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INTRODUCTION

The idea that humans could, at some point, develop machines that actually "think" for themselves and act autonomously has been embedded in our literature and culture since the beginning of civilization.[1] But these ideas were generally thought to be religious expressions—what one scholar describes as an effort to forge our own Gods[2]—or pure science fiction. There was one important thread that tied together these visions of a special breed of superhuman men/machines: They invariably were stronger, smarter, and sharper analytically; that is, superior in all respects to humans, except for those traits involving emotional intelligence and empathy. But science fiction writers were of two minds about the capacity of super-smart machines to make life better for humans.

One vision was uncritically Utopian. Intelligent machines, this account goes, would transform and enlighten society by performing the mundane, mind-numbing work that keeps humans from pursuing higher intellectual, spiritual, and artistic callings.[3] This view was captured in the popular animated 1960s television show *The Jetsons*.[4] As its title

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1. *See, e.g.*, PAMELA MCCORDUCK, MACHINES WHO THINK: A PERSONAL INQUIRY INTO THE HISTORY AND PROSPECTS OF ARTIFICIAL INTELLIGENCE, at xxiii–iv (2004).

2. *Id.* at 413.

3. *See* Anne Trafton, *Assistive Robot Adapts to People, New Places*, MIT TECHTALK, Apr. 11, 2007, at 3 (reporting developments from MIT's Humanoid Robotics Group in perfecting "Domo," a robot that can adapt to situations to assist people with everyday chores, everyday life, and everyday work), *available at* http://web.mit.edu/newsoffice/2007/techtalk51-23.pdf.

4. The history of *The Jetsons* can be found at various websites, including, *The Jetsons*, WIKIPEDIA, http://en.wikipedia.org/wiki/The_Jetsons (last visited Feb. 12, 2014), and, *Hanna Barbera Wiki*, *The Jetsons*, WIKIA, http://hanna-barbera.wikia.com/wiki/The_Jetsons (last visited Feb. 12, 2014).

suggests, the show's vision is decidedly futuristic. The main character, George Jetson, lives with his family in a roomy, bright, and lavishly furnished apartment that seems to float in the sky. George and his family travel in a flying saucer-like car that drives itself and folds into a small briefcase. All of the family's domestic needs are taken care of by Rosie, the robotic family maid and housekeeper, who does the household chores and much of the parenting.[5] George does "work." He is employed as a "digital index operator" by Spacely's Space Sprockets, which makes high tech equipment. George often complains of overwork, even though he appears to simply push buttons on a computer for three hours a day, three days a week.[6] In other words, the Jetsons live the American dream of the future.

In tangible ways, this Utopian vision of the partnership between humans and highly intelligent machines is being realized. Today, supercomputers can beat humans at their own games. IBM's "Deep Blue" can beat the pants off chess grand-masters, while its sister-super-computer "Watson" can clobber the reigning *Jeopardy* champions.[7] But intelligent machines are more than show. Highly sophisticated robots and other intelligent machines perform critical functions that not long ago were thought to be within the exclusive province of humans. They pilot sophisticated aircraft; perform delicate surgery; study the landscape of Mars; and through smart nanotechnology, microscopic machines may soon deliver targeted medicines to areas within the body that are otherwise unreachable.[8] In every one of these examples, machines perform these complex and at times dangerous tasks as well as, if not better than, humans.

But science fiction writers also laid out a darker vision of intelligent

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5. *See* Trafton, *supra* note 3 (reporting that "Domo" is based in part on "Rosie").

6. *See generally* Harry McCracken, *The Jetsons Turns 50: How the Future Looked in 1962*, TIME (Sept. 23, 2012), http://techland.time.com/2012/09/23/the-jetsons-turns-fifty/; Steve Waldis, *Keeping Up With the Jetsons*, WIRED (Jan. 7, 2014, 11:00 AM), http://insights.wired.com/profiles/blogs/keeping-up-with-the-jetsons (comparing modern advances in "smart home" technology to *The Jetsons*); Troy Wolverton, *Your Home Could Soon Be Like the Jetsons'*, SAN JOSE MERCURY NEWS (Jan. 11, 2014, 7:10 PM), http://www.mercurynews.com/troy-wolverton/ci_24893407/wolverton-your-home-could-soon-be-like-jetsons (same).

7. Daniel C. Dennett, *Higher Games*, MIT TECH. REV. (Aug. 15, 2007) (analyzing the significance of "Deep Blue's" win over chess genius Gary Kasparov in 1997), http://www.technologyreview.com/review/408440/higher-games/; John Markoff, *Computer Wins on 'Jeopardy!': Trivial, It's Not*, N.Y. TIMES, Feb. 17, 2011, at A1, *available at* http://www.nytimes.com/2011/02/17/science/17jeopardy-watson.html?pagewanted=all (describing "Watson's" commanding success over two former Jeopardy champions).

8. *See, e.g.*, Sha Jin & Kaiming Ye, *Nanoparticle-Mediated Drug Delivery and Gene Therapy*, 23 BIOTECHNOLOGY PROGRESS 32 (2007).

machines and feared that, at some point, autonomously thinking machines would turn on humans. Some of the best science fiction expresses this dystopian view, including Stanley Kubrick's 1968 classic film *2001: A Space Odyssey*.[9] The film's star is not the main character, "Dave" (Dr. David Bowman, played by Keir Dullea), or "Frank" (Dr. Frank Poole, played by Gary Lockwood), who are astronauts on a secret and mysterious mission to Jupiter. Instead, the character who rivets our attention is HAL 9000,[10] the all-knowing supercomputer who controls most of the ship's operations, but does so under the nominal command of the astronauts. The complexity of the relationship between man and the super-intelligent machine is revealed early in the film. During a pre-mission interview, HAL claims that he is "foolproof and incapable of error,"[11] displaying human-like hubris. And when Dave is asked if HAL has genuine emotions, he replies that HAL appears to, but that the truth is unknown.[12]

Once the mission begins, tensions between HAL and the astronauts start to surface. HAL wants the astronauts to tell him the details of the highly secret mission, but Dave and Frank refuse. In fact, they too do not know. Soon thereafter, HAL warns of the impending failure of a critical antenna on the spaceship's exterior. Starting to have doubts about HAL, Dave and Frank lock themselves in an evacuation vehicle to ensure that HAL cannot overhear their conversation; HAL reads their lips through the vehicle's window. Dave and Frank decide to follow HAL's advice and replace the antenna, but in the event that HAL is wrong about the antenna's defect, they agree to shut HAL down. Frank goes on a spacewalk to replace the antenna, and, as he had planned, HAL seizes the moment to kill off the humans. He first severs Frank's oxygen hose and sets him adrift in space. Dave vainly tries to rescue Frank, and as soon as Dave leaves the spacecraft, HAL turns off the life-support

9. 2001: A SPACE ODYSSEY (Metro-Goldwyn-Mayer Pictures 1968).

10. HAL is an acronym for **H**euristically programmed **Al**gorithmic computer. *See HAL 9000*, WIKIPEDIA, http://en.wikipedia.org/wiki/Heuristically_programmed_algorithmic_computer (last visited Feb. 12, 2014); KUBRICK 2001: THE SPACE ODYSSEY EXPLAINED, http://www.kubrick2001.com/ (last visited Feb. 17, 2014). Because HAL is portrayed in the film as a living being, I will use animate, not inanimate, pronouns to refer to HAL.

11. *2001: A Space Odyssey: Quotes*, IMDB, http://www.imdb.com/title/tt0062622/quotes (last visited Feb. 26, 2014) (HAL's complete answer to the interviewer's question is as follows: "The 9000 series is the most reliable computer ever made. No 9000 computer has ever made a mistake or distorted information. We are all, by any practical definition of the words, foolproof and incapable of error.").

12. *Id.* (Dave's full response to the question is as follows: "Well, he acts like he has genuine emotions. Um, of course he's programmed that way to make it easier for us to talk to him. But as to whether he has real feelings is something I don't think anyone can truthfully answer.").

system for the three remaining crew members, who were in suspended animation. HAL then refuses to let Dave back onto the spaceship, telling Dave that the plan to deactivate him jeopardizes the mission. Ultimately, Dave makes his way back onto the spaceship and starts shutting HAL down. All the while, as HAL regresses, HAL pleads with Dave to stop, and finally expresses fear of his demise.[13]

The question one might ask at this point is what relevance does *2001: A Space Odyssey* have to liability rules for autonomous thinking machines? The answer is quite a bit. Today's machines, as path-breaking as they are, all have a common feature that is critical in assessing liability. In each case, the machine functions and makes decisions in ways that can be traced directly back to the design, programming, and knowledge humans embedded in the machine.[14] The human hand defines, guides, and ultimately controls the process, either directly or because of the capacity to override the machine and seize control. As sophisticated as these machines are, they are, at most, semi-autonomous. They are tools, albeit remarkably sophisticated tools, used by humans.

Where the hand of human involvement in machine decision-making is so evident, there is no need to reexamine liability rules. Any human (or corporate entity that has the power to do things that humans do, enter into contracts, hire workers, and so forth) that has a role in the

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13. *See* 2001: A SPACE ODYSSEY, *supra* note 9; *2001: A Space Odyssey, Quotes,* IMDB, http://www.imdb.com/title/tt0062622/quotes (last visited Feb. 26, 2014) ("I'm afraid. I'm afraid, Dave. Dave, my mind is going. I can feel it. I can feel it. My mind is going. There is no question about it. I can feel it. I can feel it. I can feel it. I'm a . . . fraid."). The same intelligent machine-versus-humans theme was explored with far less nuance but much more mayhem in the 1984 film *The Terminator*, which tells the story, set in 2029, of how an artificially intelligent defense network, "Skynet," becomes self-aware and decides to wipe-out mankind through a nuclear holocaust. Skynet nearly succeeds. Only a few humans survive, and they form a resistance movement. Over time, the resistance gains enough strength that it is on the verge of beating the machines. To regain the offensive, Skynet sends the "Terminator," played by Arnold Schwarzenegger (people forget that he was the villain in the first film), back to 1984 to kill Sarah Connor, then pregnant with John Connor, who grows up to lead the resistance against Skynet. Much entertaining violence ensues, and the film ends inclusively. *See* THE TERMINATOR (Orion Pictures Corp. 1984). John Connor and his mother survive, in part because the resistance sends its own highly intelligent robot/warrior back in time to defend them, but there is no doubt that they will face another onslaught from Skynet terminators. *Id.* These onslaughts come in an unending number of sequels involving ever more intelligent and dangerous robotic assassins, but John Connor nonetheless eludes them all, mainly because of help from a highly skilled robot warrior sent by the resistance to protect him (played by Arnold Schwarzenegger). *See, e.g.*, TERMINATOR 2: JUDGMENT DAY (TriStar Pictures 1991); TERMINATOR 3: THE RISE OF THE MACHINES (Warner Bros. Pictures, Columbia Pictures 2003). But the film's basic point is a warning to humans: Be careful what we wish for. Artificially intelligent machines that have the capacity to "think" for themselves should not be trusted because they may turn on humans.

14. *See infra* notes 15–16 and accompanying text.

development of the machine and helps map out its decision-making is potentially responsible for wrongful acts—negligent or intentional—committed by, or involving, the machine.[15] The reason, of course, is that these machines, notwithstanding their sophistication, have no attribute of legal personhood. They are agents or instruments of other entities that have legal capacity as individuals, corporations, or other legal "persons" that may be held accountable under the law for their actions.

