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"Sophisticated Robots": Balancing Liability, Regulation, and Innovation

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"SOPHISTICATED ROBOTS": BALANCING LIABILITY, REGULATION, AND INNOVATION

F. Patrick Hubbard[*]

Abstract

Our lives are being transformed by large, mobile, "sophisticated robots" with increasingly higher levels of autonomy, intelligence, and interconnectivity among themselves. For example, driverless automobiles are likely to become commercially available within a decade. Many people who suffer physical injuries from these robots will seek legal redress for their injury, and regulatory schemes are likely to impose requirements on the field to reduce the number and severity of injuries.

This Article addresses the issue of whether the current liability and regulatory systems provide a fair, efficient method for balancing the concern for physical safety against the need to incentivize the innovation that is necessary to develop these robots. This Article provides context for analysis by reviewing innovation and robots' increasing size, mobility, autonomy, intelligence, and interconnections in terms of safety—particularly in terms of physical interaction with humans—and by summarizing the current legal framework for addressing personal injuries in terms of doctrine, application, and underlying policies. This Article argues that the legal system's method of addressing physical injury from robotic machines that interact closely with humans provides an appropriate balance of innovation and liability for personal injury. It critiques claims that the system is flawed and needs fundamental change and concludes that the legal system will continue to fairly and efficiently foster the innovation of reasonably safe sophisticated robots.

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INTRODUCTION

Within the next decade or so, our daily lives will be transformed by "sophisticated robots," which will have much higher levels of autonomy, intelligence, and interconnectivity than current robots. Many of these machines will be sufficiently large and mobile enough to cause physical injury and death, and people who suffer these physical injuries may seek legal redress for their injury. In addition, regulatory schemes are likely to impose requirements to reduce the number and severity of these injuries. This Article addresses the issue of whether the current approach of the legal system provides a fair, efficient method for balancing the concern for physical safety against the need to support and incentivize the innovation that is necessary to develop these transformative robots.

Part I of this Article provides context for this argument by briefly discussing innovation and robots' increasing mobility, autonomy, intelligence, and interconnections in terms of safety—particularly in terms of physical interaction with humans. Part II summarizes the current legal framework for addressing personal injuries to illustrate the framework's ability to achieve an efficient balance of innovation and liability for personal injury. Part III addresses ways the legal system may respond to address physical injury from large, mobile, and sophisticated robots that interact closely with humans. Part IV critiques proposals for fundamental change, which are based on claims that the current liability system will not adequately compensate victims or that potential liability costs under the current system inhibit robotics innovation. Part V concludes that the legal system fairly allocates the costs of injuries from innovation in robots and has not unduly hindered innovation in robotics.

I. "SOPHISTICATED ROBOTS"

A. *Size, Mobility, Autonomy, Intelligence, and Interconnection*

There is no generally accepted definition of "robot" or "robotic."[1]

1. The term "robots" originated in a science fiction play, *R.U.R. (Rossum's Universal Robots)*, by Karel Čapek, Karel Čapek, *R.U.R. (Rossum's Universal Robots)*, *reprinted in* TOWARD THE RADICAL CENTER: A KAREL ČAPEK READER 34 (Peter Kussi ed., 1990), which premiered in 1921. *Chronology*, *in* TOWARD THE RADICAL CENTER, *supra*. In its original Czech version, the play used the term "*robota*," which means "heavy labor." *R.U.R. (Rossum's Universal Robots) The Makropulous Secret Inventions*, *in* TOWARD THE RADICAL CENTER, *supra*, at 32, 33. The movie *Metropolis* also featured a robot, which was referred to in the movie as a "machine man," though it was actually a female humanoid robot. METROPOLIS (Universum Film AG 1927). The artificial entities in Čapek's play are more aptly viewed as organic artifacts. *See* Čapek, *R.U.R. (Rossum's Universal Robots), supra*, at 38–42 (depicting artificial entities grown from organic living matter, engineered, and redesigned for mass production). The term "robot" has come to refer to machines. *See* THE VISUAL ENCYCLOPEDIA OF SCIENCE FICTION

This Article views robots or robotic machines broadly as tools or machines in terms of five characteristics: (1) size; (2) mobility; (3) connectivity, in the sense that the machine can receive and transmit information; (4) "autonomy" to respond to outside input by independently engaging in physical motions; and (5) "intelligence," which refers to the rate at which the machine can receive, evaluate, use, and transmit information, and the extent, if any, to which it can learn from experience and use this learning in determining future responses. Common examples of such robotic machines include the Roomba "vacuuming robots" produced by the iRobot Corporation.[2]

This characterization of robots is sufficiently broad to include a wide range of autonomous machines, including common things like a cruise-control system "driving" an automobile, an autopilot system in an airplane, and perhaps even a "programmable," electronic thermostat providing control for a heating and air conditioning system as it responds to temperature changes. It would also include speculative artificial intelligence systems like "HAL" (**H**euristically programmed **AL**gorithmic computer) in the science fiction movie *2001: A Space Odyssey*.[3] Though HAL will remain a matter for science fiction in the near future, it appears likely that, within the next decade or so, people will live with a new class of "sophisticated robots" that differ radically from current robots, not only in terms of their autonomy, intelligence, and interconnectivity, but also in terms of increased size and mobility.[4]

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172 (Brian Ash ed., 1977) (explaining that robots may be defined as entities, often made of metal, whose minds are mechanical devices). Robots can take many forms, but humanoid robots are the most popular form in science fiction. *See id.* at 175–80 (discussing the abundance of science fiction stories featuring humanoid robots). Such robots are sometimes termed "androids," but some writers restrict the term android to humanoid robots with synthetic biological or chemical components that are grown rather than a humanoid mechanical entity that is manufactured. *See id.* at 172, 180. As indicated above, the robots in Čapek's play were such synthesized androids. For further discussion of the development of the term "robot," see Jana Horáková & Josef Kelemen, *The Robot Story: Why Robots Were Born and How They Grew Up*, *in* THE MECHANICAL MIND IN HISTORY 283–306 (Philip Husbands et al. eds., 2008). For historical examinations of robot myth and technology, see LISA NOCKS, THE ROBOT: THE LIFE STORY OF A TECHNOLOGY xvii–xx, 3–19 (2007); *see also* SIDNEY PERKOWITZ, DIGITAL PEOPLE: FROM BIONIC HUMANS TO ANDROIDS 17–84 (2004); Lev Grossman, *Iron Men and Bionic Women*, *in* RISE OF THE ROBOTS 18, 18–23 (Richard Stengel et al. eds., 2013).

2. *Our History*, IROBOT, http://www.irobot.com/us/Company/About/Our_History.aspx (last visited Aug. 15, 2014). The iRobot Corporation's website indicates that more than ten million of its home robots had been sold as of 2013. *Id.* For further discussions of robots in the home, see, for example, GREGORY BENFORD & ELISABETH MALARTRE, BEYOND HUMAN: LIVING WITH ROBOTS AND CYBORGS 136 (2007) (discussing robotic household helpers) and DAVID LEVY, LOVE + SEX WITH ROBOTS: THE EVOLUTION OF HUMAN-ROBOT RELATIONSHIPS 97–104 (2007) (discussing virtual and robotic "pets"); Michael Q. Bullerdick, *Home Is Where the Hardware Is*, *in* RISE OF THE ROBOTS, *supra* note 1, at 48–51.

3. 2001: A SPACE ODYSSEY (MGM et al. 1968).

4. *See, e.g.*, YOSEPH BAR-COHEN & DAVID HANSON, THE COMING ROBOT REVOLUTION (2009) (discussing the future emergence of humanlike robots that will have more sophisticated

B. *Design and Safety*

Robots that might cause serious bodily injury are currently designed in a way that is analogous to strict versions of the three "laws" of robotics developed by Isaac Asimov:

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 human beings 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.[5]

Asimov used these laws as plot devices involving robots, rather than as a detailed protocol for robot design. Though they are not actually used in designing robots,[6] crude forms of Asimov's laws are reflected in current practice. More specifically, the first law is reflected in design features that give robots little, if any, mobility and that isolate dangerous robots from humans or cause a robot to stop activity if a human comes within a danger zone.[7] In terms of design, a combination of the first and second laws parallel the wide use of the human-in-the-loop approach in such things as cruise control in cars, autopilot systems in airplanes,[8] regulations concerning driverless vehicles on highways,[9]

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features than the robots of today); Lev Grossman, *Drone Home*, *in* RISE OF THE ROBOTS, *supra* note 1, at 24–43 (discussing increasing use of unmanned aircraft systems).

5. ISAAC ASIMOV, ROBOT VISIONS 8 (1990); *see also* ISAAC ASIMOV, THE NAKED SUN 31–33 (1957).

6. *See, e.g.*, RODNEY A. BROOKS, FLESH AND MACHINES: HOW ROBOTS WILL CHANGE US 73 (2002) ("[W]e do not know how to build robots that are perceptive enough and smart enough to obey these three laws."); WENDELL WALLACH & COLIN ALLEN, MORAL MACHINES: TEACHING ROBOTS RIGHT FROM WRONG (2009) (discussing challenges of whether and how to design robots able to make complex decisions about "right" behavior); F. Patrick Hubbard, *"Do Androids Dream?": Personhood and Intelligent Artifacts*, 83 TEMP. L. REV. 405, 464–66 (2011) (discussing Asimov's robot novels and short stories, noting the role of the three laws as plot device and noting that these laws cannot be used to program robots); Robin R. Murphy & David D. Woods, *Beyond Asimov: The Three Laws of Responsible Robotics*, 24 IEEE INTELLIGENT SYSTEMS, July–Aug. 2009, at 14, *available at* http://www.inf.ufrgs.br/~prestes/Courses/Robotics/beyond%20asimov.pdf.

7. *See infra* notes 153–56 and accompanying text (discussing cases that illustrate lack of success of suits for injuries from industrial robots).

8. *See, e.g.*, Brouse v. United States, 83 F. Supp. 373, 374 (N.D. Ohio 1949) (holding that operator of plane "under robot control" was negligent in failing to "keep a proper and constant lookout" for other planes).

and missile-firing decisions in drone aircraft.[10] Finally, the third law is reflected in features that alert users of the need for recharging a battery or that enable a machine to find a power source and recharge its battery on its own.[11]

The safety achieved by these design features comes at a high price because their severe limits on autonomy drastically reduce the usefulness of robots. Following the first law, by isolating robots from humans by barriers or automatic stop features, this limits the ability of humans to engage in collaborative efforts with potentially dangerous robotic machines of far greater size and capabilities than a Roomba, in a wide variety of settings.[12] The human-in-the-loop approach reduces the ability of robots to replace humans in many tasks by only providing human assistance. As a result, current design approaches inhibit the development and use of robots with the autonomy of physical movement that will enable their integration into daily life to perform physical tasks in the same ubiquitous way that computers have come to handle information.

Although the present approach to robot design results in a high level of human safety, the limitations necessary to achieve this level raise a question: Is society paying too high a price in foregone benefits for this level of protection? Safety is, of course, important; but it is just one social value. All technology presents the challenge of balancing its costs

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9. *See infra* notes 190–201 and accompanying text (discussing the Nevada regulatory scheme, which requires the presence of a human being in a vehicle and equipment that enables the human being to take immediate control).

10. *See, e.g.*, P.W. SINGER, WIRED FOR WAR: THE ROBOTICS REVOLUTION AND CONFLICT IN THE TWENTY-FIRST CENTURY *passim* (2009); Peter Finn, *A Future for Drones: Automated Killing*, WASH. POST (Sept. 19, 2011), http://www.washingtonpost.com/national/national-security/a-future-for-drones-automated-killing/2011/09/15/gIQAVy9mgK_story.html (discussing research on removing humans from the decision to kill). For more on the tension between the human-in-the-loop approach and autonomy in the military context, see SINGER, *supra*, at 123–34.

11. *See, e.g.*, *Is Kiva Systems a Good Fit for Your Distribution Center?: An Unbiased Distribution Consultant Evaluation*, MWPVL, http://www.mwpvl.com/html/kiva_systems.html (last visited Aug. 15, 2014) (discussing Kiva warehouse robots that "travel to designated charge stations every couple of hours where they receive a 5-minute battery re-charge").

12. *See, e.g.*, *Safety of Human-Robot Collaboration Systems Project*, NAT'L INST. OF STANDARDS & TECH. (Nov. 10, 2011), http://web.archive.org/web/20120925043230/http://www.nist.gov/el/isd/ps/safhumrobcollsys.cfm (archived copy) [hereinafter NIST, *Human-Robot Collaboration*] (discussing safety standards that allow robots and humans to work together in the same space); *Safety of Human-Robot Systems in Flexible Factory Environments*, NAT'L INST. OF STANDARDS & TECH. (Jan. 10, 2013), http://www.nist.gov/el/isd/ps/safehumrobsysflexfactenvir.cfm (discussing the development of methods for modeling and evaluating the performance of safety systems that will allow the collaboration of robots and humans in factory environments). NIST notes: "Safe human-robot collaboration is widely seen as key to the future of robotics. When humans and robots can work together in the same space, a whole class of tasks becomes amenable to automation, ranging from collaborative assembly to parts and material handling and delivery." NIST, *Human-Robot Collaboration*, *supra*.

against its benefits. For example, because of the enormous benefits of automobiles, there is no debate about whether to use them despite their high cost, not only in terms of injuries and deaths, but also in terms of urban sprawl, pollution, and dependence on foreign oil supplies. People do try to reduce these costs; but most of us are not seriously considering abandoning automobiles. Instead, we seek an efficient balance of their costs and benefits.

Similarly, because of the benefits of robots with greater size, mobility, connectivity, autonomy, and intelligence society will likely relax the current rigid limitations on robots where it is possible to do so in a cost-effective manner. The push for such relaxation of limitations has already begun, partly because of developments in autonomous vehicles.[13] This push is likely to expand into other areas—for example, robots with increased abilities to identify humans and predict their behavior "are under development throughout the world . . . [and] will revolutionize manufacturing by allowing humans and robots to operate in close proximity while performing a variety of tasks."[14] Such capabilities will make it possible to enjoy the benefits resulting from reducing the scale of the danger zone that requires a robot to cease activity if humans come within the zone and from reducing the need for a human in the loop. Consequently, as with automobiles, society may come to accept the benefits of the technology despite the increased risk of injuries to humans.

C. *Innovation*

Innovation will be necessary for the development of large mobile sophisticated robots that can safely interact closely with humans. Despite widespread agreement that technological innovation is valuable and that innovation includes "improved products," it is not always clear what counts as innovation.[15] For example, inventions and patents are often related to innovation, but most patents are never used and thus do not result in new or improved technology.[16] Similarly, there is no agreement on the relative roles of government and the private market in

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13. *See, e.g.*, Grossman, *supra* note 1, at 24–33; *see infra* notes 180–216 and accompanying text; *infra* Section IV.B. The "robot industry" has an active trade organization, Association for Unmanned Vehicle Systems International (AUVSI), which coordinates the push to develop unmanned systems. For information on the organization, see AUVSI, http://www.auvsi.org/home/aboutus (last visited Aug. 15, 2014).

14. NIST, *Human-Robot Collaboration*, *supra* note 12.

15. NAT'L RESEARCH COUNCIL, IMPROVING MEASURES OF SCIENCE, TECHNOLOGY AND INNOVATION: INTERIM REPORT 20–26 (Litan et al. eds., 2012).

16. William Hubbard, *Competitive Patent Law*, 65 FLA. L. REV. 341, 354 n.92 (2013); *see* NAT'L RESEARCH COUNCIL, *supra* note 15, at 20–23.

promoting innovation.[17]

This Article addresses uncertainty about the nature of innovation in two ways. First, this Article considers innovation in terms of situations where humans face increased risk of physical injury from the use of sophisticated robots. Second, it considers innovation in terms of the impact of liability for harm caused by a robot on innovators' decisions to invest in developing these robots. Unfortunately, the second approach simply restates the problem of defining innovation as a question of who counts as an innovator. For example, are venture capitalists innovating if they invest in a company that is developing innovative robots? To further limit the scope of analysis, this Article will restrict the concept of innovator to manufacturers, designers, sellers, lessors, and other distributors of robots and their physical components. Thus, this Article will focus on the effect of regulation and liability on these actors. In addressing this effect, this Article assumes that these actors will base their decisions on a rational comparison of the possible economic benefits of success in innovation with the possible costs, including costs of liability for injuries and of satisfying regulatory requirements.[18]

II. Approaches for Addressing Safety and Products

In any area of technological innovation, the legal system faces the challenges of: (1) reducing the number and severity of personal injuries; (2) allocating the costs of victims' injuries;[19] and (3) incentivizing innovation. For more than two centuries, the United States has addressed these concerns with a complex system of federal, state, and local governmental entities, each of which: (1) is relatively autonomous, and (2) uses both judicial and legislative/regulatory mechanisms to address injuries. The system has changed enormously in response to problems resulting from developments like mass production of goods,

17. *See, e.g.*, Jeff Madrick, *Innovation: The Government Was Crucial After All*, N.Y. REV. OF BOOKS 50 (Apr. 24, 2014) (arguing that federal government plays a crucial role in technological innovation), *available at* http://www.nybooks.com/articles/archives/2014/apr/24/innovation-government-was-crucial-after-all/; Jim Manzi, *The New American System*, 19 NAT'L AFFAIRS (Spring 2014) (arguing that although government has had and will continue to have an important role in innovation, the role is different in the current world), *available at* http://www.nationalaffairs.com/publications/detail/the-new-american-system.

18. In practice, this comparison can be difficult and, at times, stressful. *See infra* notes 237–50 and accompanying text. Moreover, rationality in the face of uncertainty may be partly a matter of whether a person adopts a maxi-max (maximize the maximum received if potential gains exceed losses) or a maxi-min (maximize the minimum that results if things go very poorly) strategy.

19. The allocation of loss is complicated because, in addition to compensation based on liability in a corrective justice scheme, victims' injury costs can also be addressed by a wide range of both private and social insurance schemes. *See, e.g.*, F. Patrick Hubbard, *The Nature and Impact of the "Tort Reform" Movement*, 35 HOFSTRA L. REV. 437, 441–42 (2006).

mechanized transportation systems, and electronic communications systems.

The current system can be categorized in terms of two distinct approaches to safety. The first uses a judicially imposed liability system of corrective justice that requires wrongdoers to compensate victims for injuries caused by a wrong. The goal is to create market incentives that internalize the costs of wrongdoing to the wrongdoer. In this way, individual private actors decide the most efficient way to address potential liability for wrongful injury. The second approach involves collective determinations of the best way to address safety and imposes this determination with regulatory commands backed by the threat of sanctions for violations. The two approaches often work in tandem. For example, the rational driver of an automobile deciding how fast to drive would consider the possibility of being held liable for injuries caused by wrongfully excessive speed as well as the risk of receiving a speeding ticket.[20]

A. *Liability: Corrective Justice/Market Approach*

The legal system relies on the judicially administered system of contract and tort liability—largely a matter of state law—to address personal injury caused by robots. These injuries will be borne primarily by three types of victims: (1) *purchasers* (owners) or *lessees*, (2) *users* (other than purchasers or lessees), and (3) *other parties*. The important differences among these types of victims are: (1) only purchasers and lessees can bargain with innovators for contract rights at the time of sale, lease, or other distribution; and (2) purchasers, lessees, and users will enjoy benefits offsetting the risks from the vehicles, while other parties may incur only risks.[21]

Both contract and tort law impose liability—based primarily on "fault" or "wrongdoing"—for injuries caused by the use of machines. This liability provides an incentive to avoid "wrongdoing" by making safer products and using products more safely. As the development and use of robots proceeds, products liability law, including both contract and tort doctrines, will likely govern the risk of injuries from the *sale*, *lease*, or other *distribution* of robots, and the general negligence principles of tort law will primarily govern injuries from the *use* of such products.

Contract and tort are "corrective justice" schemes for allocating the risk of loss based on the following principle: Where Plaintiff (*P*) can

20. See *infra* note 25 for discussion of this point in terms of efficiency.

21. Determining whether other parties receive benefits as well as risks can be complicated in practice. For example, a person who does not own or drive a car benefits indirectly from the use of motor vehicles.

show that Defendant's (*D*'s) wrongdoing (defined as a breach of a legal duty to *P*) caused injury to *P*, *D* must correct that wrong by placing *P*—usually through compensation—in the position *P* would have been in but for the wrong by *D*.[22] Thus, in both contract and tort, the plaintiff bears the burden of proving a right to compensation from the defendant. The primary difference between contract and tort is that legal duties are generally imposed by agreement of the parties in contract and by operation of the law in tort.[23]

As indicated more fully below, efficiency in terms of requiring only cost-effective expenditures on safety plays a central role in defining the duties to potential victims owed by product sellers, lessors, and users.[24] As a result, corrective justice and the efficient reduction of accidental injury costs are *not* necessarily in conflict with each other. Instead, because efficiency generally defines duties, the corrective justice systems of contract and tort tend to promote efficiency.[25]

Contract law and tort law are largely matters of state law. This Article adopts two approaches to address the complexity resulting from variations among the states concerning the details of legal doctrine. First, this Article considers contract law primarily in terms of Article 2 of the Uniform Commercial Code (UCC), which virtually all states have adopted (with occasional minor changes). Article 2 of the UCC governs sales and other forms of distribution in terms of "transactions in goods,"[26] and Article 2A governs leases.[27] Both articles apply to robots.[28] Second, the discussions of tort law rely on sources such as

22. Traditionally, a claim or "cause of action" in tort or contract is viewed in terms of the following "elements": (1) a duty owed to plaintiff by defendant; (2) a breach of that duty ("wrongdoing"); (3) injury caused by that breach; and (4) legally cognizable damages (or other remedy) for the injury caused by the breach. *See, e.g.*, DAN B. DOBBS, THE LAW OF TORTS § 114, at 269 (2001). For general discussion of "corrective justice" and purposes of tort law, see, for example, Hubbard, *supra* note 19, at 446–48.

23. Because tort and contract law are judicially administered, the impact of the substantive rules in both legal areas is partly determined by damages rules, evidentiary rules concerning proof, and procedural rules concerning trial. Discussion of these more general rules is beyond the scope of this Article.

24. *See infra* notes 43, 54–56, 59–61, 250 and accompanying text.

25. Even though tort law incentivizes efficiency by only imposing liability for inefficiency in making decisions about safety, it does not perform this function in the same way as a regulatory system. For example, if a person acts in a negligently dangerous manner by driving twenty miles per hour over the speed limit and no one is harmed as a result, there is no wrong to correct, and thus, no liability in tort. In contrast, under regulatory schemes addressing driving, a fine for that speeding could be imposed regardless of outcome and the amount of that fine would generally be set regardless of whether harm occurred.

