰¹ If manufacturers and software vendors are separate entities, the contractual

⁹³ David Shepardson & Paul Lienert, *Exclusive: In Boost to Self-Driving Cars, U.S. Tells Google Computers Can Qualify as Drivers*, REUTERS (Nov. 24, 2017, 7:14 PM), <http://www.reuters.com/article/us-alphabet-autos-selfdriving-exclusive-idUSKCN0VJ00H>.

⁹⁴ Zipp, *supra* note 62, at 178.

⁹⁵ *Id.*

⁹⁶ See Vladeck, *supra* note 86, at 137 (recognizing consumer expectations are shaped by a manufacturer’s advertising and communication).

⁹⁷ See ACCENTURE MOBILITY, *AUTONOMOUS VEHICLES: PLOTTING A ROUTE TO THE DRIVERLESS FUTURE 4* (2017).

⁹⁸ Vladeck, *supra* note 86, at 137.

⁹⁹ Mauricio Paez, *The Internet of Things: Emerging Legal Issues for Businesses*, 43 N. KY. L. REV. 29, 53 (2016).

¹⁰⁰ FED. TRADE COMM’N., *CAREFUL CONNECTIONS: BUILDING SECURITY INTO THE INTERNET OF THINGS 6–9* (2015).

¹⁰¹ It is certainly plausible that technology companies will collaborate with vehicle manufacturing companies and provide automated vehicle technologies instead of being directly involved in vehicle production. See Daisuke Wakabayashi, *Apple Scales Back Its Ambitions for a Self-Driving Car*, N.Y. TIMES (Aug. 22, 2017) <https://www.nytimes.com/2017/08/22/technology/apple-self-driving-car.html>.

limitations of liability for software vendors agreed between the manufacturer and software vendor might preclude consumers from bringing a claim against the software vendor.¹⁰² At the same time, manufacturers might be able to limit their liability for on-board software defects.¹⁰³ This could leave the consumers with no one to hold accountable. One possible solution for allocating risk among all parties involved in making automated vehicles is to allocate risks born by manufacturers through a “workers-compensation-style” liability regime that shifts risks to insurance companies.¹⁰⁴ Also, to minimize the concerns about having to rely on experts in any product liability claim involving an automated vehicle, courts should continue to accept the malfunction doctrine to allow circumstantial evidence.

CONCLUSION

While widespread use of automated vehicles will significantly improve road safety, reduce traffic congestion, and improve mobility options for people with disabilities, it is unclear whether the current product liability theories can adequately assess and allocate liability for vehicle accidents caused by software defects. To encourage widespread development of automated vehicle technology, legislators must find a balance between deterring release of self-driving technology with inadequate testing and lowering the burden for manufacturers. A rule protecting consumers of automated vehicles by reducing the financial burden of pursuing a product liability claim could be one solution. Also, manufacturers could implement strategies to minimize product liability exposure and solve disputes in a timely manner in the event of malfunction to cultivate consumer interest in this new technology.

¹⁰² Crane et al., *supra* note 46, at 248.

¹⁰³ *Id.* at 232.

¹⁰⁴ *Id.* at 258.