But the fully autonomous machines that at some point will be introduced into the marketplace may be quite different, and for that reason, society will need to consider whether existing liability rules will be up to the task of assigning responsibility for any wrongful acts they commit. The first generation of fully autonomous machines—perhaps driver-less cars and fully independent drone aircraft—will have the capacity to act completely autonomously. They will not be tools *used* by humans; they will be machines *deployed* by humans that will act independently of direct human instruction, based on information the machine itself acquires and analyzes, and will often make highly consequential decisions in circumstances that may not be anticipated by, let alone directly addressed by, the machine's creators.[16] Artificial

15. There has been extensive litigation over the safety of surgical robots, especially the "da Vinci" robot. Not surprisingly, no one has claimed that the robot itself bears any liability; the claims all proceed on some form of agency theory. *See, e.g.*, O'Brien v. Intuitive Surgical, Inc., No. 10 C 3005, 2011 WL 304079, at *1 (N.D. Ill. Jul. 25, 2011) (granting summary judgment to robot's manufacturer); Mracek v. Bryn Mawr Hosp., 610 F. Supp. 2d 401, 402 (E.D. Pa. 2009) (same), *aff'd*, 363 F. App'x 925 (3d Cir. 2010).

16. It is useful to contrast the complexity of driver-less cars to what we think of as highly sophisticated machines in widespread use today. For instance, most commercial airplanes have "auto pilots," which shift control of the aircraft to a computer that "flies" the plane. So too do most vessels. But in comparison to driver-less cars, the autopilot devices perform a relatively simple set of tasks. Autopilots keep the plane or vessel on a course determined by the pilots, and do so by controlling for minor variations in winds and currents, but generally without reference to other traffic. For that reason, pilots have a duty to remain vigilant—while the machine may have the controls, the pilots are responsible for monitoring other traffic and ensuring that the autopilot is working correctly. *See, e.g.*, *In re* Korean Air Lines Disaster of Sept. 1, 1983, 932 F.2d 1475, 1478 (D.C. Cir. 1991); Boucvalt v. Sea-Trac Offshore Servs., Inc., 06-103 (La. App. 5 Cir. 10/17/06); 943 So. 2d 1204, 1208. In contrast, for autonomous cars, one key goal is to reduce the oversight required by the driver, both to maximize safety and to capture the possibility of increased productivity during long commutes. The systems that control autonomous cars are required to navigate through complex and rapidly changing environments—e.g., traffic, weather, detours and the like—and are responsible for making critical decisions—e.g., what route to take, what lane to be in, what exit to take, and so forth. *See* Dylan LeValley, Note, *Autonomous Vehicle Liability—Application of Common Carrier Liability*, 36 SEATTLE U. L. REV. 5, 7 (2013). And there may be good reasons why the designers of driver-less cars would want to *discourage* human drivers from intervening. A driver intervening to prevent what he perceives to be a possible accident may be less equipped to handle the situation than the car's autonomous driving system; he may not have monitored blind spots, heard the siren of an approaching emergency vehicle, or been privy to a

intelligence theorists distill the concept of full autonomy down to the paradigm of machines that "sense-think-act" without human involvement or intervention.[17] And Oxford Professor Nick Bostrom, an eminent futurist, goes as far as to suggest that machines "capable of independent initiative and of making their own plans . . . are perhaps more appropriately viewed as persons than machines."[18]

Assuming that this description of the capabilities of such machines is accurate, the key conceptual question that autonomous thinking machines will pose is whether it is fair to think of them as agents of some other individual or entity, or whether the legal system will need to decide liability issues on a basis other than agency. To be sure, it is hard to conceptualize a machine as being anything other than an agent of a person, be it a real person or an entity with legal personhood. But there is another argument that is worth exploring, namely that concepts of agency may be frayed, if not obliterated, by autonomous thinking machines, even those that are not truly "sentient." Let us go back to HAL. At some point before he turns murderous, HAL became an "agent" of no one. An agent who decides to go on his own frolic and detour, defying the instructions of his principal, is no longer an agent

communication sent by another vehicle in close proximity warning of some danger, and his reaction time is certainly going to be slower than the car's. *See id.* at 16 (pointing out that Air France flight 447 crashed over the Atlantic because of pilot error. When the plane's autopilot sensors stopped working due to the build-up of ice, the pilots took over control of the plane, and reacted in a way that exacerbated the icing problem, causing the plane to crash).

17. UGO PAGALLO, THE LAW OF ROBOTS: CRIMES, CONTRACTS AND TORTS 2 (2013). This Essay draws significantly on Professor Pagallo's path-breaking work, which broadly and ambitiously synthesizes the technical, philosophical, and legal questions surrounding the advent of fully autonomous, artificially intelligent machines.

18. Nick Bostrom, *When Machines Outsmart Humans*, 35 FUTURES 759, 763 (2003). Artificial intelligence theorists use the term "singularity" or "technical singularity" to describe the moment in time, purely hypothetical at this point, when machines exceed human intelligence. At that point, these theorists argue, machines will become fully sentient, and they will pose a raft of complex philosophical and legal questions with which society will have to wrestle. *See, e.g.*, NICK BOSTROM & MILAN CIRKOVIC, GLOBAL CATASTROPHIC RISKS (2008); RAY KURZWEIL, THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY 135–36 (2005); HANS MORAVEC, ROBOT: MERE MACHINE TO TRANSCENDENT MIND 61 (1999). Ray Kurzweil predicts that "singularity" is now within reach, and will be achieved within fifteen years. *See* Ben Rossington, *Robots 'Smarter Than Humans Within 15 Years,' Predicts Google's Artificial Intelligence Chief*, MIRROR NEWS (Feb. 2, 2014), http://www.mirror.co.uk/news/technology-science/technology/ray-kurzweil-robots-smarter-humans-3178027. This Essay does not suggest that the first generation of fully autonomous, artificially intelligent machines will necessarily meet the various definitions of "singularity" that have been propounded. They probably will not. For our purposes, it is sufficient to focus on machines that are capable of "learning" to the point where they can take actions in ways that are not necessarily pre-ordained by the programs that enable them, and thus present the difficult agency problems discussed in Part II, *infra*.

under any conventional understanding of the law.[19] And HAL plainly detoured. HAL was given the ability to think and act independently, so much so that he "decided" to violate the first rule of robotics: That is, machines must do no harm to humans or to humanity.[20] By deciding to harm humans, HAL at least arguably (if not decisively) terminated his status as an agent.

To be sure, HAL's capacity to violate that rule could be attributable to a manufacturing defect, design flaw, or the result of poor programming. In that case, existing legal principles would almost certainly place liability on the shoulders of HAL's creators. But suppose HAL's wrongful conduct was not a manufacturing, design, or programming flaw, but was instead an unforeseen byproduct of teaching machines to "think."[21] Sentient beings often choose to break rules, and all disciplines interested in artificial intelligence—technologists, scientists, ethicists, and philosophers alike—have long worried that giving machines the capacity to "think" autonomously necessarily gives them the capacity to act in ways that may be contrary to the "rules" they are given.[22] That conclusion, of course, lies at the heart of the academic debate over the wisdom of building artificially intelligent machines in the first place and is the animating force behind many science fiction classics.[23]

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19. *See generally* RESTATEMENT (THIRD) OF AGENCY § 7.07 (2006) ("An employee acts within the scope of employment when performing work assigned by the employer or engaging in a course of conduct subject to the employer's control. An employee's act is not within the scope of employment when it occurs within an independent course of conduct not intended by the employee to serve any purpose of the employer."); Lev v. Beverly Enters.-Mass., Inc., 929 N.E.2d 303, 308 (Mass. 2010).

20. The most famous exposition of the "law" of robots comes from Isaac Asimov's *I, Robot*, where he lays out the Three Laws of Robotics: (1) a robot may not injure a human being, or, through inaction, allow a human being to come to harm; (2) a robot must obey the orders given it by humans, except where such orders would conflict with the First Law; (3) a robot must protect its own existence, as long as such protection does not conflict with the First or Second Law. ISAAC ASIMOV, I, ROBOT 37 (1950). *See generally* ARTHUR C. CLARKE, 2001: A SPACE ODYSSEY (1968).

21. Once an autonomous machine decides for itself what course of action it should take, the agency relationship becomes frayed or breaks altogether. *See* RESTATEMENT (THIRD) OF AGENCY § 7.07 (2006); *id.* § 7.03 (describing that a principal is subject to vicarious liability for an agent's actions only when the agent is acting within the scope of employment).

22. *See* PAGALLO, *supra* note 17, at 4, 37–44, 49–55, 119–21. Oxford University Professor Nick Bostrom makes a similar argument. Nick Bostrom, *The Superintelligent Will: Motivation and Instrumental Rationality in Advanced Artificial Agents*, 22 MINDS & MACHINES 71–84 (2012); *see also* Bill Joy, *Why the Future Doesn't Need Us*, WIRED (Apr. 2000), http://www.wired.com/wired/archive/8.04/joy.html.

23. This is not pure speculation; there is already emerging evidence that highly "intelligent" autonomous machines can learn to "break" rules to preserve their own existence. *See* Bostrom, *supra* note 22, at 77; John Markoff, *Scientists Worry Machines May Outsmart Man*, N.Y. TIMES, July 26, 2009, at A1, *available at* http://www.nytimes.com/2009/07/26/science/26robot.

Assuming that an inevitable byproduct of giving a machine the capacity to "think" carries with it a risk that the machine will break the rules,[24] how would the law apply to HAL? Suppose Dave returns to Earth and demands compensation for the wrongful deaths of Frank and the three other crewmembers HAL murdered?[25] Unless the law is willing to invest an autonomous thinking machine like HAL with legal personhood, he is beyond the reach of the law. As one court observed, "robots cannot be sued," even though "they can cause devastating damage."[26]

The introduction of highly intelligent, autonomous machines may prompt reconsideration of that rule. After all, there is no a priori reason why truly autonomous machines should not be accorded some formal legal status, making them, like corporations and certain trusts, "persons" in the eyes of the law and thus subject to suit.[27] Perhaps justice would be

html?_r=1&ref=todayspaper; Jason Mick, *New Navy-Funded Report Warns of War Robots Going "Terminator,"* DAILY TECH (Feb. 17, 2009, 8:58 AM), http://www.dailytech.com/New%20Navyfunded%20Report%20Warns%20of%20War%20Robots%20Going%20Terminator/article14298.htm.

24. *See* Bostrom, *supra* note 22, at 77. As noted above, for our purposes, it is not essential that the machine has the capacity to actually choose to break a "rule"; it is enough that the machine's programming does not necessarily determine how the machine will act in all situations, leaving the machine to "learn" how to make decisions when confronted with a situation not within the contemplation of the machine's programmers.

25. Here we put aside any question of criminal liability. At some point, though, the science of artificial intelligence may evolve to the point where concepts of criminality will have to be applied to highly intelligent, autonomous machines. And perhaps that time will come sooner than many think. That was a central message of the 1982 science-fiction thriller, THE BLADE RUNNER (Warner Bros. 1982), which was set in 2019, and involved a detective played by Harrison Ford chasing down "replicants"—life-like robots—who were, like HAL, killing humans. *Id.*; *see also* BLADE RUNNER: 30TH ANNIVERSARY, http://bladerunnerthemovie.warnerbros.com/ (last visited Feb. 12, 2014).

26. United States v. Athlone Indus., Inc., 746 F.2d 977, 979 (3d Cir. 1984) (discussing how the manufacturer of a defective robotic pitching machine is liable for civil penalties for the machine's defects). Of course, the court's quip was not completely accurate. The court's point was that, because the robot lacked legal capacity, the robot could not be sued in personam. But the court's conclusion necessarily means that an in rem or quasi in rem action against a robot would be maintainable, precisely because the robot was an "object" rather than a legal "person."

27. As discussed in more depth *infra*, this proposal is not as far-fetched as it may seem, and may not require an upheaval in current law to achieve. Conceptualize a highly intelligent machine as one might think of a corporation, which through the income it earned or its intrinsic value was capitalized. There is no reason why the machine itself could not bear liability in case of wrongdoing. For driver-less cars, suppose as a condition of the sale of a driver-less car, state law requires the "car," not necessarily its purchaser, but maybe a pool consisting of the manufacturer, suppliers, and the purchaser, to obtain insurance sufficient to address any likely issue of liability. To ensure that the car remains insured, the car itself would be the policy-holder, and could not operate without valid insurance. The car might have to have a "kill switch" that would automatically disable the car in the event its insurance lapsed. But the point here is simply that the law could evolve to bestow "personhood" on machines, just as it has done for corporations. *See* Santa Clara Cnty. v. S.

served to put HAL in the dock. Until then, the question will be who, if anyone, should be held to account? Would it be fair to hold liable the companies that designed, programmed, or manufactured HAL 9000, even though they embedded in HAL's "thinking" systems the first rule of autonomous machines—i.e., never harm a human—and even though the evidence strongly suggests that HAL "taught" himself to defy their instructions? Or should the creators of machines that have the capacity to "think" be held strictly liable whenever anything goes wrong? If so, on what theory? The theory that the wrongful conduct itself is proof of a defect? Or on an insurance-based theory that the creators are in a better economic position to absorb the cost of the injury than the person harmed?