26. U.C.C. § 2-102 (2012); § 2-105 (defining "goods"); § 2-106(1) (defining "sale").

27. U.C.C. § 2A-102.

28. *Compare* U.C.C. § 2-102 ("[T]his Article applies to transactions in goods. . . ."), *with* § 2-105 (defining "goods" as "all things (including specially manufactured goods) which are movable at the time of identification").

widely used treatises and the *Restatements of the Law of Torts*,[29] particularly the *Restatement (Third) of Torts: Products Liability* (referred to hereinafter as *Restatement of Torts: Products Liability*).[30] These simplifying techniques are supplemented by more detailed discussion of specific examples of litigation concerning robots. This approach does not restrict the utility of this analysis of the impact of the liability system on innovation for three reasons.

First, persons considering whether to sell, buy, or develop robotic products will evaluate risk *ex ante*—i.e., before any injuries have occurred. From this perspective, they usually will not know where and how the accident may occur. As a result, they will not know which state's law will apply, and thus, will be concerned with the *risk* of liability for injury in *any* state where an injury *might* occur. The U.C.C. and the *Restatements* provide a useful basis for such a broad *ex ante* consideration of risk.[31]

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29. The Restatements provide a neutral authoritative summary of basic doctrinal areas in American law. They are prepared by the American Law Institute (ALI). The website for the ALI describes its work as follows:

> The American Law Institute is the leading independent organization in the United States producing scholarly work to clarify, modernize, and otherwise improve the law. The Institute (made up of 4000 lawyers, judges, and law professors of the highest qualifications) drafts, discusses, revises, and publishes Restatements of the Law, model statutes, and principles of law that are enormously influential in the courts and legislatures, as well as in legal scholarship and education.

ALI Overview, AMERICAN LAW INSTITUTE, http://www.ali.org/index.cfm?fuseaction =about.overview (last visited Aug. 15, 2014).

30. The *Product Liability Restatement* was adopted by the ALI on May 20, 1997. RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. (1997).

31. Unfortunately, it is not possible to address other important areas of doctrine relevant to allocating the risk of liability for injuries caused by sophisticated robots. In addition to the omitted topics discussed in *supra* note 23, the following are not addressed: (1) defenses, particularly those based on conduct by the victim; and (2) allocation of liability among innovators (and to a lesser extent, among innovators, purchasers, and users). Though the conduct of users and victims is addressed in the discussion of design and warnings at Subsection II.A.2 below and the allocation involved in the second area is addressed to some extent in the discussion of indemnity *infra* note 45, the other aspects of these doctrinal areas will not be addressed herein. Covering these other areas is simply too complicated to be addressed in an article of this length. Given, the *ex ante* nature of risk assessment, this necessary limitation on coverage should not substantially affect analysis.

Similarly, broad rights to prevent harm to person or property by engaging in self-help or by using another's robot are not addressed. For a discussion of such rights, see, for example, Vincent v. Lake Erie Transp. Co., 124 N.W. 221, 222 (Minn. 1910) (requiring one who exercises privilege of necessity to protect his property by use of another's property to compensate the person whose property is used); Ploof v. Putnam, 71 A. 188, 189 (Vt. 1908) (recognizing a privilege based on necessity to use another's property to protect one's property); A. Michael Froomkin & Zak Colangelo, Self-Defense Against Robots 7–33 (Mar. 19, 2014)

Second, the content of a legal rule or standard is always indeterminate to some extent.[32] This indeterminacy results partly from the limits of verbal communication, which makes it impossible to devise rules precise enough to decide cases outside of a "core of undisputed meaning" containing a limited class of clear cases.[33] In addition, because of the dynamism and complexity of the world, lawmakers have limited ability to determine present and future facts. As a result, they are handicapped by a "relative indeterminacy of aim" concerning the subject of the rule, and this indeterminacy presents difficulties in interpreting and applying the rule.[34] It may also result in a decision to use a broad rule that, though often indeterminate in terms of specific applications, is flexible enough to address diverse fact scenarios.[35] Analogous problems arise in programming autonomous robots to perform complex tasks in unanticipated, changing environments.[36] Finally, even relatively precise rules can be changed, and these changes can apply even if they are enacted *after* the sale of the product.[37]

Third, doctrinal uncertainties are generally less important than the wide variation in the types and amount of harms that might result when a product is wrongfully designed or used. For example, where a failure of an autonomous braking system causes an automobile collision, the injuries caused by the collision could range from minor bruises to spinal injury that renders the victim a quadriplegic. Though rare, serious injuries like quadriplegia typically involve millions of dollars in economic damages for a life care plan, as well as potentially large

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(unpublished conference draft), *available at* http://robots.law.miami.edu/2014/wp-content/uploads/2013/06/Froomkin-Colangelo-Self-Defence-Against-Robots-March-2014.pdf.

32. *See* H.L.A. HART, THE CONCEPT OF LAW 126, 144–45, 272–73 (2d ed. 1994).

33. *Id.* at 12; *see, e.g.*, *id.* at 123 ("core of certainty"); 128–29 ("paradigm, clear cases").

34. *Id.* at 128.

35. *See infra* note 57 and accompanying text.

36. *See, e.g.*, BROOKS, *supra* note 6, at 19–21 (discussing "tortoise" robots and their "remarkably unpredictable" responses to changing environments). *See generally* WALLACH & ALLEN, *supra* note 6, at 83–124 (discussing relative strengths and weaknesses of top-down and bottom-up approaches to designing robots able to handle change in complexity). Though programs are not ambiguous, it is not possible to provide rules for all possible cases because of problems involved in providing a complete model of the robot's environment. In addition, difficulties can arise as a result of emergent behavior where a robot is given some autonomy. *See infra* note 227 and accompanying text.

37. Statutory changes in law often apply to causes of actions [claims] "arising after" the effective date of the statute. Typically, a cause of action arises after the event in which a product caused the injury, regardless of whether the sale of the product occurred before the statutory change. Judicial changes often follow a similar pattern. *See, e.g.*, Marcum v. Bowden, 643 S.E.2d 85, 90–91) (S.C. 2007) (Toal, J., concurring in part, dissenting in part) (arguing that the change in rule concerning tort liability should not be prospective for claimant bringing successful challenge); Steinke v. South Carolina Dep't of Labor, Licensing, & Regulation, 520 S.E.2d 142, 156 (S.C. 1999); ROBERT E. KEETON, VENTURING TO DO JUSTICE: REFORMING PRIVATE LAW 41, 51 (1969).

awards for psychic harm.

Given all these uncertainties, the rational *ex ante* approach for innovators is to find the best mix of basic product liability insurance and self-insurance for their particular robotic product. Though the premium may vary from year to year,[38] the cost of this insurance package will provide a relatively reliable figure as to the liability cost for innovation.

Unfortunately, however, because of the nature of products liability insurance, things may be more complicated. Conceptually, liability insurance is a simple matter: The insurer sets premium rates and invests premiums in order to secure a sufficient income to cover administrative expenses (including litigation costs), to pay claims, and to make an adequate profit.[39] Yet achieving this result is challenging because of uncertainty concerning investment income and claims payouts. All types of insurance face investment uncertainty and problems in predicting the amount and timing of claims payouts. To some extent, insurance companies can address the problem in predicting claims where a large body of claims data exists, as in the areas of automobile insurance[40] and general commercial liability.[41] However, there may well be no such data available to insurers where a seller seeks liability insurance for an innovative sophisticated robot. As a result, products liability insurers may be very concerned about the potential for high claims. Therefore, insurance may be hard to get, very expensive, or both.[42]

38. A full discussion of the details of insurance is beyond the scope of this Article. In terms of details, cost variation in insurance can result from factors like increased (or decreased) competition, reduced investment opportunities for the fund established to pay claims, changes in administrative costs, and increased payouts for claims. Reductions in the amount of coverage in terms of exclusions, types of claim coverage (occurrence or claims made), and dollar amount of coverage are also important. *See, e.g.*, KENNETH S. ABRAHAM, DISTRIBUTING RISK: INSURANCE, LEGAL THEORY, AND PUBLIC POLICY 48 (1986).

39. *See, e.g.*, *id.* at 77.

40. *See, e.g.*, *id.* at 46.

41. *See, e.g.*, Mark A. Geistfeld, *Legal Ambiguity, Liability Insurance, and Tort Reform*, 60 DEPAUL L. REV. 539, 549–50 (2011) (explaining that while the insurance companies can get large pools of data on general commercial liability, there are still factors that make accurately predicting future liability costs difficult).

42. *See id.* at 552–64. For approaches to address this problem, see, for example, STEPHEN S. WU, RISK MANAGEMENT IN COMMERCIALIZING ROBOTS 6–15 (2013), *available at* http://conferences.law.stanford.edu/werobot/wp-content/uploads/sites/29/2013/04/Risk-Management-in-Commercializing-Robotics.pdf (presented at the Stanford Law School Conference "We Robot: Getting Down to Business"). For useful discussion of insurance in terms of Unmanned Aircraft Systems (UAS), see, for example, Breyer et al., *Risk, Product Liability Trends, Triggers, and Insurance in Commercial Aerial Robots* (2014), *available at* http://robots.law.miami.edu/2014/program/.

1. Contract—The Uniform Commercial Code (UCC)

A contract's allocation of risk is viewed as the result of rational choices by autonomous agents, therefore the legal system generally treats rights based on a contract as both fair and efficient.[43] Two kinds of contracts are important to the allocation of risk of personal injuries: (1) contracts made pursuant to UCC rules governing sales, leases, and other distributions;[44] and (2) contracts of indemnification, which explicitly allocate a risk of liability for loss by an agreement to shift the liability from one party (the indemnitee) to the other party (the indemnitor).[45]

The UCC has a number of default rules that structure the contracting process. One of the most important default rules in terms of product-caused injuries to persons is: Products sold or leased by "a merchant [(seller)] with respect to goods of that kind" must be "merchantable," which means, among other things, "fit for the ordinary purpose for

43. The underlying goals of contract law are the subject of dispute, primarily in terms of whether the goal is better expressed in terms of the promotion of efficiency or the protection of promise-based or expectation-based rights. *See* STEPHEN A. SMITH, CONTRACT THEORY 3 (2004). *Compare* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW § 4.9 (6th ed. 2003) (arguing for efficiency), *with* CHARLES FRIED, CONTRACT AS PROMISE: A THEORY OF CONTRACTUAL OBLIGATION 8 (1981) (discussing promise-based rights), *and* HENRY MATHER, CONTRACT LAW AND MORALITY 1, 3–6 (1999) (asserting that facilitation of reliance and beneficial coordination is the goal). Under both approaches, however, the result is the same—i.e., the wishes of the parties as expressed in the contract are generally enforced. On rare occasions, all or part of a contract will be viewed as so unfair as to be unenforceable. *See, e.g.*, U.C.C. § 2-302 (2012) (providing that a judge may refuse to enforce contract (or clause in a contract) on grounds that the contract or clause is "unconscionable"). The basic concern is "the prevention of "oppression and unfair competition." *Id.* at cmt. 1.

44. *See supra* notes 26–27 and accompanying text. Where a contract has an express warranty by the seller, the seller is liable regardless of fault for breach of that warranty. *See* DAVID G. OWEN, PRODUCTS LIABILITY LAW 32 (2d ed. 2008).

45. A person who has been held liable for injury in tort or contract, may be able to claim a right to indemnity (payment) for that liability from another party. This right to indemnity can be based on law or contract. *See, e.g.*, Marquez v. City Stores Co., 371 So. 2d 810 (La. 1979) (finding no right to contractual or legal indemnity); 41 AM. JUR. 2D *Indemnity* § 2 (West 2014). An example of a legal right to indemnity is the right of an employer to recover from its employee, who has committed a tortious act for which he would be personally liable, where the employer has been held vicariously liable for that tortious act of the employee. *See, e.g.*, RESTATEMENT (SECOND) OF TORTS § 886B & cmt. e, at 344, 347 (1977); RESTATEMENT (SECOND) OF AGENCY § 401 & cmts. a, e, at 237–38, 240 (1957); 27 AM. JUR. 2D *Employment Relationship* § 408 (West 2014). As a general rule, claims of a right of indemnity are more likely to be successful if there is a contractual basis for the claim. *Compare, e.g.*, Hudson v. Siemens Logistics & Assembly Sys., Inc., 353 F. App'x 717 (3d Cir. 2009) (accepting a claim of contractual right to indemnity), *with e.g.*, Williams v. Unit Handling Sys. Div. of Litton Sys., Inc., 449 N.W.2d 669 (Mich. 1989) (rejecting claim of right to implied indemnity against employer for manufacturer's costs of settling suit for defect in a robotic machine with employee of employer).

which goods of that kind are used."[46] Where personal injuries are involved, the standard of "fit for ordinary purposes" requires that the product be reasonably safe for such purposes.[47] This implied-by-law "warranty of merchantability" imposes a standard that is basically the same as the tort standard used for products liability.[48] Therefore, the discussion below at Subsection II.A.2.b of the tort scheme for determining defectiveness usually applies to UCC merchantability claims.

Two UCC rules are especially important in considering the warranty of merchantability. First, a seller/lessor can sometimes avoid being subject to this implied warranty of merchantability by excluding or modifying the warranty.[49] Second, if the merchant does not exclude or modify the warranty, the merchant: (1) will almost certainly be liable for physical injuries caused by breach of the warranty, even though he is entitled to limit or exclude liability for economic losses caused by the breach,[50] and (2) will likely be liable to third parties who are injured.[51]

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46. U.C.C. § 2-314 (1), (2)(c) (2012) (sales); U.C.C. § 2A-212(2)(c) (leases). A manufacturer is treated as a merchant under these provisions because the manufacturer sells or leases the product.

47. OWEN, *supra* note 44, at 32.

48. Hood v. Robi Am. Corp., 181 F.3d 608, 610 n.1 (4th Cir. 1999) (noting that, in the case involved, the tort theories and the warranty theory were "virtually identical"); Denny v. Ford Motor Co., 662 N.E.2d 730, 738 (N.Y. 1995) ("As a practical matter, the distinction between the defect concepts in tort law and in implied warranty theory may have little or no effect in most cases."); *see* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. n, at 35–36 (1997) ("Regardless of the doctrinal label attached to a particular claim, design and warning claims rest on a risk-utility assessment."); *id.* at cmt. r, at 40 ("[I]n cases involving defect-caused harm to persons or property, a well-coordinated body of law dealing with liability for such harm arising out of the sale of defective products would adopt the tort definition of product defect."); OWEN, *supra* note 44, at 32.

49. *See* U.C.C. §§ 2-316(2), 2A-214(2); *see* OWEN, *supra* note 44, § 4.9.

50. *See* U.C.C. § 2-302 ("If [a] court . . . finds the contract or any clause of the contract to have been unconscionable . . . the court may refuse to enforce the contract . . . ."); U.C.C. § 2-719(3) ("Limitation of consequential damages for injury to the person in the case of consumer goods is prima facie unconscionable but limitation of damages where the loss is commercial is not."); U.C.C. § 2A-108 (establishing a scheme for addressing unconscionability and authorizing the court to grant appropriate relief); U.C.C. § 2A-503(3) ("Limitation, alteration, or exclusion of consequential damages for injury to the person in the case of consumer goods is prima facie unconscionable . . . ."); U.C.C. § 2A-520(2) ("Consequential damages . . . include . . . injury to person or property proximately resulting from any breach of warranty."). The definitions sections of Articles 2 and 2A refer to U.C.C. § 9-109 for the definition of consumer goods. Section 9-102 defines consumer goods as goods "used or bought for use primarily for personal, family, or house hold purposes." U.C.C. § 9-109(23).

51. *See* U.C.C. §§ 2-318, 2A-216. Both sections have three alternative provisions, which vary in the breadth of coverage of third parties.

2. Tort

a. Basic Concepts

As indicated above, tort law operates as a corrective justice system to return a victim to the position the victim would have occupied but for the injury caused by defendant's wrongdoing.[52] A tort can be broadly defined as a civil "wrong" (other than a breach of contract) that causes injury, for which a victim can seek a judicial remedy, usually in the form of damages.[53] Because this definition encompasses a broad range of "wrongs," there is no single test or definition of wrong. Fortunately, there is no need to consider all the meanings of "wrong" in this Article because negligence generally serves as the basic test or principle to identify wrongdoing where personal injury is involved.

Negligence is the most common form of "fault" in tort law and is often defined by reference to a "reasonable person," whose conduct is, by definition, never negligent.[54] An alternative approach addresses negligence in terms of a cost–benefit test based on a comparison of accident costs with safety costs.[55] Under this approach, conduct is negligent if a person, when deciding whether to engage in conduct involving *foreseeable* risk of injury, chooses to engage in that conduct without adopting *feasible* safety measures that would cost less than the foreseeable injury. Defining the foreseeable injuries as accident costs (*AC*) and the safety measures as safety costs (*SC*), the test can be stated algebraically as follows: If $AC > SC$ and an actor chooses to risk *AC* rather than incur *SC*, the actor is negligent.[56] The goal is to create market incentives that internalize the costs of wrongdoing to the wrongdoer. In this way, individual private actors decide the most efficient way to address potential liability for wrongful injury.

Both tests rely on two basic terms or concepts: foreseeability and feasibility. These terms focus on what could have been expected of a person in the past at the time of the conduct involved in the eventual wrongdoing. From the point of view of the time when the conduct was undertaken, two questions arise: (1) What mishaps could the actor reasonably foresee in the future; and (2) What actions to prevent mishaps were reasonably feasible? Additional knowledge and new

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52. *See supra* note 22 and accompanying text.

53. *See, e.g.*, DOBBS, *supra* note 22, § 1, at 1–2; 1 FRANCIS HILLIARD, THE LAW OF TORTS OR PRIVATE WRONGS 1–3 (1861); SIR FREDERICK POLLOCK, THE LAW OF TORTS: A TREATISE ON THE PRINCIPLES OF OBLIGATIONS ARISING FROM CIVIL WRONGS IN THE COMMON LAW 3–4 (5th. ed. 1897); WILLIAM L. PROSSER, HANDBOOK OF THE LAW OF TORTS 1–6 (4th ed. 1971).

54. RESTATEMENT (SECOND) OF TORTS § 283, at 12 (1977).

55. *See id.* § 291.

56. *See, e.g.*, F. PATRICK HUBBARD & ROBERT L. FELIX, THE SOUTH CAROLINA LAW OF TORTS 63–65 (4th ed. 2011).

technology that was unavailable at the time of the conduct are excluded from the assessment of negligence. Unfortunately, the terms "reasonably foreseen" and "reasonably feasible" are, of necessity, extremely vague.[57] This Article addresses the approach to the use of these vague terms in the context of specific applications.[58]

b. Products Liability: Sales, Leases, and Other Distributions

i. Doctrine

(a) The Three Types of Defects

In cases of sellers, lessors, and other distributors, tort law governs liability for physical injury arising from products regardless of whether contract law applies.[59] Tort liability for product-caused injuries is based

57. *But see generally* Symposium, *The Limits of Predictability and the Value of Uncertainty*, 60 DEPAUL L. REV. 271 (2011) (discussing the benefits of uncertainty in law).

58. *See infra* notes 62–76 and accompanying text.

59. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. §§ 12–14, at 206, 221, 227 (1997). Economic losses are treated differently from physical injury because contracts are viewed as a more efficient method of allocation of economic losses arising from a product defect. As a result, the tort system generally uses the "economic loss rule," which provides that, where there is no physical injury or injury to property other than the product, only contract doctrine applies. Section 21 of the *Restatement of Products Liability* provides:

> § 21. Definition of "Harm to Persons or Property": Recovery for Economic Loss
>
> For purposes of this Restatement, harm to persons or property includes economic loss if caused by harm to:
>
> (a) the plaintiff's person; or
>
> (b) the person of another when harm to the other interferes with an interest of the plaintiff protected by tort law; or
>
> (c) the plaintiff's property other than the defective product itself. *Id.* § 21, at 293.

Comment a to this section notes as follows:

> Two major constraints on tort recovery give content to this Section. First, products liability law lies at the boundary between tort and contract. Some categories of loss, including those often referred to as "pure economic loss," are more appropriately assigned to contract law and the remedies set forth in Articles 2 and 2A of the Uniform Commercial Code. When the Code governs a claim, its provisions regarding such issues as statutes of limitation, privity, notice of claim, and disclaimer ordinarily govern the litigation. Second, some forms of economic loss have traditionally been excluded from the realm of tort law even when the plaintiff has no contractual remedy for a claim.

on the concept of "defect"—i.e., there is no liability unless a product defect caused the injury. The legal system analyzes product defects in terms of three specific types of defects: design, warnings and instructions, and manufacturing.

In considering liability for product defects, it is important to keep in mind that, while efficiency is the dominant value in allocating liability, it is not the only value. The dominance of efficiency is reflected in the general rule that a product manufacturer or distributor is not liable unless there is wrong defined in terms of efficiency. Given this general rule, it is understandable that tort law defines nearly all product defects in negligence-like terms that require a plaintiff to show that certain safety costs were not incurred by the defendant even though they were cheaper than the accident costs that they would prevent. Given the need to show a defect in this way, it is very likely that at least one person in the chain of distribution is at "fault" in the negligence sense of the term.[60]

Despite the importance of this emphasis on efficiency, products liability contains pockets of "strict liability"—i.e., liability without negligence. These pockets generally exist where tort doctrine's desire to protect the reasonable expectations of humans injured by a product "defect" can be furthered without undue "unfairness" to product distributors.[61]

Design Defects. A cost–benefit test like that used for negligence is used for identifying a design defect. Under this test, a product "is defective in design when the foreseeable risks of harm posed by the product could have been reduced or avoided by the adoption of a reasonable alternative design . . . ."[62] A "reasonable alternative design" is defined in terms of risk–utility or cost–benefit—i.e., the safer alternative design's costs (in terms of such factors as manufacturing costs, loss in utility of the product, and increase in risks of different harms) must be less than the foreseeable injuries prevented by incurring the costs of the safer alternative design.[63] For example, if it is feasible

Id. § 21 cmt. a, at 293. The economic loss doctrine has been used to bar tort claims in numerous cases involving computers and software. *See, e.g.*, Transport Corp. of Am. v. Int'l Bus. Machs. Corp., 30 F.3d 953, 955 (8th Cir. 1994) (holding that suit in tort for failure of disk drive was barred by economic loss doctrine and that because seller had disclaimed all contract remedies, buyer had no contract claim).

60. *See infra* notes 63–69 and accompanying text.

61. *See infra* notes 71–72, 80, 86 and accompanying text.

62. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(b), at 14.

63. *See id.* at cmts. d, f, g, at 19, 22–23, 27; *see also* OWEN, *supra* note 44, at 508–32, 552–58. At one time, § 402A of the *Restatement of the Law of Torts* imposed liability on sellers for injuries caused by "any product in a defective condition unreasonably dangerous to the user or consumer or to his property." RESTATEMENT (SECOND) OF TORTS § 402A. The comments to the section indicated that the determination of whether such a defect existed was based on

under the existing "state of the art" design[64] to add to an automobile's restraint system a shoulder harness that costs less than the costs of accidents prevented by the shoulder harness, the harness should be included in the system.[65] If it is not, the system is defective, and the manufacturer is liable for injuries caused by the defect.

Warning and Instruction Defects. The cost–benefit test is also used for warnings and instructions. Thus, a product "is defective because of inadequate instructions or warnings when the foreseeable risks of harm posed by the product could have been reduced or avoided by the provision of reasonable instructions or warnings by the seller or other distributor . . . ."[66] These claims raise two issues: (1) was a warning or instruction needed,[67] and (2) if a warning or instruction was provided, was that warning or instruction reasonable. As a general rule, a warning or instruction concerning a serious risk is required if: (1) the risk is foreseeable; and (2) a significant number of users will not be aware of the risk.[68]

Determining whether "reasonable instructions or warnings" were used involves a contextual consideration of "various factors, such as

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"consumer expectations" and "cost-benefit" analysis. *See id.*, cmts. g, h, i, k; F. Patrick Hubbard, *Efficiency, Expectation, and Justice: A Jurisprudential Analysis of the Concept of Unreasonably Dangerous Product Defect*, 28 S.C. L. REV. 587, 604–21 (1977); David G. Owen, *Bending Nature, Bending Law*, 62 FLA. L. REV. 569, 580–606 (2010). The "consumer expectations" test presented so many problems that it is "withering" as a free-standing basic test. OWEN, *supra* note 44, at 310; *see infra* notes 321–23 and accompanying text. Currently, the test is only used in a small "dwindling" number of states. OWEN, *supra* 44, at 310. In the other states, consumer expectations are just a factor to consider in applying the cost–benefit test or as the basis for a few narrow pockets of strict liability. *Id.* For discussion of instances of strict liability, see *infra* notes 71–72, 78–86.

64. For discussion of "state of the art," which can apply to both foreseeability of risk and feasibility of safety measures, see, for example, RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. d, case law and commentary IV-B, at 80–81 (noting the role of "good sense" and "pragmatism" in applying the concept); OWEN, *supra* note 44, § 10.4, at 706–07 (discussing state of the art and noting that, though the concept is "unrefined" and evolving, it reflects the "reluctance to impose liability . . . for dangers that were unknowable, or unpreventable").

65. *See, e.g.*, Williamson v. Mazda Motor of Am., Inc., 131 S. Ct. 1131, 1134 (2011) (holding that claim based on lack of shoulder belt was not preempted). The costs of the harnesses per vehicle must be multiplied by the number of vehicles manufactured to get the total safety costs. The total injury costs include all foreseeable injuries, each of which must be discounted by the probability that the injury will actually occur.

66. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(c).

67. For example, an ordinary paring knife does not need a warning that it is sharp.

68. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 10; HUBBARD & FELIX, *supra* note 56, at 329. There are "exceptions" to this rule. *See, e.g.*, RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 6(d) (discussing mandatory instructions and warnings for prescription drugs and medical devices); OWEN, *supra* note 44, § 9.5, at 620–24 (explaining that under the "sophisticated users doctrine," there is no need to warn because of the expertise of the buyer and under the "bulk suppliers doctrine," there is no duty to warn if there is no way to warn because of the nature of the product). In limited circumstances, a distributor may have a post-sale duty to warn. *See infra* notes 251–52 and accompanying text.

content and comprehensibility, intensity of expression, and the characteristics of expected user groups."[69] There is no "easy guideline," and "the ability of a plaintiff to imagine a hypothetical better warning in the aftermath of an accident does not establish that the warning actually accompanying the product was inadequate."[70]

Manufacturing Defects. A manufacturing defect results when a product is not manufactured in accordance with the manufacturer's specifications. For example, the product would have a manufacturing defect if the blueprint specified four bolts for an assembly but only three bolts went into that particular assembly for the product. This approach, in effect, replaces the cost–benefit test used for design and warnings with a "blueprint test" that relies on the manufacturer's own specifications. This test results in a form of strict liability because a product will be held to be "defective" even if the manufacturer used a cost-effective method to control quality in the manufacturing process.[71] The legal system views this approach as fair because: (1) unlike design and warning defects, the entire product line is not defective; (2) the product is, in fact, defective when measured by the manufacturer's own design specifications; (3) consumers (and third parties affected by the defect) are entitled to expect compliance with product specifications; (4) nonmanufacturing sellers may be able to pass liability costs up the distribution chain to the manufacturer; and (5) the manufacturers (and other sellers) are better able than victims to distribute the cost of the injuries.[72]

(b) Foreseeability, Misuse, and Obvious Risks

Two types of problems have been particularly troublesome in terms of both design and warning: "misuse" and "obvious" risks. The broad concept of "foreseeable use" addresses both. For example, if it is

69. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB., § 2(c) cmt. i, at 29; *see also* OWEN, *supra* note 44, §§ 9.3–9.4, at 593–619 (addressing reasonableness in terms of "adequacy" and "persons to be warned").

70. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(c) cmt. i, at 29.

71. *Id.* § 2(a), at 14 ("[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 . . . ."); *see, e.g.*, OWEN, *supra* note 44, §§ 7.1–7.4, at 446–75 (addressing strict liability for manufacturing defects); Jurls v. Ford Motor Co., 752 So. 2d 260, 266 (La. Ct. App. 2000) (holding that plaintiff had presented sufficient circumstantial evidence of manufacturing defect to withstand motion for directed verdict).

72. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmt. a, at 5–6; *id.* § 2 cmt. a, at 14–15; § 2 rptr. n. to cmt. d, at 70; *see, e.g.*, F. Patrick Hubbard, *Reasonable* Human *Expectations: A Normative Model for Imposing Strict Liability for Defective Products*, 29 MERCER L. REV. 465 (1978) (arguing for protection of reasonable human expectations as a value that competes with efficiency and justifies imposing liability on profit-oriented business entities in the chain of distribution regardless of whether that entity can be charged with efficiency-defined "fault").

foreseeable that a product will be used in a manner other than its intended use, design and warning decisions must be based on that foreseeability.[73] As a result, because a drunken driver might foreseeably misuse automobiles, they must be "crashworthy,"[74] which means they must have cost-effective safety measures, such as doors that will not pop open in a collision regardless of whether the driver was intoxicated.[75] Similarly, even though a dangerous risk may be "obvious," the risk must be addressed by effective warnings or a design approach if it is foreseeable that the risk will not be noticed or appreciated or that the user will not use due care to avoid the risk.[76]

(c) Strict Liability

One basic rule of products liability is that sellers are not liable where designs or warnings/instructions achieve an efficient balance of accident costs and safety costs. This rule imposes the costs of efficient injuries on innocent victims. Partly because of this imposition, a "strict liability" approach replaces this efficiency-oriented test on grounds of fairness to victims in a number of instances.[77] As indicated above, manufacturing defects are one such instance. This Subsection addresses two other instances of strict liability.[78]

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73. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmts. f, m, p, at 22–23, 33–34, 38–39; OWEN, *supra* note 44, § 13.5, at 890–95 (addressing the "Foreseeability Limitation"), § 17.3, at 1131–46 (addressing "[c]rashworthiness"). Where a seller is liable as a result of foreseeable misuse or other misconduct, the person engaging in the misuse or other misconduct (including the victim if the victim has engaged in such conduct) may also be liable to some extent as well. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. p, 38–39; § 17; OWEN, *supra* note 44, § 13.5, at 896–98 (addressing comparative fault). The application of this principle can be very complex. *See, e.g.*, Randy R. Koenders, Annotation, *Products Liability: Liability of Manufacturer or Seller as Affected by Failure of Subsequent Party in Distribution Chain to Remedy or Warn Against Defect of Which He Knew*, 45 A.L.R.4th 777 (1986) (discussing state and federal products liability cases).

74. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 16 cmt. a, at 236; OWEN, *supra* note 44, § 17.3, at 1131–46.

75. *See* Daly v. Gen. Motors Corp., 575 P.2d 1162, 1173–74 (Cal. 1978) (holding that evidence of intoxication in crashworthy case must be excluded or its effect confined to relevant issues so that it is not misinterpreted by the jury as totally barring recovery for lack of reasonable crashworthiness).

76. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB., § 2 cmts. j, l, at 31, 33; *see also* OWEN, *supra* note 44, § 10.2, at 647. Where it is not foreseeable that an obvious danger will not be noticed, there is not duty to warn. *See, e.g.*, Jones v. W+M Automation, Inc., 818 N.Y.S.2d 396, 399 (N.Y. App. Div. 2006) ("[T]here is no duty to warn of an open and obvious danger of which the product user is actually aware or should be aware as a result of ordinary observation or as a matter of common sense.").

77. *See supra* notes 71–72 and accompanying text.

78. Though not common, additional instances can also arise. *See, e.g.*, RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. §§ 12–14, at 206–30 (addressing the liability of successors and apparent manufacturers).

First, strict liability results from the imposition of liability for defects on all product distributors. As indicated in the discussion of design and warning defects, the use of the cost–benefit approach to identify design defects requires that liability be based on at least one product distributor's fault. However, if a product defect causes injury, a person in the business of selling or otherwise distributing the product is "strictly liable" for that injury regardless of whether that person was not "at fault" in the sense of being the person who made the erroneous cost–benefit decision.[79] For example, a manufacturer that did not include a particular type of shoulder harness as a part of a vehicle's safety system when it would have reduced accidental injuries in a cost effective manner was negligent and thus "at fault." In contrast, wholesalers and retailers who sell the automobile are not at fault. Nevertheless, they are legally liable as sellers of a defective product.[80] Consequently, it is

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79. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1, at 5 (applying scheme to commercial sellers and lessors); *id.* § 19, at 267 (defining "product" as "tangible personal property distributed commercially for use or consumption"); *id.* § 20, at 284 (defining "seller" and "distributor"). The concept of "selling or otherwise distributing" includes sellers of components if:

> (a) the component is defective in itself, as defined in this Chapter, and the defect causes the harm; or
>
> (b)(1) the seller or distributor of the component substantially participates in the integration of the component into the design of the product; and
>
> (2) the integration of the component causes the product to be defective, as defined in this Chapter; and
>
> (3) the defect in the product causes the harm.

Id. § 5, at 130. Special rules are established for particular types of "sellers." *See, e.g.*, *id.* § 6, at 144 (discussing liability for sellers of prescription drugs and medical devices); *id.* § 7, at 160 (discussing liability for sellers of food products); *id.* § 8, at 166 (discussing liability for sellers of defective used products); *id.* §§ 12–13, at 206, 221 (discussing liability for successors of a business that has previously sold a defective product and failed to warn consumers post-sale); *id.* § 14, at 227 (discussing liability for sellers of products sold as if they manufactured the product even though it was manufactured by another). Licensors can, under many circumstances, be subject to the same liability as the seller of a product. *See, e.g.*, OWEN, *supra* note 44, § 16.2, at 1070–77.

80. *See supra* note 79 and accompanying text. The *Restatement of Torts: Products Liability* notes that its approach results in liability without fault. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmts. e, o, at 8–9, 38. The *Restatement (Second) of Torts*, which follows a similar approach, states:

> The basis for the rule is the ancient one of the special responsibility for the safety of the public undertaken by one who enters into the business of supplying human beings with products which may endanger the safety of their persons and property, and the forced reliance upon that undertaking on the part of those who purchase such goods.

common to say that they are "strictly liable."[81] Similarly, all distributors are strictly liable for manufacturing defects.[82]

The reasons for this treatment are, in part, similar to the reasons for imposing strict liability for manufacturing defects.[83] In addition, the imposition of liability on all distributors is based on a concern for insuring that the person injured as a result of the defect can find a solvent party able to provide compensation adequate to provide corrective justice.[84]

Second, strict liability results from the following rule: a distributor who makes a non-negligent, non-fraudulent material misrepresentation of fact concerning the product is liable for injury caused by that misrepresentation even if the misrepresentation was innocent.[85] This instance of strict liability is similar to the liability imposed for manufacturing defects because the misrepresentation, like the product specifications, provides a standard for defining defect. Thus, the reasons for strict liability in this instance parallel the reasons for strict liability for manufacturing defects.[86]

ii. Practice

Specialization. To a considerable extent, products liability law is a specialized practice area for both defendants' and plaintiffs' attorneys. This specialization results partly because the area involves a distinct set of doctrinal rules. The American Law Institute's choice to adopt the *Restatement of Torts: Products Liability* as a separate publication reflects this doctrinal distinctiveness.

Plaintiffs' attorneys. Allegations that a product is defective in terms of design or warning generally require an expert qualified to testify about reasonable alternative designs or warnings.[87] The plaintiff's

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RESTATEMENT (SECOND) OF TORTS, *supra* note 45, § 402A cmt. f, at 350–51.

81. Technically, it might be more accurate to view this approach as a form of vicarious liability for the wrong of another in the way, for example, employers are vicariously liable for the wrongs of their employees. *See supra* note 45. However, at this point in time, the term "strict liability" is so widely used that a change in terms is not likely.

82. *See supra* notes 71–72 and accompanying text.

83. *See supra* note 72 and accompanying text.

84. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmt. e, at 8–9.

85. *Id.* § 9, at 187. A similar result can apply to an express warranty. *See supra* note 44 and accompanying text.

86. *Compare id.* § 9 cmt. b, at 187–88, *with supra* note 72 and accompanying text.

87. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. f, at 22–24; *see also* OWEN, *supra* note 44, § 6.3, at 362–90 (addressing the use of experts to prove whether a defect exists). An expert is not required where the feasibility of a reasonable alternative design is obvious to and understandable by laypersons. The *Restatement of Torts: Products Liability* notes:

> [W]hen a manufacturer sells a soft stuffed toy with hard plastic buttons that are

attorney pays for the expert's services as the case is being prepared and, if necessary, tried. Moreover, as indicated below in the discussion of the litigation process, product liability suits demand a considerable investment of the attorney's time and money. Under the contingency fee system, the attorneys do not get any return on their investment unless the case resolves—by trial or settlement—in the plaintiff's favor. Because this process can take years, these attorneys must, to some extent, have "deep pockets." The net effect of these economic considerations is that plaintiffs' attorneys will not accept or bring a suit unless the injuries are severe enough to justify an amount of damages sufficient to make the suit worthwhile.

As a result, product sellers and lessors are not likely to be held liable for defects that do not cause substantial personal injuries because such suits are not worth bringing. On the other hand, if the plaintiff's injuries are so severe that a very substantial amount of damages is involved, a plaintiff's attorney may take a case even if the odds are against success. Like any entrepreneur, it is rational for a plaintiffs' attorney to invest in a project with a less than fifty percent chance of success if the costs of the project are less than the likely percentage of return multiplied by the likely amount of return.

Also, like any entrepreneur, a plaintiff's attorney will seek new business. The primary way to do this is to get new clients. Thus, it is not uncommon to see attorneys engaging in advertising that informs potential plaintiffs of the possibility of suit if they have been injured by a particular product.

Defendants' attorneys. Because of the utility of products liability insurance,[88] insurance companies usually hire defense attorneys, who are frequently paid on a fee basis. In most cases, insurance companies will decide the important issues such as whether to make or accept a particular settlement offer.[89]

Experts. The experts required in a particular products case depend on the circumstances. For robotic products, an expert would be required to have sufficient engineering expertise to provide a reliable opinion on,

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> easily removable and likely to choke and suffocate a small child who foreseeably attempts to swallow them, the plaintiff should be able to reach the trier of fact with a claim that buttons on such a toy should be an integral part of the toy's fabric itself (or otherwise be unremovable by an infant) without hiring an expert to demonstrate the feasibility of an alternative safer design. Furthermore, other products already available on the market may serve the same or very similar function at lower risk and at comparable cost. Such products may serve as reasonable alternatives to the product in question.

RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. f, at 22–24.

88. *See supra* notes 38–41 and accompanying text.

89. The defendant client has rights in this process; however, partly because of typical contract terms, the insurer often has considerable power over litigation decisions.

for example, the existence of a reasonable alternative design.[90] In terms of both design and warning, a "human factors expert," who might have expertise in a field like psychology, could also testify.[91]

Process: discovery, summary judgment, settlement, trial, and appeal. The resolution of a products liability case generally takes a considerable amount of time. Well before trial, each side will engage in discovery on the other side's experts by, for example, requesting the production of documents and reports and by deposing—taking sworn testimony from—one another's experts as well as other potential witnesses. This part of the process can easily take more than a year. Typically, after most discovery is completed, a defendant will file a pretrial motion—often termed "Motion for a Judgment as a Matter of Law" or "Motion for Summary Judgment"—for a determination of whether the plaintiff has produced sufficient evidence to support a finding by a "reasonable jury" that the product was defective and that the defect caused the injury.[92] The court will grant this motion if, for example, the court finds that the plaintiff's expert lacks sufficient expertise or if, at trial, the evidence developed in discovery cannot support the expert's opinion.[93] If the motion is granted, judgment is entered in favor of the defendant, and the case will not reach the jury.

If the motion is denied, the parties are likely to settle the case instead

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90. *See, e.g.*, Hills v. Fanuc Robotics Am., Inc., No. 04-2659, 2010 WL 890223, at *5 (E.D. La. Mar. 5, 2010) (holding that a licensed mechanical engineer was qualified to testify about the defect in a robot used to stack crates on wooden pallets even though he was not a specialist in robotics); *cf., e.g.*, Knight v. Otis Elevator Co., 596 F.2d 84, 87 (3d Cir. 1979) (finding that the expert's lack of background in design and manufacture of elevators went to the permissible scope of expert's testimony, not admissibility); Murphy v. Montgomery Elevator Co., 957 S.W.2d 297, 299 (Ky. Ct. App. 1997) (concluding that a mechanical engineer was qualified to testify concerning the design of and warnings for an escalator and that his lack of background in the field attacked the expert's credibility, not the admissibility of his testimony); Graves v. CAS Medical Sys. Inc., 735 S.E.2d 650, 655–59 (S.C. 2012) (affirming grant of summary judgment on ground that testimony of software experts concerning failure of medical monitoring system was inadmissible).

91. For discussion of human factors in robotic design, see *infra* notes 253–54 and accompanying text. *See also, e.g.*, Humphries v. Mack Trucks, Inc., 198 F.3d 236, at *4 (4th Cir. 1999) (holding expert testimony by psychologist was properly admitted); Lucas v. Dorsey Corp., 609 N.E.2d 1191, 1197 (Ind. Ct. App. 1993) (opinion of human factors expert sufficient to support denial of motion for summary judgment).

92. *See, e.g.*, FED. R. CIV. P. 56.

93. *See, e.g.*, *supra* note 87 and accompanying text and *infra* notes 155–66 and accompanying text. *But cf.* OWEN, *supra* note 44, § 6.3, at 366 (stating that in some cases, juries can comprehend the facts of a defective design case without the use of expert testimony). Expert testimony may also be required to show that the defect caused the plaintiff's injury. *See* OWEN, *supra* note 44, § 6.3, at 367. Where the expert is qualified, his opinion may be enough to support a denial of the motion for summary judgment. *See, e.g.*, *Lucas*, 609 N.E.2d at 1199–1201 (holding the testimony of a human factors expert sufficient to support the denial of a motion for summary judgment). Occasionally, no expert witness on defect will be required. *See supra* note 87.

of trying it because: (1) the results of a jury trial are hard for either side to predict; and (2) a large amount of money is likely at issue since, as indicated above, incentives drive plaintiffs' attorneys to bring only those claims that have sufficient damages to justify their time and expense.[94] Thus, as settlement negotiations proceed, the plaintiff's attorney is concerned about the possibility of no recovery or a totally inadequate recovery and the defendant's attorney is worried about the potential liability for a large full recovery of damages.

If the defendant's pretrial motion is granted, the plaintiff is likely to appeal unless the defendant makes a reasonably high offer to settle. Absent such an offer, an appeal is likely because the marginal cost to the plaintiff of an appeal (beyond the costs already expended) is relatively low compared to the possible gain by a reversal on appeal or a settlement pending appeal, given the likelihood that the case would not have been brought unless a substantial amount of damages is involved. If the appeal is successful, the case may settle or return for trial.

c. Reasonable Care for Control, Use, and Maintenance

Tort law governs most liability for physical injury caused by persons who control, use, or maintain machines. These persons are generally liable if such injuries were caused by their negligence—i.e., a failure to exercise a reasonable level of care[95]—in terms of: (1) use of the machine;[96] (2) maintenance (or choice of a person to perform maintenance) of the machine;[97] (3) supervision or authorization of the machine's use;[98] or (4) prevention of others from using the machine if the machine is foreseeably dangerous.[99]

In this context, reasonable care is often articulated in terms of the conduct of a "reasonable person" rather than in the explicit cost–benefit

94. *See supra* text accompanying notes 87, 90–91; *infra* note 270 and accompanying text.

95. *See supra* notes 54–58 and accompanying text.

96. For example, one is liable for negligent driving of an automobile. *See infra* note 100. Ownership of a car also involves a duty of due care in maintenance. *See, e.g.*, 57A AM. JUR. 2D *Negligence* §§ 329–341 (West 2014).

97. *See, e.g.*, 38 AM. JUR. 2D *Garages, Service Stations, and Parking Facilities* § 53 (West 2014) (addressing liability for negligent repairs); 57A AM. JUR. 2D *Negligence* §§ 310–325 (addressing liability for negligent entrustment); *id.* § 367 (addressing liability for negligent maintenance).

98. *See, e.g.*, Mohler v. St. Luke's Med. Ctr., LP, No. 1 CA-CV 08-0078, 2008 WL 5384214, at ¶ 16 (Ariz. Ct. App. 2008) (holding that jury issue existed as to whether hospital negligently credentialed physician for use of surgical robot); RESTATEMENT (SECOND) OF TORTS § 308, at 100 (1977) (discussing negligence of permitting improper persons to use things or engage in activities).