As fanciful as it may seem, these are by no means idle questions. Machines that operate and make decisions independently will at some point be introduced into the market. The first truly autonomous artificial intelligence devices that may test the adequacy of current liability rules may be cars designed to be driver-less, or at least to give human drivers the option to let the car drive itself.[28] Google's driver-less cars have been test-driven on public roads for several years and have logged hundreds of thousands of miles.[29] Although there is a human sitting in the "driver's seat," the human is, for the most part, playing the role of potted

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Pac. R. Co., 118 U.S. 394 (1886) (observing that "corporations" may be "persons" for the purposes of the Fourteenth Amendment). My Georgetown colleague, Lawrence B. Solum, first floated this idea more than two decades ago. *See* Lawrence B. Solum, *Legal Personhood for Artificial Intelligences*, 70 N.C. L. REV. 1231 (1992).

28. Gary Marcus, *Moral Machines*, NEW YORKER (Nov. 27, 2012), http://www.newyorker.com/online/blogs/newsdesk/2012/11/google-driverless-car-morality.html. As Professor Marcus observes, it may be that truly autonomous military robots or drones will be introduced first. *See also* Jason Palmer, *Call for Debate On Killer Robots*, BBC NEWS (Aug. 3, 2009, 7:09 PM), http://news.bbc.co.uk/2/hi/8182003.stm (explaining that the capacity to introduce drones that are able to make firing decisions without direct human oversight will soon be available). But that example does not lend itself to an exploration of the application of product liability rules to autonomous machines, since the law of war will plainly trump the law of products liability. *See generally* John Markoff, *War Machines: Recruiting Robots for Combat*, N.Y. TIMES, Nov. 28, 2010, at A1 [hereinafter Markoff, *War Machines*]; Joshua Foust, *Soon, Drones May Be Able to Make Lethal Decisions on Their Own*, NAT'L J. (Oct. 8, 2013), http://www.nationaljournal.com/national-security/soon-drones-may-be-able-to-make-lethal-decisions-on-their-own-20131008.

29. *See* Jeffrey K. Gurney, Note, *Sue My Car Not Me: Products Liability and Accidents Involving Autonomous Vehicles*, 2013 U. ILL. J. L. TECH. & POL'Y 247, 249 n.6. Google is not the only company engaged in the arms-race to develop a truly driver-less vehicle. Many other companies are engaged in the same enterprise. *See, e.g.*, Kevin Funkhouser, Note, *Paving the Road Ahead: Autonomous Vehicles, Products Liability, and the Need for a New Approach*, 2013 UTAH L. REV. 437, 437–38; Bryant Walker Smith, *Proximity-Driven Liability*, 102 GEO. L.J. 18 (forthcoming 2014); Andrew P. Garza, Note, *"Look Ma No Hands!": Wrinkles and Wrecks in the Age of Autonomous Vehicles*, 46 NEW ENG. L. REV. 581, 587 (2012).

plant. The car is driven by systems that use an array of radar and laser sensors, cameras, global positioning devices, many complex analytical programs and algorithms (and other devices far beyond my comprehension) to actually drive the car in much the same way that humans do, only better.[30] The car "watches" the road, constantly looks out for other cars, pedestrians, obstructions, detours, and so forth, and adjusts its speed and course to account for traffic, weather, and every other factor that affects the safe operation of the vehicle. And they are programmed to avoid a collision with a pedestrian, another vehicle, or an obstacle.[31] Google has claimed that its driver-less cars have yet to have an accident (except when one of its cars was rear-ended)—an impressive record.[32]

It is hardly surprising that Google's experience has thus far validated the hypothesis that autonomous cars would perform far more safely than cars driven by humans. Driving is risky *because* drivers are humans.[33] Humans inject risks that can be eliminated, or at least considerably mitigated, by intelligent machines. After all, the Google system that drives cars "sees" everything in the vicinity; reacts at speeds humans cannot match; and constantly checks the performance of every component in the vehicle to ensure that it is functioning properly. What's more, the system never gets drowsy or falls asleep, does not drive drunk, does not eat Big Macs or drink hot coffee, does not get distracted, does not talk on the phone or text, and does not get road rage.[34] The system focuses solely on the one activity it is designed for: Driving from point A to point B as safely and efficiently as possible.

Like human drivers, the machines that drive Google cars will on

30. *See* JAMES M. ANDERSON ET AL., AUTONOMOUS VEHICLE TECHNOLOGY: A GUIDE FOR POLICYMAKERS 58–95 (RAND Corp. 2014) [hereinafter RAND REPORT], *available at* http://www.rand.org/pubs/research_reports/RR443-1.

31. *See* Funkhouser, *supra* note 29, at 437–38, 443–44 (discussing the technology that Google cars use to avoid collisions); Smith, *supra* note 29, at 18–19; Garza, *supra* note 29, at 587–88.

32. Burkhard Bilger, *Auto Correct: Has the Self-Driving Car at Last Arrived?*, NEW YORKER (Nov. 25, 2013), http://www.newyorker.com/reporting/2013/11/25/131125fa_fact_bilger?currentPage=all; John Markoff, *Google Cars Drive Themselves in Traffic*, N.Y. TIMES, Oct. 10, 2010, at A1, *available at* http://www.nytimes.com/2010/10/10/science/10google.html?pagewanted=all.

33. Sven A. Beiker, *Legal Aspects of Autonomous Driving*, 52 SANTA CLARA L. REV. 1145, 1149 (2012) (pointing out that "[d]river error is by far (95%) the most common factor implicated in vehicle accidents"); Markoff, *War Machines*, *supra* note 28 (describing the passive role of the "driver" in a self-driving car); *see also* RAND REPORT, *supra* note 30, at 12–16.

34. *See, e.g.*, Beiker, *supra* note 33, at 1149 (identifying human error as the primary catalyst in the vast majority of car accidents); Funkhouser, *supra* note 29, at 437–38, 443–44 (discussing Google's attempts—through its self-driving cars—to eliminate human error in driving).

occasion encounter unexpected events that call for snap judgments: a child darting in front of a car; a tree limb crashing down just a few yards ahead; a car running a red light; or a patch of black ice that is undetectable on a moonless night. There are liability rules that come into play when, as a consequence of any of these unexpected events, there is injury to humans or damage to property. No matter how well-designed and programmed self-driving cars are, factors beyond the machine's control virtually guarantee that at some point the car will have an accident that will cause injury of some kind, and will act in ways that are not necessarily ordained by their programming. The question I have been asked to address in this symposium is: What liability rules should society adopt to govern artificially intelligent machines, such as the driver-less cars that soon may be right in front of us on the highway?

Answering this question requires that two different issues be addressed. The first is how to apply the law of products liability on the assumption that any liability concern with the machine is the result of human (but not driver) error—that is, a design or manufacturing defect, an information defect, or a failure to instruct humans on the safe and appropriate use of the product. In my view, the application of these reasonably settled principles is a straightforward one, and there is no justification for treating even autonomous thinking machines differently than any other machine or tool a human may use, except, perhaps, holding them to a higher standard of care.

The second question comes into play if, and only if, fully autonomous machines cause injury in ways wholly untraceable and unattributable to the hand of man.[35] This question, in my view, crystalizes the HAL problem. It is fair to assume that, if driver-less cars become the norm, there will be accidents, perhaps few and far between, that cannot fairly be attributed to a design, manufacturing, or programming defect, and

35. Again, this is an assumption, but because the vehicle's control system itself is so highly automated and continually monitors its own performance, it is likely that the vehicle's own data will shed considerable light on the cause of accidents. Indeed, most cars sold today contain "black boxes" that monitor the car's performance and often provide important clues in ascertaining the causes of accidents. *See, e.g.*, Jaclyn Trop, *A Black Box for Car Crashes*, N.Y. TIMES, July 21, 2013, at B1, *available at* http://www.nytimes.com/2013/07/22/business/black-boxes-in-cars-a-question-of-privacy.html. There is a related consideration that is worth noting: Highly autonomous cars will communicate with cars in their vicinity to ensure that a safe distance is maintained between the two vehicles. In that case, it may be that data from *other*, nearby vehicles may shed light on vehicle failures. *See* RAND REPORT, *supra* note 30, at 66–68, 79–81; Robert B. Kelly & Mark D. Johnson, *Defining a Stable, Protected and Secure Spectrum Environment for Autonomous Vehicles*, 52 SANTA CLARA L. REV. 1271, 1310 (2012) (discussing "vehicle-to-vehicle collision avoidance" communications).

where even an inference of defect may be hard to justify.[36] What should be the rule at that point, especially where the car acts in a way that is at odds with the instructions of its creators? Tort law is ordinarily unwilling to let people injured through no fault of their own bear costs imposed by others. So the question then becomes, "Who pays?" The only feasible approach, it would seem, would be to infer a defect of some kind on the theory that the accident itself is proof of defect, even if there is compelling evidence that cuts against a defect theory. There is precedent for courts making such an inference, which is simply a restatement of res ipsa loquitor. If that is the right choice to make (and I argue it is), then there is the secondary question of how, if at all, should the law apportion liability among designers, programmers, manufacturers, and others involved in the vehicle's creation? Or, as suggested above, should liability simply be assigned to the vehicle itself?

Of course, the solution suggested by existing law would be to hold the vehicle's manufacturer liable and let the manufacturer seek indemnity or contribution from other potentially responsible parties, if any.[37] But that approach may be nothing more than an empty gesture. If it is in fact impossible to identify the cause of the accident, then the manufacturer would likely have no reasonable grounds for an indemnity or contribution action, and would thus be saddled with the entire judgment.[38] That result might make sense if the manufacturer is in the best position to bear the loss. Otherwise, it might be fairer to apportion responsibility among all of the parties that participated in building and maintaining the vehicle's autonomous systems, on the ground that the cost of error is better spread among all potentially responsible parties or

36. *See generally* RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 3(a) (1998) (providing for an inference based on concepts of res ipsa loquitor where the plaintiff can show that the product failure "was of a kind that ordinarily occurs as a product defect"); *see also In re* Toyota Motor Corp. Unintended Acceleration Mktg., Sales Practices, & Prods. Liab. Litig., __F. Supp. 2d__, 2013 WL 5763178 (C.D. Cal. Oct. 7, 2013); Douglas A. Kysar, *The Expectations of Consumers*, 103 COLUM. L. REV. 1700, 1721 & nn.89–90 (2003). These sources and others make clear that an inference can take a plaintiff only so far; the plaintiff still has to prove that the failure was of the kind *ordinarily* seen with design defects. An otherwise inexplicable failure, which is not fairly described as "ordinary," would likely not qualify under this standard.

37. *See generally* Larsen v. Gen. Motors Corp., 391 F.2d 495 (8th Cir. 1968) (applying Minnesota law and discussing apportionment of damages in automobile accidents cases); DAVID G. OWEN, PRODUCTS LIABILITY LAW § 17.4, at 1094–100 (2005).

38. The law generally limits the liability of component part manufacturers absent proof that they participated in the design or manufacture of a finished product. *See* Davis v. Komatsu Am. Indus. Corp., 42 S.W.3d 34, 43 (Tenn. 2001) (holding that the maker of a robot used in can-making was not liable when the plaintiff's injury was likely caused by unsafe maintenance and other dangerous practices); Kysar, *supra* note 36, at 1725 & n.109 (and authorities cited therein).

among the parties who could more efficiently guard or insure against the loss.[39] The other approach would be to hold the vehicle itself responsible, assuming, of course, that the law is willing to confer legal "personhood" on the vehicle and require the vehicle to obtain adequate insurance.