99. *See* Jupin v. Kask, 849 N.E.2d 829, 832 (Mass. 2006) (discussing the duty of due care to secure a handgun); 57A AM. JUR. 2D *Negligence* §§ 299, 327–28 (West 2014) (addressing requirement of reasonable precautions to prevent injury from foreseeable acts of third parties, including children).

terms addressed above.[100] Both tests foster an efficient level of reduction in injury costs. The primary difference is that the explicit costs–benefit phrasing better captures the complex, expertise-driven tasks of designing products and articulating warnings,[101] while reasonable-person phrasing is easier for a jury to apply because a layperson can understand the activity involved.[102] Where laypersons lack adequate understanding of an activity—for example, in evaluating the conduct of a doctor performing an operation with a robotic surgical system—the testimony of a qualified expert would be required to show the standard of reasonable conduct.[103]

i. Examples

(a) Employment

Because so many robots are used in factories and other employment settings,[104] injuries to workers by robotic machines have been the impetus for employees to bring numerous claims.[105] Tort suits against employers are complicated by the fact that employees injured on the job are usually covered by workers' compensation.[106] In most states, workers who are injured while working for their employer cannot sue the employer in tort; workers' compensation is their *exclusive* remedy.[107] In effect, the employer is immune from most tort suits

100. *See supra* notes 56, 62–63 and accompanying text. For example, the Massachusetts Supreme Court expressed the standard in an early automobile case, stating that "[t]he law as to drivers of motor vehicles is not different from that which governs other persons. The standard required is that of the reasonably prudent person under all the circumstances." Massie v. Barker, 113 N.E. 199, 199 (Mass. 1916).

101. *See* HUBBARD & FELIX, *supra* note 56, at 63–65 (discussing generally the use of the "calculus of risk" balancing test).

102. *See id.* at 65 (discussing generally the use of the "reasonable person" approach to negligence).

103. *See id.* at 146–49 (discussing the standard of care for professional malpractice). An expert might also be required to show breach of the standard and injury from that breach. *Id.*

104. *See infra* note 153 and accompanying text.

105. See *infra* notes 155–56 and accompanying text for discussion of products liability claims for industrial robots.

106. *See* 1 ARTHUR K. LARSON & LEX LARSON, LARSON'S WORKER'S COMPENSATION LAW § 2.08, *available at* https://advance.lexis.com/GoToContentView?requestid=168cfb53-59db-4f29-b63f-581d60c69e0c&crid=f681d21f-574f-5628-3461-8b2f8ea22c56 (paid subscription required) (last visited June 25, 2014); *see, e.g.*, Delawder v. Am. Woodmark Corp., 178 F. App'x 197 (4th Cir. 2006) (holding that suit against employer for injury from robotic paint machine barred by exclusivity doctrine); Owens v. Water Gremlin Co., 605 N.W.2d 733 (Minn. 2000) (holding that the family of a worker who suffered permanent partial disability and eventually died from being pinned against a wall by a robot arm could recover worker's compensation benefits).

107. *Delawder*, 178 F. App'x at 199; LARSON & LARSON, *supra* note 106, § 100.01. An employee injured on the job is not usually barred from suing a third party—for example, the

brought by an employee. This immunity is based on a principle of fairness: Workers receive guaranteed no-fault workers' compensation for injuries while working; in exchange, workers give up the right to sue in tort, where recovery might be higher but is far less certain.[108]

Exceptions to this immunity exist in most states. For example, some states have an exception where the employer acted with intent to injure or with a "deliberate intention" of exposing the worker to a specific unsafe working condition. Workers have made claims against their employers for injuries from robots based on such exceptions, but these claims have had only limited success.[109]

(b) Premises Liability

As a general rule, persons with control over premises have a duty to make the premises reasonably safe for persons coming on the premises to transact business.[110] Early robotic machines, such as automated elevators and escalators, have been the subject of premises liability claims, and many plaintiffs have sued for injuries allegedly cause by lack of reasonable care in the operation and maintenance of these automated machines.[111] In recent years, cases have also involved claims

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manufacturer of a workplace machine. Workers have relied on this rule to sue manufacturers of robotic machines. *See infra* note 155 and accompanying text.

108. LARSON & LARSON, *supra* note 106, § 100.01[1].

109. *Compare, e.g.*, *Delawder*, 178 F. App'x at 202 (holding that the exception was not proved and that, therefore, the exclusivity doctrine barred suit), Miller v. Rubbermaid, Inc., No. 23466, 2007 WL 1695109 (Ohio Ct. App. June 13, 2007) (finding that there was insufficient evidence of intentional conduct by employer), *and* Edens v. Bellini, 597 S.E.2d 863, 872 (S.C. Ct. App. 2004) (finding that there was insufficient evidence to show commission of an intentional tort), *with e.g.*, State *ex rel.* Scott Fetzer Co., Halex Div. v. Indus. Comm'n of Ohio, 692 N.E.2d 195 (Oh. 1998) (finding an intentional violation by an employer), *and* Behurst v. Crown Cork & Seal USA, Inc., No. 04-1261-HA, 2007 WL 987452, *7 (D. Or. Mar. 30, 2007) (holding that a jury could find that there was sufficient evidence to support intentional conduct by an employer).

110. RESTATEMENT (SECOND) OF TORTS § 332 & cmt. a (discussing "invitee"); *id.* §§ 341A–344, at 209–10 (listing duties owed to invitee).

111. *See, e.g.*, Estabrook v. J.C. Penny Co., 464 P.2d 325 (Ariz. 1970) (en banc) (affirming grant of new trial to owner in action resulting from injuries sustained by a minor while playing on an escalator); Giles v. City of New Haven, 619 A.2d 476 (Conn. App. Ct. 1993), *aff'd*, 636 A.2d 1335 (1994) (reversing jury verdict for defendant owner in negligence suit for failure to inspect, maintain, and repair an elevator); Brown v. Sears, Roebuck & Co., 514 So. 2d 439 (La. 1987) (affirming verdict in favor of plaintiff in escalator case where infant sustained injuries after his finger was caught in the space between the moving treads and a panel); Guilfore v. D.H. Holmes Co., 631 So. 2d 491 (La. Ct. App. 1994) (reversing judgment against store in defective elevator suit); M & R Inv. Co. v. Anzalotti, 773 P.2d 729 (Nev. 1989) (reversing grant of plaintiff's motion for new trial and reinstating jury verdict for defendant owner in negligence action against elevator owner); Phillip White, Jr., Annotation, *Liability of Maintainer, Repairer, or Installer of Automated Passenger Elevator for Injury Resulting from Use of Elevator*, 115 A.L.R.5th 1 (2004) (discussing federal and state cases on liability of maintainer, repairer, or

by factory visitors claiming they were injured by a failure to use reasonable care in inspecting and operating robotic machines.[112]

One group of cases involves suits against landlords, who have an obligation to use reasonable care in providing security from violent crime in a common area such as a lobby or a hallway.[113] Some cases have held that, where a landlord had humans providing security, replacing them with an interlock and buzzer system did not satisfy the landlord's duty because these were less effective than humans.[114]

Though cases like these may suggest that the robotic security systems should be measured by the capabilities of humans,[115] two points indicate that the holdings of the cases are not that broad. First, they involve the replacement of humans rather than a situation where human security had not been provided. Second, liability is based on the standard of reasonable care.[116] Consequently, the only issues would be: (1) whether, given the foreseeable risk of criminal attack, security measures were necessary; and (2) if security measures were necessary, whether the particular measure—whether human, robotic, or otherwise—was reasonable.[117] Thus, for example, under the cost–benefit test, humans would not be required for security at all if their cost as a safety measure exceeded the cost of foreseeable injuries from lack of human security. On the other hand, if the costs of human security were less than the foreseeable injuries from attacks, humans would be necessary unless robots could provide at least a similar level of security.

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installer of elevator); Philip White, Jr., Annotation, *Liability of Building Owner, Lessee, or Manager for Injury or Death Resulting from Use of Automatic Passenger Elevator*, 99 A.L.R.5th 141 (2002) (discussing federal and state cases on the liability of owner, lessee, or manager of building with automatic elevator); *infra* note 147 and accompanying text.

112. *See, e.g.*, Rodriguez v. Brooks Pari-Automation, Inc., No. Civ.A.3:03CV00515-L, 2003 WL 21517851, at *1 (N.D. Tex. June 30, 2003) (alleging injuries from accident that occurred while plaintiff was installing a robot with the defendant); Budris v. Robotic Res., R2, Inc., 1997 WL 408717, at *1 (Conn. Super. Ct. July 11, 1997), *modified*, No. CV 91036468, 1998 WL 46224 (Conn. Super. Ct. Jan. 22, 1998) (claiming injuries from defendant's testing of a robot while plaintiff electrician was working at defendant's premises).

113. *See* DOBBS, *supra* note 22, § 325, at 880.

114. *See, e.g.*, Kline v. 1500 Mass. Ave. Apt. Corp., 439 F.2d 477, 486 (D.C. Cir. 1970) (holding that where an apartment complex removed humans performing security functions, "the same relative degree of security should have been maintained" and noting that it was not deciding whether a "tenant-controlled intercom-automatic latch system . . . in the common entryways" would have been sufficient); Green Cos. v. Divincenzo, 432 So. 2d 86, 87–88 (Fla. Dist. Ct. App. 1983) (affirming that the landlord had a duty to institute procedures to keep premises safe).

115. *See infra* notes 262–64 and accompanying text.

116. *See supra* notes 54–58, 101–03 and accompanying text.

117. *See, e.g.*, DOBBS, *supra* note 22, § 325. The same analysis applies to the duty of a business to its customers. Thus, for example, guards are not required for a store unless the guards are a cost-effective measure to prevent crime in the parking lot. Posecai v. Wal-Mart Stores, Inc., 752 So. 2d 762, 768 (La. 1999).

Similarly, the need for and adequacy of robotic security would depend on the relative costs of foreseeable injuries compared to the costs of the robotic security measures that might be used.

ii. Exception for Abnormally Dangerous Activities

An exception to the general rules of negligence applies in the case of "abnormally dangerous activities." The "rule" concerning such activities is easy to state, but very difficult to apply. Section 20 of the *Third Restatement* provides:

> (a) An actor who carries on an abnormally dangerous activity is subject to strict liability for physical harm resulting from the activity.
>
> (b) An activity is abnormally dangerous if:
>
> > (1) the activity creates a foreseeable and highly significant risk of physical harm even when reasonable care is exercised by all actors; and
> >
> > (2) the activity is not one of common usage.[118]

Except for clear cases such as activities involving explosives and wild animals,[119] determining whether a risk of physical harm is "foreseeable" and "significant" even "when reasonable care is exercised" and whether an activity is "one of common usage" has challenged courts for decades.[120] As a result of this problem, as well as the current lack of knowledge about the specific characteristics of sophisticated robots, it is virtually impossible to do more than guess how a judge might treat a claim that using a sophisticated robot in a particular way constituted an abnormally dangerous activity.[121]

The lack of certainty concerning the application of the abnormally dangerous activity doctrine could inhibit innovation because the potential increased liability could have two effects. First, the expanded potential liability of innovators could negatively affect their decision to develop, for example, an Unmanned Aircraft System (UAS). Second,

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118. RESTATEMENT (THIRD) OF TORTS: LIAB. FOR PHYSICAL AND EMOTIONAL HARM § 20, at 229 (2005).

119. *See, e.g.*, *id.* § 20 cmt. e, at 233–34 (discussing blasting as "paradigm of an abnormally dangerous activity"); *id.* § 22, at 293 (discussing strict liability for wild animals); DOBBS, *supra* note 22, § 348, at 954 (discussing strict liability for explosives and high-energy activities).

120. *See* DOBBS, *supra* note 22, §§ 346–51.

121. The determination of whether an activity is abnormally dangerous is a matter of law for a judge to determine, not the jury. RESTATEMENT (THIRD) OF TORTS: LIAB. FOR PHYSICAL AND EMOTIONAL HARM § 20 cmt. l, at 240–41.

the increased liability could also reduce the demand for a robotic vehicle like a UAS because purchasers and users would need to worry about potential greater liability for personal injury.

Three points provide guidance in "guessing" whether use of a robotic machine is abnormally dangerous. First, today's automobiles are not abnormally dangerous.[122] Second, the status of aircraft is unclear, but recent cases have tended to view them as not abnormally dangerous.[123] Third, courts might consider an experimental driverless vehicle or UAS to be abnormally dangerous because experimenting with large, mobile, sophisticated robots is not currently common and arguably creates a "foreseeable and highly significant risk of harm even when reasonable care is exercised."[124] This third point does not necessarily mean that increasingly sophisticated vehicles are "experimental." There are large, important differences between a "Google car" and a mass-produced Volvo with robotic features such as electronic stability control and blind spot indicators. For example, the Volvo's design is based on prior experimentation and testing and is subject to regulation by the National Highway and Safety Administration and is similar to automobiles sold by other manufacturers.[125]

d. The Role of Standards

Where diverse companies manufacture mass-produced goods such as automobiles, some degree of standardization is necessary so that, for example, drivers can drive many different cars with a minimal learning curve, other drivers and pedestrians will know how the vehicles around them respond, and parking lots and garages can be designed efficiently. Where safety standards concerning the design and use of products are involved, standardization is sometimes achieved informally by custom. However, because of the advantages in terms of safety and predictability of carefully prepared written standards, a more formal approach has become increasingly common.[126] Formal written standards, including standards for industrial robots,[127] are often developed by independent private entities like the Society of

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122. *See id.* § 20 cmt. j, at 238–39 (stating that an activity that in is in common usage is not abnormally dangerous, even if it involves significant risk when reasonable care is exercised, and discussing the use of automobiles as an example).

123. DOBBS, *supra* note 22, § 349, at 958.

124. *See, e.g.*, Green v. Ensign–Bickford Co., 595 A.2d 1383, 1386–88 (Conn. App. Ct. 1991) (holding experimental use of volatile chemicals constituted an abnormally dangerous activity).

125. *See infra* notes 134–35 and accompanying text.

126. *See, e.g.*, OWEN, *supra* note 44, § 2.3, at 83–84.

127. *See infra* note 132 and accompanying text. For discussion of the definition and number of industrial robots, see *infra* note 153.

Automotive Engineers (SAE),[128] Underwriters Laboratories (UL),[129] the American National Standards Institute (ANSI),[130] the International Organization for Standardization (ISO),[131] and the Robotic Industries Association (RIA).[132] The government also adopts written standards—

128. For information about SAE, see SAE INT'L, http://www.sae.org (last visited Aug. 15, 2014). SAE standards were held to be relevant but not conclusive in *General Motors Corp. v. Moseley*, 447 S.E.2d 302, 311 (Ga. Ct. App. 1994), *overruled on other grounds*, *Webster v. Boyett*, 496 S.E.2d 459, 463–64 (Ga. 1998).

129. For information about UL, see UL, http://www.ul.com (last visited Aug. 15, 2014).

130. For information concerning ANSI, see AM. NAT'L STANDARDS INST., http://www.ansi.org (last visited Aug. 15, 2014). For examples of cases that use ANSI standards in addressing liability for injuries involving robots, see Payne v. ABB Flexible Automation, Inc., 116 F.3d 480, No. 96–2248, 1997 WL 311586, at *1 (8th Cir. June 9, 1997) (per curiam) (unpublished table decision) (holding that plaintiff had not shown that failure to meet ANSI standard was cause of injury); Provenzano v. Pearlman, Apat & Futterman, LLP, No. 04-CV-5394, 2008 U.S. Dist. LEXIS 86098, at *7, *10 (E.D.N.Y. Oct. 24, 2008) (holding in malpractice claim against law firm that represented plaintiff in unsuccessful suit against manufacturer of robot that, despite showing evidence of ANSI violations concerning robot, there was insufficient evidence to support malpractice claim). The ANSI standards must apply to the robotic system at issue. *See, e.g.*, Jones v. W+M Automation, Inc., 818 N.Y.S.2d 396, 399 (App. Div. 2006).

131. The IHS website describes the ISO organization as follows:

> ISO (International Organization for Standardization) is the world's largest developer and publisher of International Standards.
>
> ISO is a network of the national standards institutes of 163 countries, one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system.
>
> ISO is a non-governmental organization that forms a bridge between the public and private sectors. On the one hand, many of its member institutes are part of the governmental structure of their countries, or are mandated by their government. On the other hand, other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations.
>
> Therefore, ISO enables a consensus to be reached on solutions that meet both the requirements of business and the broader needs of society.

GLOBAL HIS, http://global.ihs.com/standards.cfm?publisher=ISO&currency_code=CAD&customer_id=21254020200A&oshid=21254020200A&shopping_cart_id=21254020200A&rid=TIA&country_code=JP&lang_code=ENGL (last visited Aug. 15, 2014). A list of ISO standards for industrial robots is available at http://www.iso.org/iso/search.htm?qt=robot&sort=rel&type=simple&published=on.

132. The RIA was founded in 1974. It "is the only trade group in North America organized specifically to serve the robotics industry. . . . [and its] [m]ember companies include leading robot manufacturers, users, system integrators, component suppliers, research groups, and consulting firms." RIA, *Company Profile*, ROBOTICS ONLINE, http://www.robotics.org/company-profile-detail.cfm/Internal/Robotic-Industries-Association/company/319 (last visited Aug. 15, 2014). A list of its standards can be found at RIA, *Industrial Robot Standards*, ROBOTICS ONLINE, http:/www.robotics.org/bookstore-cat.cfm?category_id=118 (last visited Aug. 15, 2014).

for example, standards adopted by the following: (1) the National Institute of Standards and Technology (NIST);[133] (2) the National Highway and Safety Administration (NHTSA), which promulgates the Federal Motor Vehicle Safety Standards (FMVSS)[134] and has recently adopted a preliminary policy statement concerning automated vehicles;[135] (3) the Occupational Safety and Health Administration (OSHA);[136] (4) the Federal Aviation Administration (FAA), which regulates aerial vehicles in the National Air Space (NAS);[137] (5) the Food and Drug Administration (FDA), which regulates medical devices, including robotic systems;[138] and (6) the Consumer Product Safety Commission.[139]

Four rules summarize the role of standards in tort litigation. First, both breach of and compliance with industry custom or private standards are generally admissible at trial because they are relevant to such issues as reasonable conduct and reasonable design or reasonable warning.[140] The reasons for this treatment include the following: (1) custom shows what safety measures are feasible and cost-effective; and (2) requiring a more expensive measure than customarily used can

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133. The Institute is part of the U.S. Department of Commerce and is currently engaged in a collaborative effort to develop standards for robots working in close proximity to humans in industrial settings. *See* NIST, *Human-Robot Collaboration*, *supra* note 12. For further discussion of this project, see *supra* notes 12–14 and accompanying text and *infra* note 219 and accompanying text.

134. For a useful review of the role of NHTSA in regulating traffic safety, see generally Stephen P. Wood et al., *The Potential Regulatory Challenges of Increasingly Autonomous Motor Vehicles*, 52 SANTA CLARA L. REV. 1423 (2012). For discussion of the preemptive effect of FMVSS, see *infra* notes 337–38 and accompanying text.

135. *See infra* notes 181–87 and accompanying text.

136. *See, e.g.*, Payne v. ABB Flexible Automation, Inc., 116 F.3d 480, No. 96–2248, 1997 WL 311586, at *1 (8th Cir. June 9, 1997) (per curiam) (unpublished table decision) (discussing citation of employer by OSHA for employer's removal of safety devices on robot); Behurst v. Crown Cork & Seal USA, Inc., No. 04-1261-HA, 2007 U.S. Dist. LEXIS 24922, at *7–9 (D. Or. Mar. 30, 2007) (finding OSHA investigation report relevant and admissible as business record); OSHA, OSHA TECHNICAL MANUAL § 4, ch. 4 (Industrial Robots and Robot System Safety (Sept. 22, 1995)), *available at* http://www.osha.gov/dts/osta/otm/otm_iv/otm_iv_4.html; *Industrial Robots and Robot System Safety*, OSHA (Jan. 20, 1999), http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&P_id=1703.

137. *See infra* notes 206–16 and accompanying text.

138. *See, e.g.*, Riegel v. Medtronic, Inc., 552 U.S. 312, 323–25 (2008) (discussing preemptive effect of FDA requirements); *infra* text accompanying note (discussing FDA review of robotic surgery).

139. *See, e.g.*, United States v. Athlone Indus., Inc., 746 F.2d 977, 978–79 (3d Cir. 1984) (discussing two different actions by the Commission concerning automatic baseball pitching machines).

140. *See, e.g.*, DOBBS, *supra* note 22, §§ 162–65; OWEN, *supra* note 44, § 2.3.

affect an entire industry and should, therefore, not be done lightly.[141]

The second rule is: Breach of or compliance with custom or private standards is not conclusive on issues of reasonable care.[142] One reason for limiting the effect is that allowing industries or nongovernmental entities to set safety standards might result in too little concern for safety.[143] A conclusive effect might also inhibit the development of safer alternatives.

Because the government is presumed to act in the public interest, the third rule is: Breach of a legal standard is often treated as being, in itself, wrongful and thus not reasonable care.[144] In terms of products liability, the effect of this approach is that breach of a government standard concerning the design of a product or the warnings and instructions that accompany a product generally renders the product defective.[145]

The fourth rule is that, compliance with government standards is treated like custom and private standards in that compliance are relevant and admissible at trial but not conclusive.[146] One reason for this approach is that legal standards are frequently a minimum requirement that might not always be satisfactory. For example, driving on the highway at the legal speed limit is a minimum level of safety that is sufficient under normal conditions but not in a thick fog. An exception to this rule concerning compliance arises where the legislature has indicated its intent to preempt the field. Preemption is addressed in Subsection IV.B.2 below.

As a practical matter, a plaintiff has an extremely substantial proof problem where a product's design and warnings comply with industry custom, with a private standard adopted by an independent entity, or with a government regulation. Because of the adversarial nature of trial, juries generally assume that expert witnesses for both sides have been selected with a desire to win the case. In this context, the plaintiff has problems in convincing the jury that a product is defective if the defendant followed a standard concerning design or warning endorsed by industry custom or by an independent or governmental entity. Similarly, a defendant's breach of an industry standard or of a standard

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141. *Cf.* Clarence Morris, *Custom and Negligence*, 42 COLUM. L. REV. 1147, 1158–60 (1942) (demonstrating that while evidence of custom is generally admissible, it can be evidence of negligence if a whole trade is "palpably negligent").

142. *See supra* note 140. Most states recognize an exception to this rule where professional negligence is involved. *See, e.g.*, DOBBS, *supra* note 22, §§ 242–47.

143. *See* OWEN, *supra* note 44, § 2.3, at 81.

144. *See, e.g.*, DOBBS, *supra* note 22, § 134 (discussing negligence per se).

145. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB., § 4(a), at 120 (1997); OWEN, *supra* note 44, § 2.4.

146. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 4(b); *id.* § 4(b) cmt. e, at 120, 122–23.

adopted by an independent entity substantially assists the plaintiff even if the standard is not conclusive.

e. Litigation Involving Robotic Machines

i. Early "Automatic" Machines

A number of older cases involve "automatic" machines such as elevators and escalators, which are used widely in consumer settings.[147] Vending machines have also been widely used for years, and they have been the subject of contract claims[148] and tort claims—for example, for personal injury caused by vending excessively hot soup[149] or hot chocolate,[150] or caused by soft drink vending machines that tip over too easily[151] or "invite" users to engage in dangerous measures to get a cola that was purchased but was not provided by the machine.[152]

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147. *See, e.g.*, Estabrook v. J.C. Penny Co., 464 P.2d 325, 329 (Ariz. 1970) (en banc) (holding that plaintiff made no showing of escalator defect or negligence in the maintenance and inspection thereof); Barretta v. Otis Elevator Co., 698 A.2d 810, 811–12 (Conn. 1997) (affirming jury verdict for defendant manufacturer of escalator); Leong v. Sears Roebuck & Co., 970 P.2d 972, 979 (Haw. 1998) (holding escalator a "product" for purposes of product liability claim against manufacturer and distributor); Montgomery Elevator Co. v. McCullough, 676 S.W.2d 776 (Ky. 1984) (affirming judgment against elevator manufacturer); Murphy v. Montgomery Elevator Co., 957 S.W.2d 297, 300 (Ky. Ct. App. 1997) (reversing grant of summary judgment to defendant escalator manufacturer); Brown v. Sears, Roebuck & Co., 514 So. 2d 439, 445 (La. 1987) (affirming verdict for plaintiff in escalator injury case), *superseded by statute as recognized in* Hickman v. Exide, Inc., 679 So. 2d 527, 536 (La. Ct. App. 1996); Guilfore v. D.H. Holmes Co., 631 So. 2d 491, 498–99 (La. Ct. App. 1994) (reversing judgment for plaintiff and entering judgment for escalator manufacturer); M & R Inv. Co. v. Anzalotti, 773 P.2d 729, 730–31 (Nev. 1989) (per curiam) (affirming dismissal of strict liability claim against elevator manufacturer and affirming jury verdict for defendant on negligence claim); Bilbao v. Westinghouse Elec. Corp., 751 N.Y.S.2d 177, 178–79 (N.Y. App. Div. 2002) (holding that evidence did not support jury verdict against escalator manufacturer); Otis Elevator v. Wood, 436 S.W.2d 324, 329 (Tex. 1968) (holding there was sufficient evidence to support jury verdict against manufacturer). *See generally*, 26 AM. JUR. 2D *Elevators and Escalators* §§ 16, 47 (2004); David B. Harrison, *Liability for Injury On, or In Connection with Escalator*, Annotation, 1 A.L.R.4th 144 (1980). For a discussion of claims against owner–operators of automatic elevators, see *supra* note 111 and accompanying text.

148. *See, e.g.*, Lachs v. Fid. & Cas. Co., 118 N.E.2d 555 (N.Y. 1954) (interpreting life insurance contract sold at vending machine in airport). For analysis of modern contracts cases see, for example, Ian R. Kerr, *Bot, Babes and the Californication of Commerce*, 1 U. OTTOWA L. & TECH. J. 285, 292–93 (2004).

149. *E.g.*, Abruzzo v. Campbell Soup Co., 11 Phila. Ct. Rptr. 209, 213 (Pa. C.P. Phila. 1984) (table of decisions), *rev'd*, 496 A.2d 847 (Pa. Super. Ct. 1985).

150. Valencia v. Crane Co., 132 F. App'x 171, 173 (9th Cir. 2005) (affirming grant of summary judgment for defendant on claims of defective design and warning).

151. Oden v. Pepsi Cola Bottling Co. of Decatur, Inc., 621 So. 2d 953, 954 (Ala. 1993) (finding no liability); Morgan v. Cavalier Acquisition Corp., 432 S.E.2d 915, 926 (N.C. 1993) (reversing summary judgment for defendants and holding plaintiff had shown evidence of genuine issues of material fact regarding plaintiff's design defect claim).

152. Smith v. Alexandria Coca Cola Bottling Co., 918 So. 2d 522, 525 (La. Ct. App. 2005).

ii. Recent Cases

(a) Industrial Robots

Because of the widespread use of industrial robots in factories and other work settings,[153] a number of cases have been brought by visitors and employees injured by an industrial robot.[154] Other cases have involved claims against manufacturers by workers injured by robots on the job.[155] These cases have generally been unsuccessful, which may be due, in part, to the ease of adopting safety-oriented designs in the controlled settings of factories.[156]

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153. The International Federation of Robotics (IFR) estimates: "The total worldwide stock of operational industrial robots at the end of 2012 was in the range of 1,235,000 and 1,500,000 units." *Industrial Robot Statistics*, IFR, http://www.ifr.org/industrial-robots/statistics/ (last visited Aug. 15, 2014). The IFR used the definition of "industrial robot" adopted by the International Organization for Standardization (ISO):

> An automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications.
>
> Reprogrammable: whose programmed motions or auxiliary functions may be changed without physical alterations;
>
> Multipurpose: capable of being adapted to a different application with physical alterations;
>
> Physical alterations: alteration of the mechanical structure or control system except for changes of programming cassettes, ROMs, etc.
>
> Axis: direction used to specify the robot motion in a linear or rotary mode.

Industrial Robots, IFR, http://www.ifr.org/industrial-robots/ (last visited Aug. 15, 2014).

154. *See supra* notes 104–09 and accompanying text.

155. *See, e.g.*, Payne v. ABB Flexible Automation, Inc., 116 F.3d 480, No. 96-2248, 1997 WL 311586, *1–*2 (8th Cir. 1997) (per curiam) (unpublished table decision) (affirming summary judgment in favor of defendant on claim of design defect); Hills v. Fanuc Robotics Am., Inc., No. 04-2659, 2010 WL 890223, *1, *4 (E.D. La. 2010) (addressing issue of admissibility of settlement with one manufacturer of robot in suit by employee against other manufacturers and sellers of robot used to stack crates on wooden pallets); Bynum v. ESAB Grp., Inc., 651 N.W.2d 383, 384–85 (Mich. 2002) (per curiam) (upholding jury verdict for defendant); *see also, e.g.*, Quattlebaum v. Hy-Reach Equip., Inc., 453 So. 2d 578 (La. Ct. App. 1984) (affirming judgment in favor of manufacturer of mobile hydraulic crane on basis of no showing of design or warning defect). For discussion of suits against employers, see *supra* notes 104–09 and accompanying text.

156. *See supra* notes 7–11 and accompanying text.

(b) Automobiles

Automobiles have become increasingly robotic for years.[157] As a result, they are, to a considerable extent, "computers on wheels"[158] with robotic systems such as: (1) adaptive cruise control, which not only maintains speed but also reduces it if the car approaches too close to an object;[159] (2) antilock braking systems (ABS);[160] and (3) electronic stability control (ESC).[161]

As the process of automating cars has progressed, there has been considerable litigation. For example, plaintiffs have claimed defective design of cruise control systems.[162] In addition, there have been voluntary recalls; Toyota, for example, recently recalled Prius models in order to address a software problem.[163] Despite litigation and recalls, automobile manufacturers continue to increase the computerization of automobiles and pursue the development of "self-driving automobiles."[164] Thus, it appears that tort litigation has had little negative impact on innovation in robotic automobiles.

157. *See, e.g.*, Sven A. Beiker, *Legal Aspects of Autonomous Driving*, 52 SANTA CLARA L. REV. 1145, 1146–48 (2012); Julie Goodrich, Comment, *Driving Miss Daisy: An Autonomous Chauffeur System*, 51 HOUS. L. REV. 265, 268–75 (2013).

158. Bryant Walker Smith, *Proximity-Driven Liability*, 102 GEO. L.J. 1777 (forthcoming 2014) (manuscript at 12).

159. Beiker, *supra* note 157, at 1148; Goodrich, *supra* note 157, at 268–69.

160. *See, e.g.*, Freightliner Corp. v. Myrick, 514 U.S. 280, 282 (1995) (holding that suits alleging defective design for failing to use ABS were not preempted); NHTSA, THE LONG-TERM EFFECT OF ABS IN PASSENGER CARS AND LTVS (2009) (finding safety effects of ABS to be mixed).

161. *E.g.*, Beiker, *supra* note 157, at 1148 fig.2. NHTSA has adopted Federal Motor Vehicle Safety Standards (FMVSS) concerning ESC. *Electronic Stability Control*, NHTSA, http://www.nhtsa.gov/Laws+&+Regulations/Electronic+Stability+Control+(ESC) (last visited Aug. 15, 2014).

162. *See, e.g.*, Ford Motor Co. v. Stimpson, 115 So. 3d 401, 404 (Fla. Dist. Ct. App. 2013), *review denied*, 133 So. 2d 528 (Fla. 2014) (table of decisions) (upholding jury verdict in favor of defendant); Watson v. Ford Motor Co., 699 S.E.2d 169, 180 (S.C. 2010) (reversing jury verdict for plaintiff for evidentiary errors, including allowing expert testimony from expert not qualified to give opinions); AM. L. PRODS. LIAB. § 95:117 (West 2014) (discussing U.S. litigation involving alleged defects in cruise control systems).

163. Hiroko Tabuchi & Jaclyn Trop, *Toyota Recalls Newest Priuses Over Software*, N.Y. TIMES (Feb. 12, 2014), http://www.nytimes.com/2014/02/13/business/international/toyota-issues-another-recall-for-hybrids-this-time-over-software-glitch.html; Press Release, Toyota, *Toyota Announces Voluntary Recall of Certain Toyota Prius, RAV4, Tacoma and Lexus RX 350 Vehicles* (Feb. 12, 2014), http://corporatenews.pressroom.toyota.com/releases/toyota+voluntary+recall+021214.htm.

164. *See, e.g.*, Jason Dorrier, *Ford Joins Tesla, Volvo, Nissan, BMW, and Mercedes in Race to Self-driving Cars*, SINGULARITY HUB (Jan. 5, 2014, 8:42 AM), http://singularityhub.com/2014/01/05/ford-joins-tesla-volvo-nissan-bmw-and-mercedes-in-race-to-self-driving-cars/.

(c) Da Vinci Surgical "Robots"

In recent years, surgical "robots" have become increasingly common. This widespread use has also resulted in litigation. For example, about fifty products liability suits have been filed against Intuitive Surgical, Inc., the manufacturer of the da Vinci surgical "robots."[165] Though many of the opinions in these suits involve procedural matters or successful defenses by Intuitive,[166] at least one case was settled for an undisclosed amount,[167] and there is reason to believe the da Vinci system may not have been marketed with adequate warnings and instructions concerning training.[168] One court recently

165. Intuitive Surgical, Inc., Quarterly Report (Form 10-Q) 32 (Oct. 18, 2013), *available at* http://www.sec.gov/Archives/edgar/data/1035267/000103526713000040/isrg-2013930x10q.htm. The Quarterly Report also notes that many other claims may be filed. *Id.* Though generally referred to as "robotic," the manufacturer, Intuitive Surgical, Inc., refers to its product as a "*da Vinci* Surgical System." As indicated in the following, Intuitive Surgical's website indicates that this system is not "robotic."

> Robotic surgery devices are designed to perform entirely independent movements after being programmed by a surgeon. The *da Vinci* Surgical System is a computer-enhanced system that introduces a leading edge computer interface and 3DHD vision system between the surgeon's eyes, hands and the tips of micro-instruments. The system mimics the surgeon's hand movements in real time. It cannot be programmed, nor can it can make decisions on its own to move or perform any type of surgical maneuver. So while the general term "robotic surgery" is often used to refer to our technology, it is not robotic surgery in the strictest sense of the term.

Frequently Asked Questions, INTUITIVE SURGICAL, http://www.intuitivesurgical.com/products/products_faq.html#12 (last visited Aug. 15, 2014). Hospitals, however, tend to market the *da Vinci* System as "robotics." *See, e.g.*, *Da Vinci Robotic Surgery Center*, PALMETTO HEALTH, http://www.palmettohealth.org/body.cfm?id=3201&oTopID=3095 (last visited Aug. 15, 2014).

166. *See, e.g.*, Silvestrini v. Intuitive Surgical, Inc., No. 11-2704, 2012 WL 380283 (E.D. La. Feb. 6, 2012) (addressing jurisdictional issues only); O'Brien v. Intuitive Surgical, Inc., No. 10 C 3005, 2011 WL 3040479 (N.D. Ill. July 25, 2011) (dismissing complaint against manufacturer of "da Vinci" surgical robot); Mracek v. Bryn Mawr Hosp., 610 F. Supp. 2d 401, 402 (E.D. Pa. 2009) (granting summary judgment to manufacturer of "da Vinci" surgical robot), *aff'd*, 363 F. App'x 925 (3d Cir. 2010); *cf.* Mohler v. St. Luke's Med. Ctr., No. 1 CA-CV 08-0078, 2008 WL 5384214, at *2, *3 (Ariz. Ct. App. 2008) (finding that issue of proper credentialing of surgeon to use robot existed and reversing grant of summary judgment to defendant hospital).

167. Silvestrini v. Intuitive Surgical, Inc., No. 2:11-cv-02704 (E.D. La.), Docket entries 43–46 dated Mar. 14, 2013, and Apr. 23, 2013.

168. *See, e.g.*, Geri Aston, *Surgical Robots Worth the Investment?*, H&HN, http://www.hhnmag.com/display/HHN-news-article.dhtml?dcrPath=/templatedata/HF_Common/NewsArticle/data/HHN/Magazine/2012/Apr/0412HHN_FEA_clinicalmanagement (last visited Aug. 15, 2014); Herb Greenberg, *Robotic Surgery: Growing Sales, but Growing Concerns*, CNBC (Mar. 19, 2013), http://www.cnbc.com/id/100564517; Roni Caryn Rabin, *Salesmen in the Surgical Suite*, N.Y. TIMES, (Mar. 26, 2013), http://www.nytimes.com/2013/03/26/health/salesmen-in-the-surgical-suite.html; Lindsey Tanner, *FDA Takes Fresh Look at*

held that the requirement concerning instruction of users could include a duty to train.[169] However, Intuitive won the subsequent jury trial.[170] In addition, the Food and Drug Administration (FDA) has announced an examination of robotic surgery,[171] and recent medical studies question its effectiveness.[172] Finally, a shareholder suit has been filed against Intuitive Surgical based on claims that reports were false and misleading because of their failure to disclose problems and litigation involving the robots.[173]

The da Vinci robot controversy obviously has two sides. On one hand, Intuitive Surgical has been extraordinarily innovative in developing and marketing the robot, which has been used in a large

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Robotic Surgery, USA TODAY (Apr. 9, 2013), http://www.usatoday.com/story/news/nation/2013/04/09/robot-surgery-fda/2067629.

169. Jeff Feely & Robert Langreth, *Intuitive Surgical Loses Bid to Throw Out Robot Lawsuit*, BLOOMBERG (Mar. 26, 2013), http://www.bloomberg.com/news/2013-03-26/intuitive-surgical-loses-bid-to-throw-out-robot-lawsuit.html. Such "duty to train" claims have usually been unsuccessful. *See, e.g.*, Rounds v. Genzyme Corp., 440 F. App'x 753, 756 (11th Cir. 2011) (per curiam); *see also* Carrell v. Nat'l Cord & Braid Corp., 852 N.E.2d 100, 108, 111 (Mass. 2006).

170. Patricia Guthrie & Joel Rosenblatt, *Intuitive Wins Trial, Defeats Negligent Training Claims*, BLOOMBERG (May 24, 2013), http://www.bloomberg.com/news/2013-05-23/intuitive-wins-trial-defeats-negligent-training-claims.html.

171. *See, e.g.*, Greenberg, *supra* note 168; Tanner, *supra* note 168.

172. Michelle Andrews, *Questions Arise About Robotic Surgery's Cost, Effectiveness*, KAISER HEALTH NEWS (Apr. 23, 2013), http://www.kaiserhealthnews.org/features/insuring-your-health/2013/042313-michelle-andrews-robotic-surgery.aspx; Aston, *supra* note 168; Melinda Beck, *Study Raises Doubts Over Robotic Surgery*, WALL ST. J. (Feb. 19, 2013), http://online.wsj.com/article/SB10001424127887323764804578314182573530720.html; Greenberg, *supra* note 168. The President of the American Congress of Obstetricians and Gynecologists issued a statement on March 14, 2013, questioning the cost-effectiveness of robotic surgery in comparison to vaginal and laparoscopic approaches. The statement includes the following conclusion:

> At a price of more than $1.7 million per robot, $125,000 in annual maintenance costs, and up to $2,000 per surgery for the cost of single-use instruments, robotic surgery is the most expensive approach. A recent Journal of the American Medical Association study found that the percentage of hysterectomies performed robotically has jumped from less than 0.5% to nearly 10% over the past three years. A study of over 264,000 hysterectomy patients in 441 hospitals also found that robotics added an average of $2,000 per procedure without any demonstrable benefit.

Press Release, ACOG, *Statement on Robotic Surgery by ACOG President James T. Breeden, MD* (Mar. 14, 2013), http://www.acog.org/About_ACOG/News_Room/News_Releases/2013/Statement_on_Robotic_Surgery [hereinafter *Statement on Robotic Surgery*].

173. Press Release, Shareholders Foundation, Inc., *Lawsuit on Behalf of Investors in Intuitive Surgical, Inc. (ISRG) Announced by Shareholders Foundation*, YAHOO! FINANCE (Apr. 29, 2013), http://web.archive.org/web/20130721095454/http://finance.yahoo.com/news/lawsuit-behalf-investors-intuitive-surgical-133500568.html.

number of cases without problems in terms of ease of operation and patient recovery.[174] On the other hand, critics of the robot have evidence to support claims that it has defects,[175] that it costs more than alternatives,[176] and that its widespread use may be due in part to aggressive marketing by Intuitive Surgical[177] and hospitals.[178] The challenge for the legal system is to address these competing views in a fair manner under the existing system of liability and regulation, and the system appears to be doing just that. Intuitive Surgical continues to be a successful company, even though critics, regulators, and plaintiffs challenge the nature and level of that success. More generally, innovation in the field of medical robotics appears to be progressing in a robust manner.[179]

B. *Standards: Legislative/Regulatory Approach*

1. Motor Vehicles

a. Standards

i. Federal

Uncertainty concerning how existing liability schemes will be applied to the rapidly evolving technology of developing increasingly sophisticated vehicles presents challenges to innovators. This uncertainty could be reduced if the federal government adopted national standards or facilitated the development of such standards. Unfortunately, the development of such standards has been plagued by uncertainty in terms of how and when the incremental development of technology will proceed.[180]

174. *See, e.g.*, Greenberg, *supra* note 168.

175. *See supra* notes 167–71 and accompanying text.

176. *See supra* note 172.

177. Tanner, *supra* note 172; *see also, e.g.*, Beck, *supra* note 172; Greenberg, *supra* note 168; *Statement on Robotic Surgery*, *supra* note 172.

178. *See, e.g.*, Aston, *supra* note 168 (noting that "[c]apturing market share can be the biggest advantage of investing in the robot"); Greenberg, *supra* note 168; Tanner, *supra* note 168 (noting "aggressive advertising by . . . hospitals seeking more patients"). Because laparoscopic surgery costs less than da Vinci surgery and both are generally reimbursed at the same level, hospitals lose money in using the da Vinci robot. *See* Beck, *supra* note 172. Consequently, hospitals must "absorb the costs or pass it on to other patients." *Id.*; *see also*, Andrews, *supra* note 172. Many hospitals do this because they "see robotic surgery as a marketing tool." *See* Beck, *supra* note 172.

179. *See*, David von Drehle, *Meet Dr. Robot*, *in* TIME: RISE OF THE ROBOTS, *supra* note 1, at 80–85; Aston, *supra* note 168 (discussing other companies and collaborations that are developing surgical robots).

180. For example, a European consortium studied the technological development and concluded: "The current status of development makes it very difficult to describe the state-of-the-art knowledge of ADAS [Advanced Driver Assist System], because there are so many

NHTSA recently addressed this uncertainty in a *Preliminary Statement* that notes:

> "[T]hree distinct but related streams of technological change and development are occurring simultaneously: (1) in-vehicle crash avoidance systems that provide warnings and/or limited automated control of safety functions; (2) V2V [vehicle to vehicle] communications that support various crash avoidance applications; and (3) self-driving vehicles."[181]

Given the "fair amount of confusion" concerning how to address "the confluence of these three streams of innovation," the preliminary statement concludes "that it is helpful to think of these emerging technologies as part of a continuum of vehicle control automation."[182] This continuum was expressed in terms of the following five levels:

> No-Automation (Level 0): The driver is in complete and sole control of the primary vehicle controls—brake, steering, throttle, and motive power—at all times.
>
> Function-specific Automation (Level 1): Automation at this level involves one or more specific control functions. Examples include electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone.
>
> Combined Function Automation (Level 2): This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centering.
>
> Limited Self-Driving Automation (Level 3): Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The

systems with different technology addressing even more different assisting functions." PREVENT, RESPONSE 3: CODE OF PRACTICE FOR THE DESIGN AND EVALUATION OF ADAS 1 (2009). As a result, no specific standards were adopted.

181. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., PRELIMINARY STATEMENT OF POLICY CONCERNING AUTOMATED VEHICLES 3 (2013) [hereinafter NHTSA, PRELIMINARY STATEMENT]. For a useful discussion of NHTSA's role in setting standards for increasingly autonomous vehicles, see, for example, Wood et al., *supra* note 134, at 1426–27.

182. NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 3.

> driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The Google car is an example of limited self-driving automation.
>
> Full Self-Driving Automation (Level 4): The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.[183]

Though NHTSA has not adopted standards in terms of a specific level, it has adopted policies and regulations concerning specific technology—for example, concerning electronic stability control.[184] In addition, NHTSA recently announced steps to study and enable V2V technologies in light vehicles in order to develop a basis for a possible regulatory requirement.[185] It also plans to address possible regulations on automatic braking technologies.[186] The Preliminary Statement also outlines a "Research Plan for Automated Vehicles" along with other recommendations to the states for the regulation of fully self-driving vehicles and the licensing of their operators.[187]

ii. State

Registration of motor vehicles and licensing of drivers is largely a matter of state law. Several states have adopted or are considering adopting schemes for addressing "autonomous vehicles" on their roads.[188] Nevada was the first state to adopt a scheme to regulate

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183. Press Release, NHTSA, U.S. Department of Transportation Releases Policy on Automated Vehicle Development (May 30, 2013), http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development.