I. AUTONOMOUS MACHINES AND LIABILITY RULES RELATING TO HUMAN (BUT NOT DRIVER) ERROR

The key question in discussing liability is who bears the costs when something goes wrong and injury occurs. Driver-less cars, at least those that might be on the road within the next decade, will reduce but will not entirely eliminate the possibility of driver error. As I understand it, the system Google is developing permits the person sitting in the driver's seat to take control of the car whenever he or she wants. At this point, however, it is unclear whether Google intends for the driver to have control at some points: For instance, while driving through high pedestrian traffic residential areas, construction zones, or during especially inclement weather, even though Google's driver-less cars

39. This proposal would entail application of a variation of "common enterprise" liability. As explained in detail below, I envision this as a doctrine that aims to force a group of companies that work together for a common end—here, to design and manufacture a driver-less car—to bear liability collectively when something goes wrong and injury ensues and when it is impossible to determine, let alone apportion, fault. In other words, as I envision it, common enterprise liability here would be a form of court-compelled insurance. The manufacturers and designers ("the enterprise") would jointly indemnify individuals injured by driver-less cars when it is impossible to determine fault. In the field of consumer protection, for instance, the Federal Trade Commission often invokes the "common enterprise" doctrine to seek joint and several liability among related companies engaged in fraudulent practices. *See, e.g.*, FTC v. Network Servs. Depot, Inc., 617 F.3d 1127, 1142–43 (9th Cir. 2010); SEC v. R.G. Reynolds Enters., Inc., 952 F.2d 1125, 1130–31 (9th Cir. 1991); FTC v. Tax Club, Inc., __F. Supp. 2d__, 2014 WL 199514, at *5 (S.D.N.Y. Jan. 17, 2014).

Common enterprise liability should not be confused with its first-cousin, "enterprise liability," which proposes a collective theory of liability for companies engaged separately in the same hazardous industry, when the identity of the responsible firm cannot be determined. *See generally* OWEN, *supra* note 37, § 11.3, at 752. *Compare* Hall v. E.I. Du Pont De Nemours & Co., 345 F. Supp. 353 (E.D.N.Y. 1972) (invoking "enterprise" liability theory to hold the highly concentrated blasting cap industry collectively liable for injuries to children), *with* Sindell v. Abbott Labs, 607 P.2d 924, 935 (Cal. 1980) (rejecting enterprise liability theory). *See generally* James A. Henderson, Jr., *Echoes of Enterprise Liability in Product Design and Marketing Litigation*, 87 CORNELL L. REV. 958 (2002); Gregory C. Keating, *The Theory of Enterprise Liability and Common Law Strict Liability*, 54 VAND. L. REV. 1285 (2001). *See also* Kysar, *supra* note 36, at 1708 & n.28 (collecting sources). Of course, if the number of manufacturers of driver-less vehicles was relatively small, and there were issues of identifying the manufacturer of a vehicle that caused significant harm, enterprise theory of liability might be viable in that situation as well.

have performed well in those conditions.[40] But the Google system also has a voice command that instructs the driver to take control of the vehicle, presumably when the control system detects some kind of error or is unable to determine what it should do.[41] The point of this essay is to explore liability concerns where there is no possibility that a human driver caused or contributed to the accident. So what follows is based on the understanding that the person in the driver's seat is disengaged from any aspect of driving the car, and that the car is under the sole control of the car itself.[42] Simply taking human drivers out of the equation should mean, in the long run, a considerable drop in accidents.

But even in the best of circumstances, unexpected and improbable events occur, things go wrong, and someone or something is injured. Product liability law provides a framework for resolving claims by parties injured when things go wrong. With a "product" like an autonomous car, the law groups those possible failures into familiar categories: design defects, manufacturing defects, information defects, and failures to instruct on appropriate uses.[43]

Before examining these theories of liability, it is useful to pause to consider whether the standard of care to be applied to driver-less cars will be different than the standard applied to cars driven by humans. There is every reason to think that the answer will be "yes," and that fact may bear on the analysis that follows.

As unlikely as this may seem, the standard of care question was addressed by a court more than a half-century ago. In *Arnold v. Reuther*,[44] an intermediate appellate court in Louisiana questioned

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40. According to one press report on the operation of a Google car, "[t]o gain control of the car [the driver] has to do one of three things: hit a red button near his right hand, touch the brake or turn the steering wheel." Markoff, *War Machines*, *supra* note 28. The article reports that during one lengthy test drive, the driver "did so twice, once when a bicyclist ran a red light and again when a car in front stopped and began to back into a parking space. But the car seemed likely to have prevented an accident itself." *Id.*

41. Peter Valdes-Dapena, *Thrilled and Bummed by Google's Self-Driving Car*, CNN MONEY (May 18, 2012), http://money.cnn.com/2012/05/17/autos/google-driverless-car; *see also* RAND REPORT, *supra* note 30, at 58–65, 68–69.

42. This discussion also does not address questions of the crashworthiness of the vehicle, since that question is entirely independent of the identity of the driver.

43. *See generally* OWEN, *supra* note 37, Parts I & II. No doubt prompted by Google's development of a wholly autonomous driver-less car, there has been a spate of articles and student notes and comments addressing liability questions. *See, e.g.*, Beiker, *supra* note 33; Funkhouser, *supra* note 29; Bryant Walker Smith, *supra* note 29; Kyle Colonna, Note, *Autonomous Cars and Tort Liability*, 4 CASE W. RES. J.L. TECH. & INTERNET 81 (2012); Garza, *supra* note 29; Julie Goodrich, Comment, *Driving Miss Daisy: An Autonomous Chauffeur System*, 51 HOUS. L. REV. 265 (2013); Gurney, *supra* note 29.

44. 92 So. 2d 593, 596 (La. Ct. App. 1957).

whether autonomous cars will be held to a higher standard of care than cars driven by humans. *Arnold* involved a negligence claim by Mrs. Arnold against Mr. Reuther, whose car struck Mrs. Arnold when she darted across Canal Street in New Orleans as he was making a left-hand turn. Although the facts were controverted, the court summarized the relevant, undisputed facts this way: "[J]ust before the car of Reuther reached a point opposite that at which Mrs. Arnold stood on the sidewalk among the other pedestrians, she, at a hurried pace, entered the street and attempted to cross;" the other pedestrians did not attempt to cross.[45] According to the court, Mr. Reuther testified that "he did not see Mrs. Arnold as she left the sidewalk and, in fact, did not see her until she was actually 'in front' of his car."[46]

Mrs. Arnold did not dispute that she attempted to cross the street without looking and that her conduct was negligent.[47] Her argument was that Mr. Reuther had the "last clear chance" to avoid the accident, but failed to do so and should be held liable for that reason.[48] The court disagreed, concluding that Mr. Reuther's efforts, although ineffective, were sufficient to avoid liability because, after all, he was only human.[49] The court said:

> A human being, no matter how efficient, is not a mechanical robot and does not possess the ability of a radar machine to discover danger before it becomes manifest. Some allowances, however slight, must be made for human frailties and for reaction, and if any allowance whatever is made for the fact that a human being must require a fraction of a second for reaction and cannot respond with the mechanical speed and accuracy such as is found in modern mechanical devices, it must be realized that there was nothing that Reuther, a human being, could have done to have avoided the unfortunate result which the negligence of Mrs. Arnold brought upon herself.[50]

Fifty years later, the court's insight seems remarkably prescient. Had Mr. Reuther been sitting behind the wheel of a driver-less car, it is quite possible that, as the Louisiana court forecast, the accident would have been averted; the car would have immediately detected Mrs. Arnold's ill-considered dash across the street and rapidly applied the brakes (after

45. *Id.* at 595–96.
46. *Id.* at 596.
47. *Id.*
48. *Id.*
49. *Id.*
50. *Id.*

confirming that there was no vehicle behind it that would be unable to stop safely) to come to a stop before striking Mrs. Arnold and before Mr. Reuther was even alert to the danger.

As this example illustrates, in all likelihood, in the first accident case involving a driver-less car, the court will not ask whether the self-driving car performed as well as a reasonable human. The question in *Arnold* was one of negligence: Did Mr. Reuther behave reasonably under the circumstances? And the court said he had. But with a driver-less car, and no human at the controls, the focus will be on whether the car performed as well as it should have. To be sure, one could state that question in the language of negligence, and there may be questions about whether the car or some of its key components were designed, manufactured, or maintained negligently. But the court in the first driver-less car case will likely ask whether the car involved in the accident performed up to the standards achievable by the majority of other driver-less cars, as well as the performance specification set by the car's manufacturer.[51]

Just how demanding would that standard be? Under contemporary products liability law, the standard would likely be set by a risk-utility analysis of the sort described in the *Restatement (Third) of Torts*. To be sure, in the past, cases like *Arnold* proceeded under negligence theories, in large part because the focus was on the conduct of humans, not the performance of machines. But since then, as negligence claims involving product failures became more difficult to prove, strict liability principles took root to govern product liability cases. Products liability plaintiffs often plead both negligence and strict liability claims. But cases involving complex products are now typically viewed through the lens of products liability law. Take Mrs. Arnold's case. Imagine that the car that struck her was a driver-less car, and taking her cue from the court, she claims that the car Mr. Reuther was operating (but not driving) should have been designed in a way that would have averted the accident. That is a question of design, technological and economic feasibility, and consumer expectations, and there is no doubt that there will be design defect cases brought against the manufacturers and designers of self-driving cars.[52] Under current law, Mrs. Arnold would

51. On the duty of care, *see generally* RESTATEMENT (THIRD) OF TORTS: PHYSICAL & EMOTIONAL HARM § 7(a) (2010) ("[A]n actor ordinarily has a duty to exercise reasonable care when an actor's conduct creates a risk of physical harm.").

52. Whether programmers will also be subject to design claims is less clear. Computer code has not generally been considered a "product" but instead is thought of as a "service." As a result, to the extent that there are cases seeking compensation caused by allegedly defective software, those cases have ordinarily proceeded as breach of warranty cases under the Uniform Commercial Code rather than product liability cases. *See, e.g.*, Motorola Mobility, Inc. v. Myriad France SAS, 850 F. Supp.

have a design defect claim against the manufacturer, but whether she would have a winning case is far from clear, and would depend heavily on the facts leading up to her accident.

To explain why that is so, consider two scenarios, both of which are based on the supposition that there are no mechanical or manufacturing defects with the car. In scenario one, assume that the evidence shows that a driver-less car's sensors were capable of detecting Mrs. Arnold moving into the car's path at a point when she was 15 feet away. And suppose further that, to the extent that there is an industry "collision avoidance" standard, it is that a driver-less car should be able to detect objects (human or not) in its path and avoid a collision (by applying the brakes or by taking evasive maneuvers) if the object is detected within 12 feet of the car. In scenario two, we reverse the numbers so now the industry "collision avoidance" standard is 15 feet, but it is clear that Mrs. Arnold was not detected by the sensors until she was 12 feet from the car.[53]

Determining the proper test for design defects has been the central and most contentious question in products liability law for the past half-century, and it does not appear that the debate has been conclusively resolved.[54] Under current law, there are two potentially viable liability

2d 878 (N.D. Ill. 2012) (case alleging defective software pleaded as a breach of warranty); *In re* All Am. Semiconductor, Inc., 490 B.R. 418 (Bankr. S.D. Fla. 2013) (same); Daniel B. Garrie, *The Legal Status of Software*, 23 J. MARSHALL J. COMPUTER & INFO. L. 711, 714–20 (2005); David W. Lannetti, *Toward a Revised Definition of "Product" Under the Restatement (Third) of Torts: Products Liability*, 55 BUS. LAW. 799, 806–07 (2000). But those are typically cases between the software purchaser and provider. That dynamic appears to be changing, as increasingly software systems operate cars, trucks, planes and other machines, that, on occasion, malfunction and injure non-purchaser third parties. These plaintiffs allege that the product failure that caused their injury was a result of defectively designed or manufactured software, though it may be hard to ascertain the root cause. At the time of this writing, there are product liability cases alleging that software defects "caused" serious accidents, including those involving deaths. Perhaps most notable are the many defective software design claims being brought in *In re Toyota Motor Corp. Unintended Acceleration Mktg, Sales Practices, & Prod. Liab. Litig.*, __F. Supp. 2d__, 2013 WL 5763178 (C.D. Cal. Oct. 7, 2013), a multi-district litigation matter in which the plaintiffs allege, inter alia, that certain vehicles manufactured by Toyota have a software defect that causes, at times, the vehicles to accelerate notwithstanding measures the drivers take to stop the vehicle. Typically, of course, the software is licensed into the vehicle by the manufacturer, and thus in the case of an inexplicable failure the plaintiff can always bring suit against the manufacturer, which, in turn, can seek contribution or indemnification from the software provider under breach of warranties and other contract-based theories.

53. Of course, these scenarios assume that the car was driving at a speed (say twenty miles per hour) within the speed limit and with due attention to the then-current driving conditions (surrounding traffic, road conditions, weather, time of day, and so forth). *See generally* RAND REPORT, *supra* note 30, at 59 (addressing the technological aspects of how a driver-less car would respond to these kinds of scenarios).

54. I have no intention of joining the debate over the proper formulation of the design defect test;

theories that plaintiffs may be able to employ to demonstrate that a product was defectively designed. In the jurisdictions that still follow the *Restatement (Second) of Torts* or some variant of it, Mrs. Arnold could proceed under a "consumer expectations" test.[55] Putting aside that courts and academics have been critical of using a consumer expectations test in design defects,[56] and especially in cases involving complex products,[57] that claim permits juries to find for the plaintiff whenever a

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suffice it to say that many eminent tort scholars have waded into this thicket and have emerged arguing for a wide variety of approaches. *See, e.g.*, Richard A. Epstein, *Products Liability: The Search for the Middle Ground*, 56 N.C. L. REV. 643, 647–49 (1978) (describing judicial confusion in assessing design defects); W. Page Keeton, *Product Liability—Design Hazards and the Meaning of Defect*, 10 CUMB. L. REV. 293, 298 n.23 (1979) ("The search for the universally acceptable definition of defect has been the most elusive one in the products liability field."); Kysar, *supra* note 36, at 1709 & n.30; Joseph W. Little, *The Place of Consumer Expectations in Product Strict Liability Actions for Defectively Designed Products*, 61 TENN. L. REV. 1189, 1190 (1994) ("The difficult and politically contentious cases are those that involve allegations of defective design."); Marshall S. Shapo, *In Search of the Law of Products Liability: The ALI Restatement Project*, 48 VAND. L. REV. 631, 638 (1995) ("[A] crucial aspect of products liability law—perhaps the core concept, if any one idea may be described that way—lies in the definition of defect."); Marshall S. Shapo, *Products at the Millennium: Traversing a Transverse Section*, 53 S.C. L. REV. 1031, 1033 (2002) ("However divided analysts of products law may be about definitions, most would agree that the heart of the matter in products liability is the concept of defect."); David G. Owen, *Design Defects*, 73 MO. L. REV. 291, 292 (2008) ("The quest for understanding design defectiveness perennially vexes courts and accomplished products liability lawyers attempting to unravel design defect problems; delights law clerks, young associates, and law students, furnishing them with an occasion to display their erudition; and provides fertile grist for law professors aspiring for the renown that accompanies discovery of the key to any riddle wrapped in a mystery inside an enigma.") (footnotes omitted).

55. *See* RESTATEMENT (SECOND) OF TORTS § 402A cmt. g (1965); Kysar, *supra* note 36, at 1712–13.

56. *The Restatement (Third) of Torts* formally abandons the consumer expectations test for design defect claims. *See* RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2 cmt. g (1998) ("[C]onsumer expectations do not constitute an independent standard for judging the defectiveness of product designs."). Many commentators suggest, however, that the risk-utility test adopted by the new Restatement permits consideration of consumer expectations, and, in any event, many jurisdictions continue to permit cases to proceed under a consumer expectations theory. *See, e.g.*, Potter v. Chi. Pneumatic Tool Co., 694 A.2d 1319, 1333 (Conn. 1997) (continuing to permit cases to proceed under the consumer expectations test); Kysar, *supra* note 36, at 1726–29 & nn.111–25; Owen, *supra* note 54, at 335, 342.

57. For instance, in *Potter v. Chicago Pneumatic Tool Co.* the Connecticut Supreme Court held that

> Although today we continue to adhere to our long-standing rule that a product's defectiveness is to be determined by the expectations of an ordinary consumer, we nevertheless recognize that there may be instances involving complex product designs in which an ordinary consumer may not be able to form expectations of safety.

694 A.2d at 1333. Accordingly, the Court adopted a new test where complex products are involved to incorporate elements of a risk-utility test. The governing test is as follows:

> [I]n determining the reasonable expectations of the ordinary consumer, a number of factors must be considered. The relative cost of the product, the gravity of the potential harm from the claimed defect and the cost and feasibility of eliminating or minimizing the risk may be

product is in a "defective condition unreasonably dangerous to [a] user or consumer."[58] An "unreasonably dangerous" defect is one that makes a product "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."[59] Although there are difficulties with this test (discussed below), it does provide Mrs. Arnold a path to get her case before a jury, where jurors can then "draw[] their own reasonable conclusions as to the expectations of the ordinary consumer and the knowledge common in the community at large."[60]

The second test is the risk-utility test laid out in the *Restatement (Third) of Torts: Products Liability*, which would require Mrs. Arnold to show that "the foreseeable risks of harm posed by the product could have been reduced by the adoption of a reasonable alternative design."[61] That is a formidable burden. The word "reasonable" is intended to import a quantitative cost-benefit analysis into the test, and thus under the *Restatement*'s formulation, Mrs. Arnold would have to shoulder the burden of proving that some modified version of the product would have avoided the collision at a cost that is reasonable in relation to the degree of harm reduced.[62]

Under scenario one, where the car's sensors should have detected Mrs. Arnold's presence in time to avoid the collision but failed to do so, Mrs. Arnold is likely to prevail under each theory. She would likely prevail under the consumer expectations test because consumers would reasonably expect that Mr. Reuther's driver-less car would meet or

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> relevant in a particular case. In other instances the nature of the product or the nature of the claimed defect may make other factors relevant to the issue.

Id. (internal quotations omitted); *see also* Seattle-First Nat'l Bank v. Tabert, 86 Wash. 2d 145, 542 P.2d 774 (1975) (earlier adoption of the same test by the Washington State Supreme Court); Gurney, *supra* note 29, at 260–62. *See generally* Owen, *supra* note 54, at 346–53.

58. RESTATEMENT (SECOND) OF TORTS § 402A(1) (1965); *see also* Greenman v. Yuba Power Prods., Inc., 377 P.2d 897, 900 (Cal. 1963) (Traynor, J.) ("A manufacturer is strictly liable in tort when an article he places on the market, knowing that it is to be used without inspection for defects, proves to have a defect that causes injury to a human being.").

59. RESTATEMENT (SECOND) OF TORTS § 402A cmt. i; *see also* Kysar, *supra* note 36, at 1709 & nn.51–52.

60. Giglio v. Conn. Light & Power Co., 429 A.2d 486, 488 (Conn. 1980) (internal quotations omitted).

61. RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2(b) (1998).

62. *See id.*; Connelly v. Hyundai Motor Co., 351 F.3d 535, 541 (1st Cir. 2003) (noting that, under New Hampshire law, the jury could have reasonably found that the airbag was not defective: "[o]n balance, the benefit to the public of including the overly aggressive airbag system in the Sonata outweighed the danger caused by the airbag system (because the system saved many more lives than it took)"); Owen, *supra* note 54, at 330–36.

exceed the existing 12-foot "collision avoidance" industry standard.[63] The analysis conducted under the risk-utility test should come out in her favor as well. She would not have to advocate in favor of an "alternative" design; her argument would be that the market had already weighed the relative costs and benefits of the 12-foot collision avoidance standard and determined that the cost of such a standard is justified by the corresponding risk reduction.[64]

Scenario two raises much more difficult questions because most, perhaps all, driver-less vehicles would have been unable to stop or take evasive action quickly enough to avoid the accident. For starters, it is not clear that Mrs. Arnold could prevail under a consumer expectations test. To be sure, given the indeterminacy of the test—the standard is, after all, what reasonable consumers say it is—it could be her salvation or her undoing.[65] On the one hand, the consumer expectations test might work to Mrs. Arnold's advantage. There has been considerable hype about the enhanced safety of driver-less cars—so much so that some experts forecast that these cars, once we rid the roads of drivers, will put an end to accidents.[66] Reacting to that hype, consumers may expect (putting aside questions of reasonableness) driver-less cars to be designed in a way that would avert accidents even where, as is the case with Mrs. Arnold, the initial "fault" lies with the person and the machine had at best a second or two to detect and react to the impending accident. Indeed, even if the industry's evidence shows that the 15-foot collision avoidance standard pushes the limits of technological and economic

63. *See* Soule v. Gen. Motors Corp., 882 P.2d 298, 308 (Cal. 1994) (noting that the ordinary consumer expectations test is appropriate when the everyday experience of the particular product's users permits the inference that the product did not meet minimum safety expectations).

64. Of course the manufacturer would have defenses to liability, but given the presence of a prevailing industry standard and the vehicle's evident non-compliance with that standard, the burden of proof would likely shift to the manufacturer. *See, e.g.*, Richard C. Ausness, *"Fasten Your Seatbelt Orville!": Exploring the Relationship Between State-of-the-Art, Technological and Commercial Feasibility, and the* Restatement*'s Reasonable Alternative Design Requirement*, 45 IND. L. REV. 669, 686–89 (2012); O'Brien v. Muskin Corp., 463 A.2d 298, 302 (N.J. 1983), *overruling recognized by* Dewey v. R.J. Reynolds Tobacco Co., 577 A.2d 1239 (N.J. 1990).

65. Among the criticisms leveled at the consumer expectations test is that it is indeterminate, or to put a finer point on it, "so vague as to be lawless." James A. Henderson, Jr. & Aaron D. Twerski, *Achieving Consensus on Defective Product Design*, 83 CORNELL L. REV. 867, 882 (1998). The same authors have made the same claim repeatedly. *See, e.g.*, James A. Henderson, Jr. & Aaron D. Twerski, *Drug Designs are Different*, 111 YALE L.J. 151, 178 (2001).

66. Beiker, *supra* note 33, at 1149 (pointing out that driver error is "by far (95%) the most common factor implicated in vehicle accidents"); Markoff, *War Machines*, *supra* note 28; Chunka Mui, *Will Auto Insurers Survive Their Collision with Driverless Cars? (Part 6)*, FORBES (Mar. 28, 2013), http://www.forbes.com/sites/chunkamui/2013/03/28/will-auto-insurers-survive-their-collision-with-driverless-cars-part-6/.

feasibility, jurors might conclude that designers are capable of doing better and hold the manufacturer of Mr. Reuther's car liable on that basis.[67] Whether the court would let a verdict like that stand is open to question,[68] but the consumer expectations test is a double-edged sword; expectations are often shaped by industry, but industry standards do not necessarily define the outer boundary of enforceable consumer expectations.[69]

On the other hand, one downside of the test is that consumer expectations are generally a reflection of the existing state of the marketplace.[70] Manufacturers, through advertising and other communications with consumers, play a key role in shaping consumer expectations. Unless the manufacturer makes inflated and unjustified representations about its product's performance, consumers are likely to expect that their products will perform in a way that is consistent with prevailing standards as articulated by the products' manufacturers, even if better and safer products are achievable at a nominal cost. Under this

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67. The law has never treated industry custom as even the de facto standard of care. Eighty years ago, Learned Hand's famous decision in *The TJ Hooper*, 60 F.2d 737, 740 (2d Cir. 1932), made clear that a negligence standard should not strictly be set by industry custom because "a whole calling may have unduly lagged in the adoption of new and available devices." In most jurisdictions, the defendant is permitted to show that the product's design was "state-of-the-art" (that is, what is technologically feasible, not just industry custom) to rebut claims of defect. *See, e.g.*, Potter v. Chi. Pneumatic Tool Co., 694 A.2d 1319, 1346–47 (Conn. 1997) (collecting cases). Although not conclusive, that evidence is highly probative. *Id.* Mrs. Arnold might have to prove that the design, although meeting industry's custom, was not in fact state-of-the-art and further improvements were technologically achievable. *See id.*

68. The California Supreme Court in *Soule v. General Motors Corp.*, 882 P.2d 298, 309–10 (Cal. 1994), for example, suggests that using a consumer expectations test to determine liability when "esoteric circumstances" and "complicated design considerations" are present would be improper. Mrs. Arnold's case would likely fall into that category.