184. *See* NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 5–6. For further discussion of such regulation, see *supra* note 161.

185. Press Release, NHTSA, U.S. Department of Transportation Announces Decision to Move Forward with Vehicle-to-Vehicle Communication Technology for Light Vehicles (Feb. 3, 2014), http://www.nhtsa.gov/About+NHTSA/Press+Releases/2014/USDOT+to+Move+Forward+with+Vehicle-to-Vehicle+Communication+Technology+for+Light+Vehicles. This Press Release notes the "DOT believes that the signal this announcement sends to the market will significantly enhance development of this technology and pave the way for market penetration of V2V safety applications." *Id.*

186. NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 6.

187. *Id.* at 5–14.

188. *See, e.g.*, Bryant Walker Smith, AUTOMATED VEHICLES ARE PROBABLY LEGAL IN THE UNITED STATES, TEX. A&M L. REV. 411, 500–08 (2014) (arguing that autonomous cars would be legal without specific legislation and noting that Nevada, Florida, and California have adopted legislation), *available at* http://cyberlaw.stanford.edu/files/publication/files/2012-Smith-AutomatedVehiclesAreProbablyLegalinTheUS_0.pdf.

autonomous cars.[189] Nevada's scheme provides a useful example of a regulatory approach to experimental vehicles. In 2011, the Nevada Legislature adopted a bill defining "autonomous vehicle" and directing the Department of Motor Vehicles (DMV) to establish regulations addressing: (1) licensing operators of autonomous vehicles; (2) operation of these vehicles on highways in the state; (3) requirements and safety standards for the vehicles; (4) testing of the vehicles; (5) insurance for testers or operators of the vehicles; and (6) other requirements the department determines to be necessary.[190]

The regulations adopted by the Nevada DMV[191] address autonomous vehicles in terms of three categories of licensees: operators,[192] testers,[193] and certifiers.[194] The regulations also address the registration of autonomous vehicles,[195] insurance and bond requirements,[196] operation and testing requirements,[197] sale requirements,[198] and vehicle requirements.[199] Though the regulations authorize "driverless" or "self-driving" cars, they require that at least two persons must be present in an autonomous vehicle being tested and that one of these people must be able to take control of the vehicle.[200] The vehicle is required to have the equipment to make such a shift to human control possible.[201] Thus, the scheme retains the human-in-the-loop approach to safety.[202]

When sophisticated robotic vehicles develop beyond the experimental stage, licensing of maintenance and repair facilities might be necessary. Without such regulation, the performance of these complex vehicles could become unreliable. If such a licensing scheme is adopted, the Nevada scheme for licensing certifiers could provide a useful guide.

b. Other Impacts

Increasingly autonomous vehicles will impact the driving

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189. *Id.* at 81.

190. Assemb. B. 511, 2011 Assemb., 76th Sess. §§ 2, 5 (Nev. 2012) (enacted).

191. NEV. DEPT. OF MOTOR VEHICLES, LCB FILE NO. R084-11 (2012).

192. *Id.* §§ 5, 27.

193. *Id.* §§ 7–15.

194. *Id.* §§ 17–26.

195. *Id.* §§ 6, 11.

196. *Id.* §§ 6.2, 8.3(a), 8.4(b), 18.3(b).

197. *Id.* §§ 4, 7–16.

198. *Id.* § 16.

199. *Id.* §§ 6.1, 16.2.

200. *Id.* § 10.1. These persons must have a driver's license and be trained to operate an autonomous vehicle. *Id.* § 10.2. However, they are not necessarily the same persons as the licensed "operator" and "testers." *See id.* §§ 4, 8, 10.

201. *Id.* § 16.2.

202. *See supra* Section I.B.

environment in a wide variety of ways. For example, the increasing wireless connectivity among vehicles and with other systems may require the allocation of a sufficient amount of radio frequency spectrum to achieve the coordination necessary for safety.[203] The impacts on highway infrastructure are unclear. But it is likely that driverless cars will increase demand for highways because, for example: (1) autonomous vehicles will allow all passengers to do things other than drive; (2) people not currently able to drive cars will be able to use cars; and (3) vehicles will be able to deliver and pick up goods without a driver.[204] On the other hand, it will be possible to use roadways more efficiently.[205]

2. Unmanned Aircraft Systems (UAS)

The use of Unmanned Aircraft Systems (UAS), commonly known as drones, has increased dramatically during the past decade.[206] The Federal Aviation Administration (FAA), which regulates aircraft in the National Air Space (NAS), currently groups UAS into three separate categories: public, civil, and private.[207] Under current FAA regulations, use of UAS in the NAS requires special permits, which are issued by the FAA on a case-by-case basis and were unavailable for commercial purposes until recently.[208] Though the FAA has shown little, if any, concern for private recreational use of UAS by hobbyists, the proliferation of small UAS appears to be causing a more aggressive

203. *See* Robert B. Kelly & Mark D. Johnson, *Defining a Stable, Protected and Secure Spectrum Environment for Autonomous Vehicles*, 52 SANTA CLARA L. REV. 1271, 1285 (2012).

204. Bryant Walker Smith, *Managing Autonomous Transportation Demand*, 52 SANTA CLARA L. REV. 1401, 1409–10. Other negative effects are also possible. For example, driverless vehicles could increase urban sprawl because commuting would be less onerous. *Id.* at 1417.

205. *Id.* at 1412–13.

206. *See* Unmanned Aircraft Operations in the National Airspace System, 72 Fed. Reg. 6689 (Feb. 13, 2007) (to be codified at 14 C.F.R. pt. 91); Lev Grossman, *Drone Home*, *in* TIME: RISE OF THE ROBOTS, *supra* note 1, at 24. For general discussion of legal issues concerning UAS, see, for example, UNMANNED AIRCRAFT IN THE NATIONAL AIRSPACE: CRITICAL ISSUES, TECHNOLOGY, AND THE LAW (Donna A. Dulo ed., forthcoming 2014); Cameron R. Cloar & Donna A. Dulo, *Considerations of a Legal Framework for the Safe and Resilient Operation of Autonomous Aerial Robots* (Apr. 5, 2014), http://robots.law.miami.edu/2014/wp-content/uploads/2013/06/Cloar-and-Dulo_Considerations-of-a-Legal-Framework-for-Aerial-Robots_WE-ROBOT-2014-Conference.pdf; Donna A. Dulo, *UAS in the National Airspace: Aerial Goldmine or Legal Landmine*, UNMANNED SYSTEMS, June 2014, at 14, 14–17, *available at* http://www.mckennalong.com/assets/attachments/uas_nationalairspace.pdf.

207. *See* Unmanned Aircraft Operations in the National Airspace System, 72 Fed. Reg. at 6689.

208. *See id.* at 6689–90 (explaining that public UAS require a Certificate of Waiver or Authorization, civil UAS require a special airworthiness certificate, and private UAS require operators to observe special restricted-flying rules); *FAA Type Certifies ScanEagle, Puma for Commercial Flight*, UNMANNED SYSTEMS, Sept. 2013, at 12, 12 (discussing approval of observation missions in the Arctic).

approach.[209]

In recent years, the FAA has begun to address ways to accommodate private commercial use of UAS in the NAS.[210] An initial step was to appoint a taskforce to update and implement new regulations to address the use of UAS in the public, private, and commercial sectors.[211] The time line for the FAA's integration of UAS into the NAS is longer than the UAS industry may prefer, and some commentators view the lack of federal regulations as a major restriction on the innovation and use of UAS in the United States.[212] The FAA has responded that an extended period is needed to test and safely implement new regulations.[213] On December 30, 2013, as a part of the testing process, the FAA announced

209. For years, the FAA relied on informal directives designed for voluntary compliance. *See* Unmanned Aircraft Operations in the National Airspace System, 72 Fed. Reg. at 6689 (noting, among other things, that "[m]odel aircraft" flown as a hobby "should be flown below 400 feet above the surface" and that the "FAA expects that hobbyists will operate these recreational model aircraft within visual line-of-sight"); FAA ADVISORY CIRCULAR AC 91-57 (1981) (noting that the circular "encourages voluntary compliance" and stating that airport authorities should be notified when private operators "fly[] aircraft within 3 miles of an airport").

In 2012 the FAA fined Raphael Pirker $10,000 for flying a UAS in violation of law. Huerta v. Pirker, Docket CP-217, N.T.S.B. (ALJ) 1, 1 (Order Mar. 6, 2014), http://www.ntsb.gov/legal/pirker/Pirker-CP-217.pdf. This fine was reversed on appeal by an Administrative Law Judge on the ground that, at the time of Pirker's conduct, "there was no enforceable FAA rule or FAR Regulation applicable to model aircraft or for classifying model aircraft as an UAS." *Id.* at 8. On April 7, 2014, the FAA filed an Appeal Brief requesting the Board to reverse the ALJ's decision. Huerta v. Pirker, Docket CP-217, N.T.S.B. 1, 18 (Appeal Brief Apr.7, 2014), http://www.ntsb.gov/legal/pirker/Administrator'sAppealBrief.pdf. An FAA spokesperson said recently that the agency "expects to publish the formal rule on small drones 'later this year.'" Brian Fung, *Realtors and Soybean Farmers Agree: Drone Rules are Overdue*, WASH. POST BLOG (Apr. 8, 2014), http://www.washingtonpost.com/blogs/the-switch/wp/2014/04/08/realtors-and-soybean-farmers-agree-drone-rules-are-overdue/ (last visited Aug. 15, 2014).

On April 21, 2014, a volunteer organization using radio-controlled UAS petitioned the U.S. Court of Appeals for the D.C. Circuit to set aside a cease and desist order requiring the cessation of the use of such UAS. Brief of Petitioner, Tex. Equusearch Mounted Search and Recovery Team v. FAA, No. 14-1061 (D.C. Cir. Apr. 21, 2014), *available at* http://www.kramerlevin.com/files/upload/TES-v-FAA.pdf (last visited Aug. 15, 2014).

210. *See generally* FAA, U.S. DEP'T OF TRANSP., INTEGRATION OF CIVIL UNMANNED AIRCRAFT SYSTEMS (UAS) IN THE NATIONAL AIRSPACE SYSTEM (NAS) ROADMAP (2013), http://www.faa.gov/about/initiatives/uas/media/UAS_Roadmap_2013.pdf (discussing the need to adopt new regulations for the use of UAS in the NAS).

211. *See id.* at 4–5.

212. *See* Nancy Averett, *Drones Take Off as Wildlife Conservation Tool*, AUDUBON, *available at* http://www.audubonmagazine.org/articles/conservation/drones-take-wildlife-conservation-tool (last visited Aug. 15, 2014); *Morning Edition: Will Bureaucracy Keep the U.S. Drone Industry Grounded?* (National Public Radio broadcast Apr. 30, 2013) [hereinafter *Morning Edition*], *available at* http://www.npr.org/blogs/alltechconsidered/2013/05/06/179843540/will-bureaucracy-keep-the-u-s-drone-industry-grounded.

213. *See Morning Edition*, *supra* note 212.

the selection of six public entities that "will develop unmanned aircraft systems (UAS) research and test sites around the country . . . . [to] conduct critical research into the certification and operational requirements necessary to safely integrate UAS into the national airspace over the next several years."[214]

The FAA has noted that security and privacy concerns must be addressed in order to accommodate commercial UAS in the NAS, and these concerns will present challenges for innovation of UAS.[215] In contrast, even though UAS sometimes crash,[216] the FAA does not seem to perceive liability for physical harm as a serious problem.

3. General-Purpose Robots

The sensor and control technology used in automobiles can be adapted for large, mobile, general-purpose robots equipped with the functional equivalents of human arms and hands (and perhaps legs rather than wheels).[217] The robotic rovers sent to Mars indicate one possible form of these robots.[218]

It is difficult to know when large robots like these will be available for consumer markets and, once available, what risks and capabilities they will involve. Consequently, a specific regulatory scheme could be difficult to devise at this time, and attempts to do so too early might impose arbitrary limits on innovation. On the other hand, well-conceived safety standards could reduce injuries and also foster innovation by reducing uncertainties about requirements. Because of concern for safety and innovation, the National Institution of Safety and Standards (NIST) has undertaken a project to:

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214. Press Release, FAA, FAA Selects Unmanned Aircraft Systems Research and Test Sites (Dec. 30, 2013), http://www.faa.gov/news/press_releases/news_story.cfm?newsid=15576. The six entities are: University of Alaska, State of Nevada, New York's Griffiss International Airport, North Dakota Department of Commerce, Texas A&M University, and Virginia Polytechnic Institute and State University (Virginia Tech). *Id.*

215. *See, e.g.*, FAA, U.S. DEP'T OF TRANSP., *supra* note 210, at 11–12; Benjamin Kapnik, Note, *Unmanned but Accelerating: Navigating the Regulatory and Privacy Challenges of Introducing Unmanned Aircraft into the National Airspace System*, 77 J. AIR L. & COM. 439, 464 (2012) (discussing civil tort liability for invasion of privacy from use of drones).

216. *See* Grossman, *supra* note 206, at 31; Breyer et al., *supra* note 42, at 3–8 (discussing data concerning Air Force UAS "mishaps"); Neal Ungerleider, *What Happens When a Drone Crashes?*, FAST COMPANY, *available at* http://www.fastcompany.com/3028781/what-happens-when-a-drone-crashes (last visited Aug. 15, 2014) (discussing crashes and possible litigation for personal injuries).

217. *See, e.g.*, Mike Hammer, *A Few Good Bots*, *in* RISE OF THE ROBOTS, *supra* note 1, at 34–37 (portraying modern-day robots); Bullerdick, *supra* note 2 (same); Daniel Cray, *Search Engines*, *in* RISE OF THE ROBOTS, *supra* note 1, at 60–65 (same). For discussion of sophisticated general-purpose robots that operate without a human in the loop, see *infra* Section III.B.

218. *See* Jeffrey Kluger, *To Infinity and Beyond!*, *in* TIME: RISE OF THE ROBOTS, *supra* note 1, at 68–73.

> 1. Develop the safety standards and performance measures to enable humans and robots to work together in the same space.
>
> 2. Develop performance measures for sensors used to monitor the work area and ensure safety of robots, vehicles, and people.[219]

III. Application of the Liability System to Sophisticated Robots

Because of their increased autonomy, intelligence, and connectivity, sophisticated robots that are large and mobile will challenge the liability system in a number of ways. Contract doctrine is likely sufficiently flexible to address these challenges in the same manner as it has responded to new technologies in transportation and telecommunications.

However, two types of contract problems may arise. First, some may argue that too many consumers will, as a result of irrationality or coercive marketing, agree to contract terms that should be unenforceable. Such arguments have been made on behalf of buyers in the context of software licensing contracts that severely restrict buyers' rights—for example, by warranty disclaimers or compulsory arbitration clauses.[220] These arguments have been unsuccessful where physical injuries were not involved.[221] However, if physical injuries are involved, it is more likely that such terms will be held unenforceable. Moreover, even if the contract terms were enforceable, tort doctrine would also apply to any physical injuries.[222] Second, sophisticated robots will complicate the problems of proving that a contract was breached and whether any breach caused a plaintiff's injury.[223]

Because similar problems of proof will also arise in tort, and because tort doctrine will apply to physical injuries, this Article focuses on the impact of sophisticated robots on the tort system. This Article addresses these impacts primarily by focusing on automobiles, which are likely to be the first examples of widespread use of large, mobile, sophisticated

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219. NIST, *Human-Robot Collaboration*, *supra* note 12. The goal of the project is to "develop and deploy the measurement science needed by industry (manufacturers, integrators and end-users) and robot safety standards organizations to enable safety and effectiveness of human robot collaborative activities by 2014." *Id.* For a discussion of NIST's role, see *supra* note 133 and accompanying text.

220. *See, e.g.*, Robert A. Hillman & Ibrahim Barakat, *Warranties and Disclaimers in the Electronic Age*, 11 YALE J.L. & TECH. 1, 2–3 (2009).

221. *See supra* note 59 and accompanying text.

222. *See supra* note 59 and accompanying text (discussing economic loss rule).

223. For a discussion of similar problems in the context of tort litigation, see *infra* notes 227–33 and accompanying text.

robots. This discussion of automobiles also applies to Unmanned Aircraft Systems (UAS), which are likely to become common in the near future.[224]

A. *Sophisticated Automobiles with Human Drivers*

As indicated above, NHTSA has divided automation in vehicles into five levels.[225] The following discussion addresses automobiles in categories 0–3, which include automobiles that exist today and automobiles that will exist in the near future. All of these have a significant role for the human driver at all times. Section III.B. addresses Level 4 (“Full Self-Driving Automation”).

1. Sales, Leases, and Other Distributions

It is unlikely that the development of sophisticated robotic vehicles with human operators will result in changes in the basic structure of tort *doctrine* governing sellers and distributors. In particular, plaintiffs would still have to show a safety defect in manufacturing, design, or warning. For example, plaintiffs claiming that a cruise-control system was defectively designed currently have to show that: (1) a reasonable alternative design existed, and (2) had this design been used, the accident would not have happened.[226] This requirement is so fundamental and well established that it is not likely to change. However, as indicated below, sophisticated vehicles could affect the application of the tort system in a number of important ways.

a. Complexity

One reason for these effects on the application of tort law is that sophisticated robotic automobiles have two characteristics that will challenge the ability of the tort system to make the factual determinations necessary to allocate responsibility for injuries on the basis of fault. The first characteristic is “emergent” behavior—i.e., unpredictable behavior that the vehicle, in effect, “learned” as a way to achieve a goal.[227] The second is interconnection and coordination of behavior with other sophisticated vehicles, with highway infrastructure systems, and with other systems (for example, global positioning data systems).

Both characteristics may raise virtually insurmountable proof

224. For further discussion of legal issues involving UAS, see, for example, UNMANNED AIRCRAFT IN THE NATIONAL AIRSPACE: CRITICAL ISSUES, TECHNOLOGY, AND THE LAW, *supra* note 206; Breyer et al., *supra* note 42.

225. *Supra* notes 182–83 and accompanying text.

226. *See supra* note 62 and accompanying text.

227. *See, e.g.*, BROOKS, *supra* note 6, at 19–20.

problems concerning such issues as defectiveness and causation. For example, if someone is injured in a collision involving automobiles that have been designed to "learn" from and to interact with each other and with electronic aspects of the highway, it may be hard to identify what went wrong, why things went wrong, and what caused the injury.[228]

Current doctrines can address both characteristics. For example, the problem of emergent behavior would be addressed under current law by requiring plaintiffs to provide reliable expert testimony: (1) that the use of emergent behavior (or a particular approach to emergent behavior) did not satisfy the cost–benefit standard for design or for warnings and instructions, and (2) that this failure to satisfy the standard caused the plaintiff's injury.[229] Plaintiffs who cannot adequately address problems in proving breach of standard and causation will lose their cases; this has been the fundamental approach to failure to provide evidence of breach and causation for centuries.[230] Victims may attempt to address these problems by urging courts and legislatures to change burden of proof rules to make it easier for plaintiffs to recover. However, victims are unlikely to have much success because changing such a basic rule of the corrective justice system would radically expand the liability of sellers and designers.

Another area that may present complex fact issues is the allocation of "fault" among multiple component suppliers of hardware and software in terms of product defect and causation. Once again, current rules provide clear guidance. First, as a general rule, the seller or distributor of a completely assembled product will be liable for design or warning defects in the assembled product.[231] Second, the seller or distributor of a component part is not liable unless: (1) the component is defective; or (2) participation by the component seller (or distributor of the component) in integrating the component into the design caused the defect.[232]

Plaintiffs are not likely to care about the liability of a component part distributor unless the sellers of the assembled product cannot pay a judgment—for example, because the sellers are judgment-proof, no

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228. *See, e.g.*, Curtis E.A. Karnow, *Liability for Distributed Artificial Intelligences*, 11 BERKELEY TECH. L.J. 147, 187–89, 192 (1996).

229. *See supra* notes 54–55 and accompanying text. Sellers of assembled products and sellers of components may want to consider addressing issues of allocation among themselves through the use of a contract requiring one or more parties to indemnify others. However, unless the contract is drawn very carefully, difficult fact issues may remain. For discussion of indemnity, see *supra* note 45.

230. *See supra* notes 22, 91, 93, 147–79 and accompanying text. Courts occasionally alter rules about breach of standard or about causation, but almost never change both in the same context.

231. *See supra* notes 79–80 and accompanying text.

232. *See supra* note 79 and accompanying text.

longer exist, or cannot be sued for some reason such as lack of jurisdiction. However, if problems like these exist, it may be hard to determine whether the problem arose because a component was defective or because the manufacturer's integration of the component into the final product resulted in the defect.

These problems will be especially complicated where an autonomous vehicle injures someone through emergent behavior on the robot's part or because of interaction with other robots.[233] As indicated above, if the plaintiff cannot adequately address these proof problems, the plaintiff will lose the case.

In one respect, fact issues may be simplified with robotic cars. Currently, event data recorders, which can record data about a vehicle's operation prior to a collision, provide useful evidence in trial concerning operation of vehicles.[234] Though privacy concerns may complicate matters,[235] it is likely that the "memory" of a robotic car would provide even more information that would be useful in assessing liability.

b. Software

Where software is part of a physical product like an automobile, it is very unlikely that the software component will be treated as a distinct non-product part of the total product to be addressed in a different way than the mechanical components of the automobile.[236] However, sophisticated robotic vehicles might present difficulties in applying the distinction between manufacturing defects and design defects where software is concerned. Such difficulties could arise because the software design expressed in the form of a flow chart or algorithm is distinct from the implementation of that design in the form of the specific

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233. *See supra* notes 227–28 and accompanying text.

234. *See, e.g.*, Majorie A. Shields, Annotation, *Admissibility of Evidence Taken from Vehicular Event Data Recorders (EDR), Sensing Diagnostic Modules, or "Black Boxes*,*"* 40 A.L.R.6th 595 (2008).

235. *See, e.g.*, Dorothy J. Glancy, *Privacy in Autonomous Vehicles*, 52 SANTA CLARA L. REV. 1171, 1175–76, 1202–03 (2012).

236. Software is likely to be viewed as a product, particularly if it is sold as a general-purpose package or is designed to control a machine. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 19 rptr. n. to cmt. d, at 278 (1997). *But see* OWEN, *supra* note 44, § 16.8, at 1114–15 ("At least when the defect lies solely in the software program design, rather than the substantive information fed into the program, a defective software program might seem to lie closer to a defective navigational chart for which a producer should be subject to strict liability for resulting harm."). *See generally* Frances E. Zollers et al., *No More Soft Landings for Software: Liability for Defects in an Industry that Has Come of Age*, 21 SANTA CLARA COMPUTER & HIGH TECH. L.J. 745 (2005) (arguing for the adoption of a strict liability regime for software that produces physical injury). On the other hand, software prepared for a specific purpose might be treated as a service rather than a product.

coding that runs a computer.[237]

If there is an error in coding, is that a design error or a manufacturing error? The answer to this question is important because, as indicated above, strict liability is imposed in cases of manufacturing defect,[238] while issues of design are addressed in terms of the cost–benefit test.[239] One reason for this difference in treatment is that a manufacturer's "blueprint" provides a clear standard for consumer expectations.[240] However, a flowchart lacks the specificity of design specifications when compared to, for example, a blueprint indicating assembly involving four bolts of a particular size and type. Another reason for the difference in treatment, is that, in contrast to a manufacturing defect (which involves only the particular unit or units with the defect), a finding of a design defect affects the entire product line using that design.[241] An example illustrating the importance of this effect on the product line is Toyota's recent voluntary decision to recall 1.9 million vehicles to address a programming error.[242] Thus, because a flowchart lacks the specificity of a traditional blueprint and because the specific coding that implements the algorithm is used in the entire product line, it would be better to treat coding as a design defect, rather than a manufacturing defect.[243]

Applying the "reasonable alternative design" test to software will also present problems because a programming error in the software will constitute a defect that, having been discovered, might be easily fixed by a reprogrammed version of the software. Will expert testimony about the new version be sufficient to enable a plaintiff to convince the trial judge that the issue of reasonable alternative design should go to a jury?[244] In such a case, because there is literally evidence of an alternative design for coding, there is a good argument that the plaintiff has satisfied the burden of showing a reasonable alternative design and that using the alternative design would be less expensive than the injury costs avoided by its use.[245] However, with more than 100 million lines of software code in a modern automobile,[246] it is unclear whether

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237. *See, e.g.*, Daniel B. Garrie, *The Legal Status of Software*, 23 J. MARSHALL J. COMPUTER & INFO. L. 711, 716, 718 (2005).

238. *See supra* note 71 and accompanying text.

239. *See supra* note 62 and accompanying text.

240. *See supra* note 71 and accompanying text.

241. *See supra* note 71 and accompanying text.

242. *See* Tabuchi & Trop, *supra* note 163.

243. *Cf.* Zollers et al., *supra* note 236, at 778–79.

244. For a discussion of methods to prevent a plaintiff from proceeding to the jury, see *supra* notes 92–93 and accompanying text.

245. *See* Zollers et al., *supra* note 236, at 779.

246. *See* Robert N. Charette, *This Car Runs on Code*, IEEE SPECTRUM (Feb. 2009), *available at* http://www.real-programmer.com/interesting_things/IEEE%20SpectrumThisCar

plaintiffs should be able to rely solely on the existence of the error and of a way to fix the error available at the time of trial but not necessarily reasonably available at the time of sale. Arguably, expert testimony of reasonably attainable error elimination at the time of design and sale should also be required.[247]

If plaintiff is allowed to rely on the reprogramming testimony alone in persuading a judge to allow the case to go to the jury, the defendant should be allowed to present evidence of the "state of the art" of programming as a way to show that the error was not reasonably knowable at the time of design and manufacture and that, therefore, the program was not "defective."[248] Given the underlying policy bases for products liability, liability should be based on the conduct of the manufacturer at the time of manufacture and sale.[249] The *Restatement of Torts: Products Liability* notes:

> Most courts agree that, for the liability system to be fair and efficient, the balancing of risks and benefits in judging product design and marketing must be done in light of the knowledge of risks and *risk-avoidance techniques reasonably attainable at the time of distribution*. To hold a manufacturer liable for a risk that was not foreseeable when the product was marketed might foster increased manufacturer investment in safety. But such investment by definition would be a matter of *guesswork*. Furthermore, *manufacturers may persuasively ask to be judged by a normative behavior standard to which it is reasonably possible for manufacturers to conform*.[250]

In assessing the "risks-avoidance techniques" that were "reasonably attainable," the ability of a reasonable programmer to eliminate a particular programming error would be relevant to knowing what was reasonably attainable. Therefore, the defendant should be allowed to present expert testimony on reasonable attainability, and the judge should instruct the jury that reasonable attainability is the standard for programming defects.

RunsOnCode.pdf. Charette quotes an expert who states that a premium-class vehicle available in 2009 "probably contains close to 100 million lines of software code." *Id.* (internal quotation marks omitted). Many of today's vehicles probably exceed that number substantially.

247. The textual analysis on this point is tentative because so much depends on the details of the problem. For a useful discussion of identifying defective software in the regulatory context, see Wood et al., *supra* note 134, at 1478–82. In terms of liability in tort, where the precise error is not clear, the issue might be phrased in terms of the adequacy of circumstantial proof. *See, e.g.*, RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 3, at 111 (1997); OWEN, *supra* note 44, § 7.4, at 464–65 (discussing the doctrine of res ipsa loquitur).

248. For a discussion of "state of the art," see *supra* notes 64–65 and accompanying text.

249. *See supra* notes 54–58, 62–65, and accompanying text.

250. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. a, at 16–17 (emphasis added).

c. Design, Warnings, and Instructions

The application of existing doctrines to sophisticated automobiles could also change significantly. For example, sellers and other distributors currently have a post-sale duty of reasonable care to warn if the costs of giving that warning are less than the potential harm that can be prevented.[251] If the manufacturer of a sophisticated automobile can communicate easily with the automobile, the costs of giving a warning will be drastically reduced.[252] Consequently, there will be more instances in which a warning will be required.

More generally, the standards for design and for warnings and instructions may be affected. NHTSA has identified three key areas that need to be researched for the development of increasingly autonomous vehicles: "human factors research, development of system performance requirements, and addressing electronic control system safety."[253] Human-factors concerns include communication between the driver and the vehicle and proper allocation of control functions between the driver and vehicle.[254] Electronic-control-systems concerns involve two areas: (1) reliability of the automated systems, and (2) cybersecurity.[255] Performance standards will require the development of performance tests and associated pass/fail criteria.[256]

Litigation in all three of these key areas will require expert witnesses to evaluate design, warnings, and instructions and to offer expert opinions. Until relatively clear government or industry standards are developed, innovators may face considerable uncertainty concerning liability. Fortunately, NHTSA appears to be addressing the need for standards. In the meantime, manufacturers can address this uncertainty by pushing for private standards and by adopting (and keeping records about) a detailed safety-testing program in development based on the key areas identified by NHTSA.[257]

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251. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 10, at 191.

252. The cost will never be close to zero because one of the costs involves the users' time and attention. Thus, if there are too many warnings, users may no longer give them sufficient attention. *See, e.g.*, Cotton v. Buckeye Gas Prods. Co., 840 F.2d 935, 938 (D.C. Cir. 1988) (rejecting plaintiff's claim of warning defect, partly because of the cost "in time and effort required for the user to grasp" all the risks).

253. NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 6.

254. *Id.* at 6. *See generally* Bryant Walker Smith, Human Factors in Robotic Torts (Mar. 30, 2013) (unpublished manuscript), *available at* http://conferences.law.stanford.edu/werobot/wp-content/uploads/sites/29/2013/04/HumanFactorsRoboticTorts_BryantWalkerSmith.pdf. *See supra* note 91 and accompanying text for discussion of experts in human factors testifying concerning design and warnings.

255. *See* NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 7.

256. *Id.* at 8–9.

257. *See supra* notes 38–42 and accompanying text for discussion of approaches to reduce risk and uncertainty.

d. Trials

Application of existing doctrines to robots will also affect trials in many ways. For example, expert witnesses in a case involving a sophisticated robotic automobile might be required to have greater degrees of expertise. As a result, simply being a licensed mechanical engineer might be insufficient; an expert might be required to have expertise in robotic design or in a specific aspect of robotics.[258]

e. Doctrinal Changes

As indicated in the discussion of complex factual determinations, plaintiffs might urge courts to address these problems through doctrinal changes concerning the burden of proof.[259] The increased sophistication of robots may also affect specific doctrines in many other ways. For example, where special training is required to safely use a robot, manufacturers and other distributors may be required either to provide training or to make offers of training accompanied by strong warnings concerning the need for training. As indicated above, doctrinal requirements like this might be imposed for robotic surgical systems.[260] Similarly, manufacturers and distributors of sophisticated automobiles (and the drivers themselves) may not be able to assume that a driver with a license to drive ordinary cars can drive a very sophisticated car without special training.

Another possible doctrinal change may arise in the context of product recalls. Currently, a manufacturer or distributor has no duty to recall a product unless a government directive requires the recall.[261] However, because of the increased connectivity between manufacturers and users of sophisticated vehicles, there is less reason to take the position that manufacturers do not have, for example, a duty of reasonable care to update software or, at least, to offer such updates without government intervention.

In a suit for defective design, the current standard of reasonable alternative design is unlikely to change.[262] Given this standard, if the

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258. *Compare, e.g.*, Hills v. Fanuc Robotics Am., Inc., No. 04-2659, 2010 WL 890223, at *5 (E.D. La. Mar. 5, 2010) (holding that mechanical engineer qualified to testify about defect in robot even though not a specialist in robotics), *with, e.g.*, Watson v. Ford Motor Co., 699 S.E.2d 169, 178 (S.C. 2010) (holding that testimony of electrical engineer was not reliable in matter concerning design of cruise-control system).

259. *See supra* note 230 and accompanying text.

260. For discussion of the current system, see *supra* notes 165–70 and accompanying text.

261. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 11, at 201 (1997). However, if the seller or distributor voluntarily undertakes to recall, it must be done with reasonable care. *Id.* As indicated at *supra* notes 251–52 and accompanying text, ease of communication could also affect the application of the current duty to use cost-effective post-sale warnings.

262. *See supra* notes 62–65, 244–50, and accompanying text.

plaintiff alleges a design defect in a partially autonomous driving system, the issue would be whether, *on the whole*, automobiles with the defective system at issue are no less safe than they would be either with a proposed alternative system or with a human driver. Thus, if the system at issue is as safe on the whole, it would be irrelevant to consider whether a proposed alternative system or a reasonable human driver would have avoided the accident by acting differently in the unique factual circumstances involved in the plaintiff's suit.[263]

Similarly, manufacturers of autonomous cars will not avoid liability just because, on the whole, these cars are safer than manually driven cars. For example, even if a human-driven car with an adaptive cruise-control system combined with a lane-centering system[264] is safer on the whole than a car without the system, the manufacturer of the car would be liable if a reasonable alternative design for the combined systems could have prevented the injury. Any other approach would conflict with the current approach and would effectively immunize sellers of cars with electronic stability control systems from liability and thus eliminate incentives to make these systems safer.

2. Control, Use, and Maintenance

Because increasing sophistication of robots is an incremental process,[265] there is no reason to expect changes in the underlying principles and doctrines of tort law addressed in Subsection II.A.2.c. above. However, the application of tort law could be affected. For example, as robots become more sophisticated, greater skill might be required for using or maintaining more sophisticated robots with reasonable care.

3. Distributional Impacts

It is likely that, as automobiles become increasingly robotic,[266] accidents will be caused more and more by features of the car itself and less and less by the conduct of drivers.[267] This increased role of the car

263. The textual analysis is based, in part, on the fact that trade-offs are involved in design. For example, placing the gas tank in the rear of a car might reduce the risk of fires from side collisions while increasing the risk of fires from rear collisions. Similarly, there are trade-offs involved in using a robotic driving system vis à vis a human driver.

264. Adaptive cruise control automatically applies the brakes if objects are within a certain distance and the lane centering steers the car. *See supra* notes 159, 181 and accompanying text. A car with this level of automation would be at level 2 in the NHTSA scheme of levels of automation. *See supra* notes 159, 181, 183 and accompanying text.

265. For a discussion of the incremental stages of automatic car development, see *supra* notes 157–61, 181–83, and accompanying text

266. *See supra* notes 180–83 and accompanying text.

267. *See, e.g.*, NIDHI KALRA ET AL., CAL. PARTNERS FOR ADVANCED TRANSIT & HIGHWAYS, LIABILITY AND REGULATION OF AUTONOMOUS VEHICLE TECHNOLOGIES 20 (2009).

vis-à-vis the driver will likely shift liability costs away from owners and drivers, who could be liable based on negligence law, to sellers and distributors, who could be liable under products liability law for defective features.[268] Such a shift might result in higher liability costs for sellers and distributors and thus higher costs for cars. However, these more expensive cars would not necessarily reduce demand for increasingly autonomous vehicles because the cost of owning a car includes the cost of liability insurance, which would decrease if cars were safer and the remaining liability costs shift from automobile owners to sellers. As a result, a shift to increased use of products liability schemes and decreased use of automobile driver liability schemes may have little effect on incentives for manufacturers to continue to pursue innovation in autonomous features.[269]

Some victims of automobile accidents could be worse off if there is an increase in the use of products liability as the basis for recovery. As indicated above, because products liability cases require experts and are expensive to bring, they are only brought where potential damages are high.[270] In contrast, automobile claims are relatively inexpensive because jurors can usually assess driving conduct without expert witnesses. Consequently, victims with lower-cost injuries are not likely to bring claims that might have previously been brought for a claim of negligent human driving of a less autonomous car. One result of this lack of fault-based claims is that the costs of lower cost personal injuries will be left on the victims, even if there is a defect in the vehicle. This distributional impact could exist even if, on the whole, the number of automobile accidents is reduced by autonomous drive features.

A no-fault scheme of automobile insurance might address this problem.[271] However, there are several problems with this approach. First, the states have traditionally regulated automobile insurance.[272] As a result, a national scheme is likely to face resistance. In addition, no-fault schemes require legislation, and there will likely be opposition to such proposals at both the state and federal levels, particularly from

268. *Id.* at 22.

269. Kalra et al. argues that this effect of liability shift might cause manufacturers to be reluctant to introduce technology that will increase their liability. *Id.* Yet no such reluctance appears to be developing at present. *See supra* note 164 and accompanying text.

270. *See supra* notes 87, 90–91 and accompanying text.

271. *See, e.g.*, KALRA ET AL., *supra* note 267, at 20 (suggesting that no-fault schemes may be more attractive if the shift occurs).

272. *See* Harvey Rosenfield, *Auto Insurance: Crisis and Reform*, 29 U. MEM. L. REV. 69, 72, 86–87 (1998) (discussing the origin and history of auto insurance regulation by the states, while noting some recent proposals for limited federal regulation). Rosenfield acknowledged the success of large auto insurers at avoiding federal preemption of state regulation of the industry. *Id.* at 124 & n.161.

plaintiffs' attorneys, who have an interest in continued use of the fault system.[273] Another problem is that manufacturers may oppose any scheme that follows the approach of current no-fault schemes, such as workers' compensation and no-fault automobile insurance, which generally allow products liability suits against manufacturers.[274] Finally, unless benefits are very low and administrative savings are very high, no-fault insurance may cost more than third-party liability insurance because coverage will include all accidental injuries caused by automobiles, regardless of whether negligent driving was involved.

B. *Fully Autonomous Sophisticated Robots—Eliminating the Human in the Loop*

At some point, large, mobile, sophisticated robots will be able to act in a fully autonomous manner and thus will not need a human to act in the control process. For example, automobiles in Level 4 of the NHTSA scheme will be able "to perform all safety-critical driving functions and monitor roadway conditions for an entire trip."[275] This category "includes both occupied and *unoccupied* vehicles."[276] The self-driving capability of such automobiles is one of the advantages often given for sophisticated robotic automobiles; these vehicles will probably be much safer and will provide transportation for people who cannot drive.[277] This capability would also make it possible to have driverless delivery vehicles, including perhaps aerial deliveries by Amazon.[278] Similarly,

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273. *See, e.g.*, THOMAS F. BURKE, LAWYERS, LAWSUITS, AND LEGAL RIGHTS 105–06 (2002) (discussing failure to adopt automobile no-fault schemes in California and the role of plaintiffs' attorneys in fighting no-fault).

274. *See, e.g.*, N.Y. INS. LAW § 5104(b) (McKinney 2013) (allowing suit against a "non-covered person," which is a category that would include product sellers); *supra* notes 107–09 and accompanying text (discussing right of workers covered by workers' compensation to sue manufacturers).

275. NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 5. For further discussion of categories under the NHTSA scheme, see *supra* text accompanying notes 182–83.

276. NHTSA, PRELIMINARY STATEMENT, *supra* note 181, at 5 (emphasis added).

277. *See, e.g.*, Gary E. Marchant & Rachel A. Lindor, *The Coming Collision Between Autonomous Vehicles and the Liability System*, 52 SANTA CLARA L. REV. 1321, 1330 (2012); Dana M. Mele, *The Quasi-Autonomous Car as an Assistive Device for Blind Drivers: Overcoming Liability and Regulatory Barriers*, 28 SYRACUSE J. SCI. & TECH. L. 26, 30 (2013).

278. *See* Alistair Barr, *Amazon Testing Delivery by Drone, CEO Bezos Says*, USA TODAY (Dec. 2, 2013, 1:32 PM), http://www.usatoday.com/story/tech/2013/12/01/amazon-bezos-drone-delivery/3799021/. The Amazon proposal will face considerable hurdles. *See, e.g.*, James Ball, *Amazon to Deliver by Drone? Don't Believe the Hype*, GUARDIAN (Dec. 2, 2013, 5:57 AM), http://www.theguardian.com/commentisfree/2013/dec/02/amazon-drone-delivery-jeff-bezos-hype; Greg McNeal, *What FAA Rules Will Amazon Need to Navigate Before a 30 Minute Delivery Drone Becomes Reality?*, FORBES (Dec. 2, 2013 1:09 AM), http://www.forbes.com/sites/gregorymcneal/2013/12/02/what-faa-rules-will-amazon-need-to-navigate-before-a-30-minute-delivery-drone-becomes-reality/.

there could be driverless general-purpose robots[279] that would perform tasks now done, for example, by security guards, maintenance workers, and human caretakers for elderly and disabled persons.

When large mobile robots become this diverse and sophisticated, the liability system might change in two ways.[280] First, the application of the current system could change in response to the difference in factual context. Second, courts may expand existing no-fault doctrines to include highly sophisticated robots.

1. Traditional Doctrine—Changes in Application

Where the tort system continues to use traditional fault approaches to address the control, use, and service of robots, the application of concepts like reasonable care will change where increasingly sophisticated robots are involved because the legal system measures the level of skill reasonably required by the nature of the activity undertaken. For example, persons who drive an automobile on the highway or drive a large bulldozer for a construction project would be negligent if they failed to perform at the level of a reasonably skilled operator.[281] Similarly, in order to satisfy the standard of reasonable care, users of driverless cars would need to use the skills necessary to operate the car reasonably, by, for example, knowing when the driving system was malfunctioning and, to some extent, how to respond to the malfunction. Under this standard, those responsible for maintenance and control of use would need to be able to use reasonable care in maintenance and control. As indicated above, the skills required to use, maintain, and control driverless cars may also affect licensing schemes.[282]

Reasonable use of a sophisticated, general-purpose robot may also require considerable skill—for example, in giving the robot orders or knowing when it has misunderstood an order or is malfunctioning. The person controlling a sophisticated general-purpose robot would be expected to have reasonable knowledge of its characteristics and to use reasonable care to prevent harm to others. This approach is consistent with the requirement that doctors who use a da Vinci Surgical System

279. See *supra* notes 217–18 and accompanying text for a discussion of general-purpose robots.

280. Areas related to torts—for example, automobile insurance—may also be affected. *See, e.g.*, Robert W. Peterson, *New Technology—Old Law: Autonomous Vehicles and California's Insurance Framework*, 52 SANTA CLARA L. REV. 1341, 1358–59 (2012) (discussing problems with a court adopting the approach of treating driverless car as a "permissive user" of the car).

281. *See supra* notes 8, 96, 100 and accompanying text.

282. *See supra* notes 188–201.

must use it with the requisite skill.[283]

If special skill is required for maintaining a sophisticated type of robot, a person claiming the ability to perform such maintenance could be held to the standard of a reasonably skilled sophisticated robot maintenance "expert."[284] As a result, expert testimony might be required to show negligence and causation.[285] Claims of improper maintenance would also be affected by governmental adoption of regulatory standards for persons who maintain sophisticated robots.[286] If such regulations are adopted, evidence of compliance or non-compliance with regulations would be admissible to show negligence.[287]

2. Possible Doctrinal Expansions

Expansions of some doctrines have been proposed to address sophisticated robots. For example, some authors have suggested that sophisticated robots may have such high levels of learning and autonomy that they could be treated as employees under the respondeat superior doctrine (which imposes vicarious non-fault liability on employers),[288] as children,[289] or as animals (which could also result in non-fault liability of owners or users).[290] Another proposal is to impose non-fault liability by treating the use of these robots in some settings as

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283. *See, e.g.*, Mohler v. St. Luke's Med. Ctr., LP, No. 1 CA-CV 08-0078, 2008 WL 5384214, at *2–3 (Ariz. Ct. App. Dec. 26, 2008) (finding that issue of proper credentialing of surgeon to use robot existed and reversing summary judgment for the hospital with control of the system). See *supra* notes 165–79 and accompanying text for discussion of da Vinci Surgical Systems.

284. *See, e.g.*, D.C. Hous. Auth. v. Pinkney, 970 A.2d 854, 864–65 (D.C. 2009) (discussing expert testimony for standard of care for elevator maintenance). For more examples of tort litigation involving automatic elevators and escalators, see *supra* notes 111, 147, and accompanying text.

285. *See, e.g.*, *Pinkney*, 970 A.2d at 864–65. For a discussion of the role of expert testimony in products liability suits, see *supra* note 93.

286. *See, e.g.*, *Pinkney*, 970 A.2d at 864–65 (discussing industry standard for automatic-elevator maintenance). For a comparison of non-government and government standards, see *supra* notes 126–46 and accompanying text.

287. *See, e.g.*, *Pinkney*, 970 A.2d at 864; *see also supra* notes 144–46 and accompanying text.