69. *See, e.g.*, *Potter*, 694 A.2d at 1333.

70. As the Supreme Court of California drove home in *Barker v. Lull Engineering Co.*, 573 P.2d 443, 451 n.7 (Cal. 1978), relying on the consumer expectations test can undermine incentives for manufacturers to enhance the safety features of their products: "The flaw in the Restatement's analysis, in our view, is that it treats such consumer expectations as a 'ceiling' on a manufacturer's responsibility under strict liability principles, rather than as a 'floor.'" The *Barker* court formulated the applicable design defect test in this way:

> [A] product may be found defective in design, so as to subject a manufacturer to strict liability for resulting injuries, under either of two alternative tests. First, a product may be found defective in design if the plaintiff establishes that the product failed to perform as safely as an ordinary consumer would expect when used in an intended or reasonably foreseeable manner. Second, a product may alternatively be found defective in design if the plaintiff demonstrates that the product's design proximately caused his injury and the defendant fails to establish, in light of the relevant factors, that, on balance, the benefits of the challenged design outweigh the risk of danger inherent in such design.

Id. at 455–56. *Barker* was explained and reaffirmed in *Soule*, 882 P.2d at 308 n.4. *See also Potter*, 694 A.2d at 1333–34.

theory, it may be fair to assume that consumers would expect driver-less cars to operate in a safe manner and might even have a reasonable expectation that driver-less cars will deliver higher levels of safety than cars driven by humans. But it seems a stretch to assume that consumers would have formed a reasonable expectation that driver-less cars can stop quickly enough to avoid hitting a person who darts in front of the car. This point might take on added force if the manufacturers of driver-less cars seek to dampen consumer expectations about the safety features of the cars, if for no other reason than to quell wholly unrealistic expectations that might lead consumers to think, as Mrs. Arnold may have thought, that no matter how risky her conduct was, the car would be able to stop quickly enough to avoid impact.[71] For these reasons, even under the consumer expectations test, perceived by many to be more plaintiff-friendly, Mrs. Arnold would face a tough and uncertain path to victory.

Equally uncertain is whether the risk-utility test embodied in the *Restatement (Third) of Torts* would provide Mrs. Arnold a road to recovery. Her burden would be to show that the incremental benefit of altering the car's design to improve stopping distance from 15 feet to 12 feet would be worth the cost—that is, that the value of the accidents avoided would equal or exceed the added cost of the alternative design.[72] Presenting evidence to that effect would be difficult. After all, Mrs. Arnold would need to retain an expert engineer to demonstrate that a reduction in the stopping distance is technologically feasible, as well as another expert (likely an economist) to establish that the savings achieved by the reduction would outweigh the attendant costs of modifying the vehicle.[73] Her experts would also have to do battle with

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71. *See* Jon D. Hanson & Douglas A. Kysar, *Taking Behaviorism Seriously: A Response to Market Manipulation*, 6 ROGER WILLIAMS U. L. REV. 259, 324–70 (2000); Jon D. Hanson & Douglas A. Kysar, *Taking Behaviorism Seriously: Some Evidence of Market Manipulation*, 112 HARV. L. REV. 1420 (1999).

72. This balancing test may itself be troublesome because it asks jurors to place values on things that do not come with an attached price tag—including the "value" of human life, injury and suffering, and the "value" to be gained or sacrificed by design modifications. Making matters worse, jurors not only have to assign values, they then have to weigh them against one another and pick a winner and a loser. For a critique of using economic modeling to make such choices, see generally FRANK ACKERMAN & LISA HEINZERLING, PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING (2004).

73. Although there was much critical commentary on the burdens that the risk-utility test would place on plaintiffs, *see, e.g.*, Kysar, *supra* note 36, at 1721–22 & n.84 (collecting authorities), the tools for lessening those burdens would not apply here. They include cases (a) where the product defect was one in which the *everyday experience* of the product's users permits a conclusion that the product's design violated *minimum* safety assumptions, and is thus defective regardless of expert opinion about the merits of the design, *Soule*, 882 P.2d at 308 (emphasis in original), or (b) where

the manufacturer's experts, who would likely claim that the design pushed the limits of technological feasibility.[74] To be sure, if she could make the showing that additional modifications could have made the vehicle safer at a reasonable cost, she might have a case. But finding and retaining experts to put on a case might be a dauntingly expensive enterprise for an individual plaintiff to bear.

Mrs. Arnold's path to victory would be far surer if it turned out that there was a manufacturing defect or component failure that caused or contributed to the accident. A product with a manufacturing defect is a product with an unintended flaw; that is, the finished product does not conform to the manufacturer's own specifications or requirements.[75] A plaintiff can prevail in a manufacturing defect case if she can prove that the product does not conform to the manufacturer's specifications and that the defect played a role in causing the accident. For autonomous cars, there are certain to be instances in which vital components of the system fail because of a manufacturing or maintenance defect. For example, assume that one of the key components responsible for keeping track of objects that might enter the path of the car (for instance, a radar or laser sensor) failed on Mr. Reuther's car prior to the accident with Mrs. Arnold. Assuming that the failing component can be identified, and assuming that there is a link to the failed component and the accident, liability can be established and properly allocated. If the component is analyzed and does not meet the manufacturer's specification, then the case is an easy one, and liability may be appropriately meted out.[76]

Even if there is no tangible sign of defect, Mrs. Arnold may have a viable claim, at least in some jurisdictions, if she can prove that the component malfunctioned and, for instance, resulted in the car failing to

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the product defect was of the kind that "ordinarily occurs" so it is fair to base liability on a res ipsa loquitor theory. *See* RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 3(a) (1998) (providing for an inference based on concepts of res ipsa loquitor where the plaintiff can show that the product failure "was of a kind that ordinarily occurs as a result of product defect"); Kysar, *supra* note 36, at 1721 & nn.89–90.

74. *See supra* note 67 and accompanying text on the availability of a "state-of-the-art" defense.

75. Greenman v. Yuba Power Prods. Inc., 377 P.2d 897 (Cal. 1963); RESTATEMENT (THIRD) OF TORTS: PRODUCTS LIABILITY § 2(a) ("[A] manufacturing defect [exists] when the product departs from its intended design even though all possible care was exercised in the preparation and marketing of the product . . . ."). In the past, product manufacturers ordinarily were held strictly liable for defectively manufactured products. *See generally* RESTATEMENT (SECOND) OF TORTS: PRODUCTS LIABILITY § 402A (1965).

76. As a general matter, in cases where a product or component is manufactured in a way that fails to comport with the defendant's own intended design specifications, courts routinely find liability. *See* RICHARD A. EPSTEIN, MODERN PRODUCTS LIABILITY LAW 70 (1980); Kysar, *supra* note 36, at 1709 & n.29.

stop in a manner consistent with the manufacturer's specifications. The law permits such a claim to go forward so long as the component was properly used, properly maintained, and had not been altered or damaged in a way that might have caused the malfunction.[77] But take note: In cases involving other autonomous machines, liability has been difficult to establish where alternative theories of liability are present.[78]

Finally, there is the issue of information defects. Although it is unlikely that Mrs. Arnold would have a claim under this theory, the "duty to train" often plays a role when humans interact with, and have to operate, complex machines. The duty to train may play an important role in the introduction of driver-less cars onto the market. Driver-less cars are highly sophisticated systems, and learning how to "drive" and "operate" them may be difficult for consumers used to being in control while they are in the "driver's seat." Especially if the "driver" must remain alert and ready to assume the conventional role of "driver," the burden of teaching consumers how to manage those tasks may fall to manufacturers, and they may face liability if they fail to adequately communicate information about the safe use of driver-less cars.[79]

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77. There are often questions about whether the manufacturer or service provider that maintained the part is responsible for the defect, but that issue has no bearing here. *See supra* note 37 and accompanying text. Once driver-less cars enter the market, however, maintenance may become a significant issue. As Anderson's *RAND Report* observes, many of the key sensors degrade over time, software will need to be updated regularly, and GPS systems will have to be updated constantly to reflect road openings and closings. RAND REPORT, *supra* note 30, at 66. Although the car itself will play a key role in continually monitoring the updating and performance of its component parts, other entities will play a role as well in ensuring that these components are maintained and functioning properly, potentially complicating the liability questions. *Id.*

78. For example, in *Ferguson v. Bombardier Service Corp.*, 244 F. App'x 944 (11th Cir. 2007), the court rejected a manufacturing defect claim against the manufacturer of an autopilot system in a military cargo plane that suffered a catastrophic crash while the plane was on autopilot. The plaintiffs cited some evidence that the autopilot failed to function properly. But the court found equally credible the defense theory that the plane was improperly loaded, so much so that a strong gust of wind caused the plane to crash—a theory consistent with the information salvaged from the aircraft's flight data recorder. And in *Nelson v. American Airlines, Inc.*, 70 Cal. Rptr. 33 (Cal. Ct. App. 1968), the plaintiff was a passenger on an American Airlines flight who was injured when the plane suddenly descended. One theory was that when the pilots engaged the autopilot, a fault in the autopilot caused the sudden descent. The court applied the doctrine of res ipsa loquitor to find an inference of negligence by American Airlines, but ruled that the inference could be rebutted if American Airlines could show that the autopilot did not cause the accident or that an unpreventable cause triggered the accident. The court said that a defect in the autopilot could have caused the accident, as well as the negligent maintenance of the device. Accordingly, the court reversed the lower court's ruling in favor of American and remanded the action for further proceedings. *See also* Payne v. ABB Flexible Automation, Inc., No. 96-2248, 1997 WL 311586 (8th Cir. June 9, 1997) (per curiam).

79. Many of the cases addressing this informational defect are those where airplane manufacturers are alleged to have failed to provide adequate training to pilots in the safe use of their

As this brief review shows, the introduction of truly autonomous vehicles is unlikely to present legal issues that tax our current product liability regime, at least so long as the product failure linked to the injury can be traced to, or reasonably imputed to, the activity of an identifiable person or legal entity. To be sure, the increasing complexity of automotive technology will provide even more ammunition to those who criticize the continued use of a consumer expectation test in design defect litigation. Supporters of the test may have a difficult time defending its use in cases involving driver-less cars, given the vehicles' intricate and interdependent technologies and the argument from opponents that consumers will not have a sufficient basis to form a reasonable judgment about what level of safety to expect. On the other hand, as many academics have suggested, when properly applied, the risk-utility test laid out in the *Restatement (Third) of Torts* does embody some elements of consumer expectations, and that test may adequately safeguard the interests of those injured by driver-less vehicles.[80]

II. MACHINES WITHOUT PRINCIPALS AND LIABILITY RULES RELATING TO INEXPLICABLE ACCIDENTS

Thus far, this Essay has addressed the application of conventional products liability principles to machines that are capable of operating independently of human direction, but where the machine's failure can fairly be attributed to some act or omission by a human that can be said to have "caused" the accident. As we have seen, apart from the vexing question of whether the "operator" or manufacturer of the driver-less car should be the defendant in a case where the car and not the driver had control, products liability law will apply in much the same way as it would apply if the car involved in the accident were driven by a human. And as we have also seen, resolution of the proper defendant question is likely to have little bearing on the important question of "Who pays?" In a fault-based system, drivers will bear the loss when they are responsible for the accident, and manufacturers will bear the loss when the driver-less car they have designed or manufactured fails. But in all of these scenarios, it is easy to avoid the question of agency because some human—Mrs. Arnold, Mr. Reuther, the designer, the programmer, or the

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aircraft. *See, e.g.*, Glorvigen v. Cirrus Design Corp., 796 N.W.2d 541 (Minn. Ct. App. 2011) (considering but ultimately rejecting failure-to-train claim); Driver v. Burlington Aviation, Inc., 430 S.E.2d 476 (N.C. Ct. App. 1993); Berkebile v. Brantly Helicopter Corp., 311 A.2d 140, 142 (Pa. Super. Ct. 1973), *aff'd*, 337 A.2d 893 (Pa. 1975).

80. Kysar, *supra* note 36, at 1761–82; Owen, *supra* note 54, at 336–53.

manufacturer of the vehicle or its component parts—was the key causal link in the events that led to the injury and thus can be assigned the blame.

Now switch gears and assume that an accident occurs involving a truly autonomous vehicle where it is impossible to reasonably assign the responsibility for the accident to a human. The hard question that may arise when autonomous machines are involved in accidents is what should the liability rule be when it is unreasonable to infer that the accident was caused by a design or manufacturing defect. It may be that those cases prove to be the null set. After all, an inference of defect is reasonably drawn when a product fails, even when a defect cannot be determined by engineers, when the failure occurs with some frequency and the failure follows a common pattern. In those circumstances, courts routinely apply principles of res ipsa loquitor and conclude that the car, not the driver, is at fault.[81]

As one example, consider the recent flood of design defect cases brought against Toyota alleging that certain Toyota-manufactured vehicles (both Toyota and Lexus) are prone to "sudden acceleration" through no act by the driver and the acceleration cannot be stopped by the driver, by either disengaging the accelerator pedal or by applying the brakes. Notwithstanding an exhaustive inquiry, engineers have been unable to identify a specific design or manufacturing defect that causes the uncontrolled acceleration, although theories abound.[82] Nonetheless, because of the substantial number and common features of these complaints, Toyota has decided not to contest liability. It settled a class action lawsuit for economic loss due to the defect brought by owners of affected Toyota and Lexus vehicles for $1.3 billion and other relief.[83]

81. Indeed, in the multidistrict litigation (MDL) case against Toyota for personal injuries allegedly resulting from sudden acceleration, the evidence shows that Toyota received upwards of 60,000 complaints about sudden acceleration in certain of its vehicles. *In re* Toyota Motor Corp. Unintended Acceleration Mktg., Sales Practices, & Prods. Liab. Litig., __F. Supp. 2d__, 2013 WL 5763178, at *26 n.66 (C.D. Cal. Oct. 7, 2013).

82. *See, e.g.*, Sharon Silke Carty, *Toyota's Sudden Acceleration Problem May Have Been Triggered By Tin Whiskers*, HUFFINGTON POST (Jan. 22, 2012), http://www.huffingtonpost.com/2012/01/21/toyota-sudden-acceleration-tin-whiskers_n_1221076.html (reporting that tiny threads of tin had developed in areas in which they might conduct electricity to the systems that control acceleration, and pointing out that this problem had been "implicated in crippling defects besetting a range of equipment, including communications satellites, pacemakers, missiles and nuclear power plants"); *see also In re Toyota Motor Corp.*, 2013 WL 5763178, at *34–35 (discussing several of the plaintiffs' theories of causation).

83. This settlement excluded the personal injury cases part of the multidistrict litigation and involved a class action involving defect claims for owners who sought damages for the diminished value of their vehicles and certain repairs. *See, e.g.*, Jessica Dye, *Toyota Acceleration Case Settlement Gets Final OK*, INS. J. (July 22, 2013), http://www.insurancejournal.com/

More recently, Toyota took steps to settle the pending 400 personal injury cases against it after an Oklahoma jury, applying the doctrine of res ipsa loquitor,[84] awarded the plaintiffs $3 million. The jury apparently concluded that, even though the plaintiffs could not isolate the cause of sudden acceleration, the accident was more likely caused by the car than the driver.[85] As the Toyota case makes plain, existing products liability law is well-positioned to address cases where the evidence strongly suggests a defect, but technology cannot isolate the cause.

What about failures involving driver-less vehicles that are rare,

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news/national/2013/07/22/299154.htm; Greg Risling, *Toyota Tackles Acceleration Lawsuits; Questions Remain*, USA TODAY (Jan. 21, 2013), http://www.usatoday.com/story/money/cars/driveon/2013/01/21/toyota-sudden-acceleration-lawsuits/1851813/; TOYOTA ECONOMIC LOSS SETTLEMENT WEBSITE, http://www.toyotaelsettlement.com (last visited Feb. 18, 2014) (laying out terms and conditions of settlement).

84. *See, e.g.*, Jacklyn Trop, *Toyota Seeks Settlement for Lawsuits*, N.Y. TIMES, Dec. 14, 2013, at B3, *available at* http://www.nytimes.com/2013/12/14/business/toyota-seeks-settlement-for-lawsuits.html; Ken Bensinger, *Toyota Looks to Settle Sudden-Acceleration Lawsuits*, L.A. TIMES (Dec. 12, 2013), http://articles.latimes.com/2013/dec/12/business/la-fi-toyota-settlement-20131213. This settlement involves personal injury claims resulting from accidents allegedly caused by sudden acceleration, which have been consolidated in *In re Toyota Motor Corp.*, 2013 WL 5763178. These settlement negotiations are potentially nearing a final resolution. Jaclyn Trop & Ben Protess, *Toyota in Talks on Final Settlements Over Car Recalls*, N.Y. TIMES (Feb. 9. 2014), http://www.nytimes.com/2014/02/10/business/toyota-in-talks-on-final-settlements-over-car-recalls.html?hpw&rref=*automobiles*; *see also* Estate of Edward W. Knoster v. Ford Motor Co., 200 F. App'x. 106, 114 (3d Cir. 2006) (applying New Jersey law and finding that section three of the *Restatement (Third) of Torts* preserved the res ipsa loquitor inference so that sometimes when a product fails, "'common experience' indicates it would not have done so absent a defect").

85. *See, e.g.*, Bloomberg, *Toyota Loses First Acceleration Lawsuit, Must Pay $3 Million*, AUTOMOTIVE NEWS (Oct. 24, 2013), http://www.autonews.com/article/20131024/OEM11/131029935#axzz2r8ypeVIJ (reporting that an Oklahoma jury awarded $3 million in actual damages and Toyota settled the punitive damage claim for an undisclosed amount in a sudden acceleration case resulting in injury to the driver and the death of a passenger). The court presiding over the multidistrict litigation involving personal injury claims applied this rationale in rejecting Toyota's claim for summary judgment in one of the MDL cases (which may have influenced Toyota's decision to settle all of these claims). The court said:

> Toyota's Motion for Summary Judgment is premised on the uncontroverted fact that Plaintiff has been unable to identify a precise software design or manufacturing defect and point to physical or otherwise traceable evidence that the defect actually caused the Camry throttle to open from an idle position to a much wider angle without analog input from the driver via the accelerator pedal. To a lesser extent, it is also premised upon the fact that Plaintiff cannot prove the actual failure of Toyota's fail-safe mechanisms in the Camry on the day of the collision. As explained more fully below, Plaintiff's burden at the summary judgment stage is not so onerous.
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> Essentially, Toyota asks the Court to conclude that the only reasonable inference that may be drawn from the volumes of evidence proffered by the parties is that Mrs. St. John mistakenly applied the accelerator pedal instead of the brake pedal. The Court cannot so conclude. As Plaintiff points out, and as detailed by the Court more fully below, Mrs. St. John's testimony, together with other evidence, much of it expert evidence, support inferences from which a reasonable jury could conclude that the Camry continued to accelerate and failed to slow or stop despite her application of the brakes.

In re Toyota Motor Corp., 2013 WL 5763178, at *33.

untraceable to any defect, and inexplicable in that the vehicle's actions are incompatible with the vehicle's decision-making design? Who, if anyone, should bear liability then? To make the question more concrete, suppose daredevil Mrs. Arnold again darts in front of a driver-less vehicle. In this scenario, assume that the vehicle's designers have programmed instructions that it should at all costs avoid striking a human. And further assume that, in order to avoid hitting Mrs. Arnold, the vehicle has only two choices: It can either (1) take evasive action by making a sharp turn that would likely avoid any impact with Mrs. Arnold, but would also likely result in the vehicle striking a brick wall (thereby risking the safety of the vehicle's occupants), or (2) apply the brakes with great force, even though, given the distance and vehicle's speed, that course of action would not guarantee that the vehicle would stop before hitting Mrs. Arnold; nor would it ensure that there would be no collision between it and the car following closely behind.[86]

Suppose that the vehicle does not adhere to its basic instruction to avoid a collision with a human if at all possible and takes neither of these courses of action. Instead, the car applies its brakes gently, decreasing the car's speed, and avoiding the brick wall and a possible collision with the car behind it, but nonetheless striking and injuring Mrs. Arnold. As noted, the car was not "supposed" to make the choice it did. The engineers and programmers who designed the car's autonomous driving system "instructed" the car to avoid the possible collision with Mrs. Arnold and the car behind it by braking and by steering itself (and its passengers) into the brick wall, recognizing that the vehicle was sufficiently crash-worthy to sustain the impact without unreasonable risk to the safety of the car's occupants.

In some sense, this is the HAL question presented in a more benign form. It may be that truly intelligent machines will learn to adapt the instructions they initially receive from humans to circumstances not directly forecast at the time of their creation. And perhaps these machines will learn to internalize values that are not the ones their creators tried to embed. HAL, for instance, was not programmed to value self-preservation, but we know that he held that value dearly, and placed it above human life.[87]

86. Of course, one might suppose that if the trailing vehicle were also driver-less, the two cars would be communicating course, position, and speed to one another and the trailing vehicle would thus leave sufficient room between the vehicles to stop safely even in an emergency. *See also* Marcus, *supra* note 28 (using a slightly different hypothetical to demonstrate the moral questions raised by driver-less vehicles).

87. In testing prototypes of war-fighting robots, one study cited as a potential threat modern war robots that—like HAL—could "turn on" their human creators, in part as a mode of self-

The intended lesson of this hypothetical is that at some point it will be hard to conceptualize truly intelligent machines as mere agents or tools of humans. Agency principles can take us only so far. A machine that can define its own path, make its own decisions, and set its own priorities may become something other than an agent. Exactly what that may be, though, is not a question that the law is prepared to answer.[88]

Nor does current product liability law yield answers that are particularly satisfying. Consider the hypothetical sketched out above. In that case, even though the car might have been capable of avoiding Mrs. Arnold, her recovery would be uncertain, even if her claim were stronger. First, we can rule out a manufacturing defect claim; the mechanical features of the car functioned perfectly. To the extent that Mrs. Arnold has a path to recovery, it lies with a design defect claim. The consumer expectations test, even in those jurisdictions that have crafted a hybrid form of consumer expectations/risk-utility test, is unlikely to aid Mrs. Arnold. Whatever else this case may be, it is not an "ordinary" case where it is fair to presume that jurors will have reasoned expectations about how the vehicle should have performed.

Nor will Mrs. Arnold get much traction under the risk-utility theory, which, in a case like our hypothetical, would likely place the burden of showing a design alternative on the plaintiff. Again, the complexity and sophistication of driver-less cars, and the complications that will come with the fact patterns that are likely to arise, are going to make proof of wrongdoing in any individual case extremely difficult. The question whether there are alternative designs that would make driver-less cars even safer and prevent one-off accidents will be so infused with complex technical and economic questions that individual cases will be difficult and expensive to try, and even harder for jurors to resolve.

This case illustrates the point. Even though the vehicle did not perform in a way that was consistent with its designer's intentions, the vehicle did make an objectively reasonable choice: The vehicle took swift and decisive action to minimize the harm to Mrs. Arnold while safeguarding the vehicle's passenger from possible harm. The jurors may see that choice as a sensible one. And we know that Mrs. Arnold cannot argue that the better design choice is a return to the status quo ante, where cars were driven by humans. Even with today's safety features—automatic braking, anti-lock brakes, traction control, airbags,

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preservation. *See* Mick, *supra* note 23.

88. PAGALLO, *supra* note 17, at 152–53. *See generally* Solum, *supra* note 27.

backup cameras, "blind spot" cameras, and the like[89]—the rate of accidents and injuries on the roads in the United States remains frighteningly high.[90] Whatever flaws may emerge in driver-less cars, their introduction will almost certainly make a considerable dent in the accident and injury rate in the United States.

In my view, in cases where driver-less cars fail and cause injuries to persons or property and it would be unreasonable to attribute the failure to the vehicle's manufacture or design, the law will need to fashion a response that best serves the collective interests of the affected parties. My proposal is to construct a system of strict liability, completely uncoupled from notions of fault for this select group of cases. A strict liability regime cannot be based here on the argument that the vehicles are "ultra-hazardous" or "unreasonably risky" for the simple reason that driver-less vehicles are likely to be far less hazardous or risky than the products they replace. Indeed, it is precisely because these machines are so technologically advanced that we expect them not to fail. For these reasons, a true strict liability regime will be needed; one that does not resort to a risk-utility test or the re-institution of a negligence standard for the simple fact that those tests will be difficult, if not impossible, for the injured party to overcome.

In this instance, a system of strict liability would, in effect, impose a court-compelled insurance regime to address the inadequacy of tort law to resolve questions of liability that may push beyond the frontiers of science and technology. There are four strong policy reasons to establish a strict liability regime for this category of cases.

First, providing redress for persons injured through no fault of their own is an important value in its own right. The idea that individuals should bear a loss that is visited upon them, even when the causal failure is inexplicable, runs counter to basic notions of fairness, compensatory justice, and the apportionment of risk in society.

Second, a strict liability regime is warranted because, in contrast to the injured party, the vehicle's creators are in a position to either absorb the costs, or through pricing decisions, to spread the burden of loss widely. After all, it is not unreasonable that the costs of inexplicable

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89. *See, e.g.*, Mercedes Benz Safety, MERCEDES BENZ, http://www.mbusa.com/mercedes/benz/safety (last visited Feb. 17, 2014) (describing various safety features available on Mercedes automobiles).

90. Although the frequency of automobile crashes is slowly declining in the United States, there were still more than 5.3 million crashes in 2011, resulting in more than 2.2 million injuries and 32,000 fatalities. Alcohol was a factor in 39 percent of the fatal crashes. *See* RAND REPORT, *supra* note 30, at xiv.

accidents be borne, at least in part, by those who benefit from risk-reducing, innovative products.

Third, a strict liability regime will spare all concerned the enormous transaction costs that would be expended if parties had to litigate liability issues involving driver-less cars where fault cannot be established.[91] The first law of litigation is as follows: As the complexity of products rises geometrically, the cost of litigating products liability cases increases exponentially. It is better to spend money compensating the injured than paying lawyers and experts. Indeed, although Toyota has not discussed this issue publicly, it is possible that Toyota decided to settle the sudden acceleration cases not because it feared losing them in court, but because it feared that litigating each case to judgment, even if it won, would cost the company far more than settling the cases because of the complexity of the cases. If so, Toyota would not be the first company to settle a case to avoid transaction costs, regardless of the case's merits.

And fourth, a predictable liability regime may better spur innovation than a less predictable system that depends on a quixotic search for, and then assignment of, fault. If driver-less cars deliver even a fraction of their promised benefits of less carnage on the highways, more leisure time for consumers, and reduced fuel consumption, they will provide a substantial benefit to society. A liability system should not stifle innovation; it should encourage responsible innovation. Stability, coupled with a cost-spreading approach, would doubtlessly serve that goal better that an uncertain fault-based liability system.

Assuming that the courts can be persuaded to adopt a strict liability regime, the question then becomes, "Who bears the cost?" Should the burden be placed on the operator, owner, the manufacturer, the programmers, the designers, or all of them, or should the law simply declare that the driver-less car itself is a legal "person" and require it to insure itself against liability? Under prevailing products liability law, if someone is injured by the failure of an automobile (and not the driver),

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91. Lest there be any doubt, my argument is not based on notions of a "no-fault" liability system, that is, a system that substitutes mandatory insurance and eliminates access to the judicial system. My proposal is a strict liability regime implemented by the courts. Although the idea of "no fault" systems took hold in the 1970s and 1980s, and was expected to drive down insurance costs by limiting the transaction costs related to litigation, it is by now apparent that those systems have not worked as envisioned. *See, e.g.*, JAMES M. ANDERSON ET AL., THE U.S. EXPERIENCE WITH NO-FAULT AUTOMOBILE INSURANCE: A RETROSPECTIVE, at xiii (2010), *available at* http://www.rand.org/pubs/monographs/MG860. It is likely, however, that the introduction of driver-less cars will shift liability from the "driver" to the manufacturer, and that shift may trigger a resurgence of interest in "no fault" insurance regimes.

the manufacturer is the target of choice. It is the manufacturer who bears front line responsibility for design and manufacturing defects, and is generally the principal if not the only defendant in litigation. That allocation of responsibility makes sense, because the manufacturer sets the price for the vehicle, and so the manufacturer can build in an "insurance premium" into the vehicle's sale price to offset expected liability costs.[92]

There are at least two concerns about making the manufacturer shoulder the costs alone. One is that with driver-less cars, it may be that the most technologically complex parts—the automated driving systems, the radar and laser sensors that guide them, and the computers that make the decisions—are prone to undetectable failure. But those components may not be made by the manufacturer. From a cost-spreading standpoint, it is far from clear that the manufacturer should absorb the costs when parts and computer code supplied by other companies may be the root cause. Second, to the extent that it makes sense to provide incentives for the producers of the components of driver-less cars to continue to innovate and improve their products, insulating them from cost-sharing even in these kind, of one-off incidents seems problematic. The counter-argument would of course be that under current law the injured parties are unlikely to have any claim against the component producers, and the manufacturer almost certainly could not bring an action for contribution or indemnity against a component manufacturer without evidence that a design or manufacturing defect in the component was at fault.[93] So unless the courts address this issue in fashioning a strict liability regime, the manufacturer, and the manufacturer alone, is likely to bear all of the liability.

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92. For that reason, it does not seem fair to saddle the vehicle's owner with the liability. The scenario assumes that the owner's conduct has nothing at all to do with the accident. Nonetheless, if the risk of accidents involving driver-less cars is as low as some experts forecast, then the costs of insuring the vehicle may be so low that it is simply easier for all concerned to make the owner, through mandatory insurance (as is the case in most states already), the responsible party. Moreover, one could easily envision a system where private ownership of vehicles becomes a relic. Instead, companies (or cities or smaller communities) would own fleets of driver-less cars and dispatch them when requested, the way we now use cab services or Uber. This approach could also be used to promote ride-sharing, thereby further reducing the demand for vehicles, fuel costs, and traffic congestion.

93. *See supra* notes 37–39 and accompanying text. There is an additional point that might cut in favor of having the manufacturer bear the costs. If one accepts the principles of "Moore's Law"—that computing power doubles every eighteen months—we can expect that the costs of the software components will decrease or remain stable over time while the cost of the other components of the vehicle will continue to rise. If this prediction is borne out, then the manufacturer will increasingly be in the best position to pay, as the software will be an ever decreasing part of the vehicle's overall cost.

One way—perhaps the only way under conventional law—to untie this Gordian Knot would be to apply a variation on the settled doctrine of "common enterprise" liability. Under that theory, "each entity within a set of interrelated companies may be held jointly and severally liable for the actions of other entities that are part of the group."[94] The variations here would require a substantial deviation from the doctrine. For one thing, the proposed liability theory would not require that the companies function jointly; all that would be required is that they work to a common end—to design, program, and manufacture a driver-less car and its various component parts. For another, there is the question of fault. The common enterprise doctrine is ordinarily applied to ensure that once liability has been established, all of the participating wrongdoers are held to account. Here, of course, there would be no "wrongdoers." There would instead be an inference of liability drawn by operation of law to protect a blameless party (the person who sustained injured) by making others bear the cost. But the basic point is the same: A common enterprise theory permits the law to impose joint liability without having to lay bare and grapple with the details of assigning every aspect of wrongdoing to one party or another; it is enough that in pursuit of a common aim the parties engaged in wrongdoing. That principle could be engrafted onto a new, strict liability regime to address the harms that may be visited on humans by intelligent autonomous machines when it is impossible or impracticable to assign fault to a specific person.[95]

There is one other possible solution that avoids the legal fiction of having the creators of the vehicle bear the cost even without a hint of

94. FTC v. Tax Club Inc., __F. Supp. 2d__, 2014 WL 199514, at *5 (S.D.N.Y. Jan. 17, 2014); *see also* FTC v. Network Servs. Depot, Inc., 617 F.3d 1127, 1142–43 (9th Cir. 2010); SEC v. R.G. Reynolds Enters., Inc., 952 F.2d 1125, 1130 (9th Cir. 1991). To determine whether a common enterprise exists, the court considers factors such as common control; the sharing of office space and officers; whether business is transacted through a maze of interrelated companies; the commingling of corporate funds and failure to maintain separation of companies; unified advertising; and evidence that reveals that no real distinction exists between the corporate defendants. FTC. v. Grant Connect, LLC, 827 F. Supp. 2d 1199, 1216 (D. Nev. 2011) (quoting FTC v. Nat'l Urological Grp., Inc., 645 F. Supp. 2d 1167, 1182 (N.D. Ga. 2008)).

95. There are other liability systems that are similar to the one suggested here. One form of "enterprise liability" is the system underlying the National Childhood Vaccine Injury Act of 1986, which sets up a no-fault system of compensation for children injured by certain vaccines, with funding mainly from the companies that make and sell the vaccines. *See* 42 U.S.C. §§ 300aa-1–300aa-34 (2006). The Act imposes a tax on the sale of vaccines to create a fund to pay for injuries attributable to vaccines. *See* 26 U.S.C. § 9510 (2006) (establishing the Vaccine Injury Compensation Trust Fund). If the plaintiff determines that the compensation offered by the program is inadequate, the plaintiff may then file suit against the manufacturer, but most cases are resolved without litigation. *See generally* Bruesewitz v. Wyeth LLC, __U.S.__, 131 S. Ct. 1068 (2011).

fault, and that is to have the vehicle itself bear the cost. Instead of suing the manufacturer, let the injured party do what is now not possible—sue the vehicle. As suggested earlier, at some point the courts will have to wrestle with the underlying question of how to treat machines that are agents of no one—i.e., machines without principals. One solution would be to reconceptualize these autonomous, intelligent machines as entities with the status of a "person" under the law. Conferring "personhood" on these machines would resolve the agency question; the machines become principals in their own right, and along with new legal status would come new legal burdens, including the burden of self-insurance. This is a different form of cost-spreading than focusing on the vehicle's creators, and it may have the virtue of necessitating that a broader audience—including the vehicle's owner—participate in funding the insurance pool, and that too may be more fair.

CONCLUSION

The introduction of highly sophisticated autonomous machines may be literally around the corner. Truly autonomous machines may be driving cars through our neighborhoods or piloting drones that fly above our heads sooner than we think. So long as we can conceive of these machines as "agents" of some legal person (individual or virtual), our current system of products liability will be able to address the legal issues surrounding their introduction without significant modification. But the law is not necessarily equipped to address the legal issues that will start to arise when the inevitable occurs and these machines cause injury, but when there is no "principal" directing the actions of the machine. How the law chooses to treat machines without principals will be the central legal question that accompanies the introduction of truly autonomous machines, and at some point, the law will need to have an answer to that question.