288. SAMIR CHOPRA & LAURENCE F. WHITE, A LEGAL THEORY FOR AUTONOMOUS ARTIFICIAL AGENTS 128–30 (2011). *See supra* note 45 and *infra* notes 292–93 for discussion of vicarious liability of employers for torts by their employees.

289. CHOPRA & WHITE, *supra* note 288, at 120.

290. *Id.* at 130–31; *see also, e.g.*, Sophia H. Duffy & Jamie Patrick Hopkins, *Sit, Stay, Drive: The Future of Autonomous Car Liability*, 16 SMU SCI. & TECH. L. REV. 453, 471–73 (2013) (arguing for a strict liability scheme like that with animals with abnormally dangerous tendencies); Richard Kelley et al., *Liability in Robotics: An International Perspective on Robots as Animals*, 24 ADVANCED ROBOTICS 1861, 1863–64 (2010) (arguing for a negligence standard by comparison to owners of generally predictable domesticated animals).

an "abnormally dangerous activity."[291] Such doctrinal expansions could affect innovation because, to the extent that owners and users view any increased liability costs as an additional cost of having large, mobile, sophisticated robots, demand for these robots is likely to be reduced.

Respondeat superior. Literally translated, the Latin phrase "respondeat superior" means "let the superior make answer."[292] Roughly translated, the phrase can be viewed as a Latin equivalent of "Let's speak to the boss; he is the one who is responsible because his employees are just the hired help." This rough translation captures the rule's effect: An employer is liable in tort for the injuries committed by his employee within the scope of the employee's employment, even if the employer used reasonable care in hiring, training, and supervising the employee.

Though multiple policy grounds have been given to justify the doctrine, it is based in large part on the view that fairness requires that the employer, who benefits from being able to control a human employee's conduct in the pursuit of the employer's business, be held liable for the torts committed by the employee.[293] From a more practical point of view, artificial persons like corporations can only act through human employees and, thus, can only be liable vicariously.

Policy reasons like these are based on the unique nature of human employees—i.e., the benefit of a human to do your business and the unique ability of humans to act as responsible agents for an artificial person. Thus, their application to a robot is questionable, unless the robot's capacities approach those that humans possess, particularly the ability to engage in complex, intellectual interaction as a self-conscious member of a community.[294] If a sophisticated robot does not possess these characteristics, the argument that respondeat superior should apply loses considerable force. On the other hand, if the robot did possess these characteristics (which appears unlikely in the near future), then the doctrine might apply. However, the legal system would also have to

291. CHOPRA & WHITE, *supra* note 288, at 131–32; KALRA ET AL., *supra* note 267, at 21 (discussing possibility of treating sophisticated vehicles as "ultrahazardous").

292. BLACK'S LAW DICTIONARY 1426 (9th ed. 2009); *see, e.g.*, PROSSER, *supra* note 53, § 69, at 459.

293. *See, e.g.*, DOBBS, *supra* note 22, § 334, at 908; HUBBARD & FELIX, *supra* note 56, at 725–28.

294. *See* Kenneth Einar Himma, *Artificial Agency, Consciousness, and the Criteria for Moral Agency: What Properties Must an Artificial Agent Have to be a Moral Agent?*, 11 ETHICS & INFO. TECH. 19, 24–28 (2009) (arguing that consciousness is required to be an agent responsible for its actions); Hubbard, *supra* note 6, at 419–33, 441–50 (discussing a test of capacity for personhood and applying that test to machines). *See generally* CHOPRA & WHITE, *supra* note 288, at 153–91 (discussing legal personhood for "artificial agents").

decide whether a robot with these characteristics could be owned.[295] If the answer to this question is "no," then a robot with self-ownership should also be liable in tort in the same way that an employee is liable for his torts regardless of whether the employer is vicariously liable under respondeat superior.[296]

Children. Parents must use reasonable care in supervising their children and in warning others concerning risks from their children.[297] As a general rule, parents are not vicariously liable for torts of their children.[298] However, statutes occasionally impose limited vicarious liability on parents for intentional torts committed by their children.[299] Thus, if a robot is viewed as a child, reasonable care in terms of use is likely to be the standard in most instances.

Animals. Because the intellectual capacity of sophisticated general-purpose robots will likely be less than that of humans, animals might be a better analogy for non-fault liability than respondeat superior.[300] However, it is not clear what the effect would be.

A person controlling an animal has a duty of reasonable care to supervise the animal.[301] Generally, there is no strict liability for harm from the animal unless: (1) the animal (other than a dog or cat) causes physical harm by trespassing on the land of another; (2) the animal is wild; or (3) the person knows or should have known that the animal has dangerous tendencies abnormal for the animal's category.[302]

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295. *See* Hubbard, *supra* note 6, at 428–33, 441–55 (arguing for consideration of personhood in terms of self-ownership for highly intelligent, self-conscious machines).

296. *See id.* at 423–24 (arguing that an entity with self-ownership is required to recognize responsibility for violations of the rights of others). For a discussion of individual liability of the negligent employee, see, for example, HUBBARD & FELIX, *supra* note 56, at 722–23.

297. *See* RESTATEMENT (SECOND) OF TORTS § 316, at 123–24 (1965).

298. DOBBS, *supra* note 22, § 340, at 935. Though vicarious liability was imposed at one time on the basis of the "family purpose doctrine," the doctrine is now abolished or narrowly applied in most states. *See id.*

299. *See, e.g.*, S.C. CODE ANN. § 63-5-60 (West 2013) (imposing vicarious liability on parents for up to $5,000 for malicious injuries their children cause).

300. *See, e.g.*, CHOPRA & WHITE, *supra* note 288, at 130–31 (describing how strict liability laws pertaining to keepers of dangerous animals can be similarly applied to artificial agents who lack autonomy). *See generally* Kelley et al., *supra* note 290, at 1862–63 (discussing treating robots as animals in an international context based on varying laws involving animals throughout Europe and Asia).

301. *See* DOBBS, *supra* note 22, § 344, at 945–46.

302. RESTATEMENT (THIRD) OF TORTS: LIAB. FOR PHYSICAL AND EMOTIONAL HARM § 21, at 274 (2010) (discussing strict liability for trespassing animals); *id.* § 22, at 293 (discussing strict liability for wild animals); *id.* § 23, at 303 (discussing strict liability for abnormally dangerous animals); *see id.* §§ 24–25, at 325, 335–36 (discussing the scope of liability for an animal owner who causes another person physical or emotional harm and the ability of animal owners to defend themselves by arguing the injured party was contributorily negligent); *id.* § 29, at 493 (providing that an "actor's liability is limited to those harms that result from the risks that made the actor's conduct tortious").

Where the duty for controlling animals is reasonable care, the same duty would apply to controlling machines.[303] It is difficult, if not impossible, to apply any of the three strict liability exceptions to a very sophisticated general-purpose robot without knowing more about the characteristics the robot is likely to have. For example, one needs to know whether it has a tendency to trespass and whether it is sufficiently dangerous and unpredictable to be viewed as wild or abnormally dangerous for its category.

Abnormally Dangerous Activities. As indicated above, though the law imposes strict liability on a person engaged in an abnormally dangerous activity for injuries caused by that activity, it is hard to know whether a particular sophisticated robot or use the of such a robot is abnormally dangerous.[304] However, because one factor in the determination of abnormally dangerous is whether the activity "is not one of common usage,"[305] the more common and less experimental the robot or its use is, the less likely it is that using it will be determined to be an abnormally dangerous activity.

IV. PROPOSALS FOR FUNDAMENTAL CHANGE

Liability law is designed to achieve an efficient balance between the concern for physical safety and the desire for innovation.[306] As a result, the basic tests for design defects and for instruction and warning defects have two distributional effects: (1) Sellers are liable for injuries caused by a failure to use a safer approach that costs less than the injuries it prevented; and (2) victims are not compensated for injuries where a safer approach costs more than the accidents that would have been prevented by the approach.[307]

There are two types of proposals to replace this balancing approach and alter its distributional effects. The first approach focuses on the concern for victims and proposes no-fault schemes that will spread the cost incurred. To the extent that these spreading schemes impose additional injury costs on sellers, they increase the cost of innovation and thus risk an inefficient reduction of incentives for innovation. The second approach emphasizes the need for innovation and proposes ways to reduce the impact of liability costs on sellers. To the extent that these proposals shift costs in this way, they risk inefficiently low levels of liability and could, in effect, subsidize innovation by forcing some

303. See *supra* Subsection II.A.2.c. for a general discussion of this standard and *supra* notes 282–84 and accompanying text for a discussion of the skill required to control fully autonomous, sophisticated robotic machines.

304. *See supra* notes 118–20 and accompanying text.

305. *See supra* note 118 and accompanying text.

306. *See supra* notes 43, 54–56, 59–61, 249 and accompanying text.

307. *See supra* notes 54–56 and accompanying text.

victims to bear the costs of this inefficiency.

Both types of proposals have two flaws. First, the persons proposing change simply assume, with little or no argument, that there is a problem that needs to be addressed in a particular way. For example, compensation-oriented proposals in the first approach assume that the liability system can and should be used to insure accident costs from sophisticated robots by imposing these costs on manufacturers, who can spread the injury costs by making them a part of the price of the robot. Proposals in the second approach to limit liability either assume the current system of products liability unduly hinders innovation,[308] or rely on criticisms expressed in conclusory terms and supported by extreme examples of litigation and by anecdotal complaints about uncertainty and fear of excessive liability.[309] Second, supporters of both proposals either: (1) do not develop the alternative proposal in enough detail to determine whether and to what extent the "proper" balance between safety and innovation will be achieved; or (2) totally abandon any need for balance.

A. *Compensating Victims*

1. No-Fault First Party Insurance Schemes

Two approaches could be used to compensate victims of injuries "caused" by the "activities" of distributing andusing sophisticated robotic automobiles. First, no-fault first party automobile insurance schemes could be adopted.[310] The problems with getting these schemes adopted are addressed above.[311] Second, a no-fault insurance-type scheme could be adopted by imposing on automobile distributors the costs of establishing a fund to pay for injuries caused by automobiles.[312] In exchange for establishing this fund, distributors would be immune

308. For example, Marchant and Lindor seem to regard any litigation or liability for "malfunction" as unduly hindering innovation. *See* Marchant & Lindor, *supra* note 277, at 1328–29, 1337. Apparently, their view is that, if a product has a "net safety benefit," there should be no liability even if it would be cost-effective to make the product safer. *See id.* at 1331.

309. *See id.* at 1325–26 (relying on extreme examples and anecdotes involving malfunctioning autonomous vehicles, cruise control, and autopilot for airplanes); WU, *supra* note 42, at 1, 3–5 (discussing extreme and occasionally misleading examples and anecdotes involving fictional robots that arrest individuals before they commit a crime, a plaintiff awarded $125 million in punitive damages from an accident involving a Ford Pinto, and a plaintiff awarded over $250 million after a prescription drug killed her husband).

310. *See supra* note 271 and accompanying text.

311. *See supra* notes 271–74 and accompanying text.

312. *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, 459–62 (proposing that a no-fault scheme like that used for children's vaccines could be used for autonomous cars).

from tort liability.[313]

Implementing this approach requires answers to a wide range of questions that have not been sufficiently addressed by supporters of no-fault schemes. Because the proposed no-fault schemes will be funded as part of the cost of the activity of manufacturing or distributing automobiles, the proposals must not only identify the activity but must also identify the costs associated with that activity. For example, workers' compensation insurance covers the activity of employment and the injuries incurred while working.[314] Other focused schemes operate in a similar fashion.[315] Would all injuries caused by the activity of manufacturing or of distributing automobiles be covered by the scheme, including not only those involving some possible "defect" but also those involving such things as: (1) human error in driving or in maintenance; (2) bad weather; and (3) situations where the autonomous system was somehow involved but not defective? The scheme would also have to address issues like the following: (1) the nature and level of benefits; (2) the types of injuries covered (for example, would noneconomic damages like pain and suffering be included?); (3) the persons covered (would relationship interests like loss of consortium be covered?); (4) coordination with other benefit schemes like workers' compensation and social security; and (5) administration. Because the proposals fail to address these issues, they are so incomplete that they cannot be evaluated and thus should not be implemented.

2. No-Fault Third Party Liability Schemes

Some authors have proposed that manufacturers be "strictly liable" for personal injuries caused by driverless automobiles.[316] This proposal is based on the concern that, where an automobile is fully autonomous (driverless), "assignment of liability is more complicated"[317] and

313. *Id.*

314. *See* 1-2 LARSON & LARSON, *supra* note 106 (discussing "arising out of and in the course of employment" as test for coverage); *supra* notes 106–09 and accompanying text.

315. *See, e.g.*, Duke Power Co. v. Carolina Envtl. Study Grp., Inc., 438 U.S. 59, 64–65, 85 (1978) (discussing the Price Anderson Act, 42 U.S.C. § 2210, which adopted an insurance scheme up to $560 million and imposed a limitation on liability of that amount for nuclear accidents at power plants. In the event the losses exceeded that amount, it was contemplated that "Congress would likely enact extraordinary relief provisions to provide additional relief". Robert L. Rabin, *The Renaissance of Accident Law Plans Revisited*, 64 MD. L. REV. 699, 703–08 (2005) (discussing no-fault compensation schemes for black lung disease and childhood vaccines).

316. *See, e.g.*, Jeffrey K. Gurney, *Sue My Car Not Me: Products Liability and Accidents Involving Autonomous Vehicles*, 2013 U. ILL. J.L. TECH & POL'Y 247, 271–72 (proposing to impose "strict liability" for accidents on manufacturers of autonomous technology for injury caused by fully autonomous (driverless) cars).

317. *Id.* at 274.

"current products liability law will not be able to adequately assess . . . fault . . . .[because] current law is too cost-prohibitive"[318] insofar as expert witnesses are likely to be required by the plaintiff.[319] While products liability suits will eliminate some suits for careless driving that could be brought today,[320] this fact alone does not indicate these suits are "*too* cost-prohibitive." Since its inception, fault-based tort law has always had the effect that plaintiffs "lose" if the litigation costs are too high to justify litigation. More is needed to demonstrate that a speculative new technology will involve litigation costs that are *too* prohibitive.

In addition, a "strict liability" proposal will need to provide a new test for defective design, warnings, and instructions to replace the current cost–benefit approach. Section 402A of the *Restatement (Second) of Torts*, which was adopted in 1964, imposed strict liability for injuries caused by "any product in a defective condition unreasonably dangerous to the user or consumer." However, even though a corrective system like tort needs a definition of wrong, no clear definition or test of "defective condition unreasonably dangerous" was provided.[321] Moreover, the reasons given for adopting strict liability were questionable, and, "as the initial flush of excitement over the new strict liability doctrine subsided, commentators increasingly questioned the wisdom and logic of the doctrine's rationales."[322] As a result of the experience gained from applying an extraordinarily vague test based on questionable rationales, the *Restatement of Torts: Products Liability* followed the approach generally adopted by the courts in the decades following the adoption of Section 402A. The *Restatement* adopted a more detailed and precise scheme that relies primarily on the cost–benefit approach to design and to warnings and instructions to identify wrongs discussed above.[323]

In order to avoid the problems resulting from Section 402A, any proposal to impose no-fault liability for accidents caused by fully autonomous cars needs to provide a test for determining which accident costs will be imposed on sellers. "All" driverless automobile accidents would impose such a high level of actual or potential liability that innovation is likely to be severely hindered, particularly in an

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318. *Id.* at 273.

319. *Id.* at 265.

320. *See supra* notes 266–70 and accompanying text.

321. *See* Hubbard, *supra* note 63, at 597 (seeking to define an unreasonably dangerous product defect by focusing on two potential tests, one of which involves section 402A).

322. OWEN, *supra* note 44, § 5.4, at 296. For a useful review of the evolution of products liability following the adoption of section 402A, see, for example, Owen, *supra* note 63, at 23–25. For a short critique of judicial adoption of cost-spreading tort schemes designed to serve the goal of compensation rather than corrective justice, see Hubbard, *supra* note 19, at 448–52.

323. *See supra* Subsection II.A.2.b.i.

environment where many cars are still driven by humans. Like any no-fault insurance scheme, a no-fault insurance-like liability scheme must address coverage issues, including, for example, which accidents are covered.[324] Vague references to "comparative fault" (as a way to address, for example, the specific "circumstances of the driver [passenger in charge]") do not address this problem.[325] Simply referring to the manufacturer's ability to spread the cost[326] ignores these tasks as well as the reasons for abandoning cost-spreading as a basis for products liability.[327]

Concern for victims is important. However, if a no-fault spreading scheme is desired, it is much better to use a first-party scheme like no-fault automobile insurance, which does not require a test of wrongdoing and is cheaper to administer than a third party liability system. It may be difficult to adopt such a first party scheme.[328] Nevertheless, distorting the corrective justice scheme of tort law by converting it to an open-ended third party insurance-like spreading system would be a giant step backward to the world created by the flaws in Section 402A of the Second Restatement.

B. *Fostering Innovation: "Subsidies" by Reducing Liability*

Proposals to reduce liability rely on the following two-part argument: (1) sophisticated robots like autonomous vehicles are desirable because they will increase safety and convenience; and (2) liability costs should, therefore, be reduced in order to foster innovation of such desirable products. The second part of the argument simply ignores the need to balance innovation with injury costs in a way that incentivizes safety improvements. In addition, proposals for reducing liability either fail to address the question of whether the current system achieves a proper balance or rely on conclusory criticisms supported by extreme examples and anecdotes.[329]

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324. *See supra* notes 314–15 and accompanying text.

325. *See* Gurney, *supra* note 316, at 276.

326. *Id.* at 272.

327. *See* OWEN, *supra* note 44, § 5.4, at 295–96; Hubbard, *supra* note 19, at 448–52 (questioning compensation as a goal of tort law and the legitimacy of judicially imposed spreading schemes).

328. *See supra* notes 271–74 and accompanying text.

329. *See, e.g.*, *supra* notes 308–09 and accompanying text. This approach is very different from the discussion in this Article showing that technological innovation has not been unduly hindered by litigation and tort liability. *See, e.g.*, *supra* Subsection II.A.2.e (discussing the growth of technology from elevators and escalators to the da Vinci surgical robot that faced and survived tort litigation); *cf.* Section II.B (detailing the growing technological sophistication, automation, and regulation of vehicles, aircraft, and robots).

1. Immunity

Because of the transformative benefits of sophisticated robots, the legal system might foster innovation (or a particular approach to innovation) in robot development by adopting immunity for sellers of these robots from liability under the current fault-based system.[330] Such immunity for a wrongdoer from liability could be total or partial. Partial immunities take two forms. One approach is to limit the amount of damages to compensate for injury caused by a wrong.[331] The other approach limits the types of wrongs that would result in liability. For example, "Good Samaritan" statutes partially immunize people for voluntarily helping others by prohibiting suits for negligence in providing assistance, but imposing liability for more egregious conduct like, for example, gross negligence.[332] There are several objections to limiting the liability system in this way as a means to foster innovation in robot development.

First, eliminating liability for sellers is not likely to foster innovation unless the costs of owning robots, including the owners' costs and liability costs from defective robots, are also limited. Otherwise, buyers will view their additional costs (or their additional insurance costs) resulting from product defects as part of the cost of owning a robot. As a result, demand will drop. If both buyers and sellers are immune, a substantial fairness issue arises: Why should victims of defective robots be forced to bear the costs of injuries from the defects rather than the sellers and owners, who are enjoying the benefits of improved robots?

Second, immunity schemes that grant total (or almost total) immunity generally have two features: (1) the activity immunized is subject to regulation designed to address safety; and (2) victims are provided at least a partial alternative to the compensation for wrongful injury that would have resulted if there were no immunity.[333] Immunity proposals for sellers of sophisticated robots generally fail to address the need for these features.[334]

330. *See* M. Ryan Calo, *Open Robotics*, 70 MD. L. REV. 571, 576, 601–04, 609–10 (2011) (proposing a scheme to immunize manufacturers of "open robotic platforms" from tort liability and to, perhaps, require robot owners to carry liability insurance); Marchant & Lindor, *supra* note 277, at 1337–38 (proposing immunity for manufacturers of sophisticated motor vehicles).

331. Such a limit or "cap" would be similar to "tort reform" proposals to limit liability for medical malpractice in order to reduce the costs of healthcare and thus provide greater access to care. *See, e.g.*, Hubbard, *supra* note 19, at 476, 493–94.

332. *See, e.g.*, S.C. CODE ANN § 15-1-310 (West 2013); DOBBS, *supra* note 22, § 252, at 663 (describing the adoption of Good Samaritan statutes throughout the United States to reduce or eliminate liability for individuals helping out in emergency situations); *see also id.* § 283, at 765 (describing charitable immunity for nonprofit corporations and individual volunteers).

333. *See supra* notes 314–15 and accompanying text (discussing no-fault insurance schemes).

334. *See, e.g.*, Marchant & Lindor, *supra* note 277, at 1337–38.

Finally, any immunity scheme, as well as any compulsory insurance scheme, would require legislation that would be hard to achieve because it would be subject to both policy objections and political resistance. Economic competitors would object that immunizing manufacturers of sophisticated robots (or of a particular type of sophisticated robot) provides an unfair advantage. Moreover, to the extent that sophisticated robots can replace workers, unions might object. In addition, if only a particular approach to development of these robots is favored, those pursuing other alternatives would be disadvantaged, thus potentially stifling innovation the immunity is meant to promote. Finally, consumer advocate groups (and perhaps plaintiffs' attorneys) would object on behalf of owners and victims.[335]

2. Preemption

Preemption can take two forms. First, a state legislature can preempt a field and thus deny courts the power of using common law tort as a way of addressing liability for particular conduct within that field. Second, Congress can preempt the field and thus prevent states, whether acting through the state legislature or through the state courts as they apply common law, from addressing a field. Given the national nature of the market for automobiles, the second form of preemption has been urged for robotic automobiles.[336] However, as indicated above, these proposals fail to address whether the current system properly balances innovation and liability. Thus, the need for this preemption is not adequately addressed.

Moreover, in practice, preemption can become very complicated and therefore very uncertain. For example, there has been considerable litigation over the issue of which Federal Motor Vehicle Safety Standards (FMVSS) are preemptive. In one case, the Supreme Court held that a version of the FMVSS for air bags preempted state tort law;[337] a later case held that the FMVSS giving manufacturers a choice of lap belts or lap and shoulder belts on inner rear seats did not preempt state claims.[338]

Uncertainty of this nature could be addressed by more explicit statutory language preempting all state tort claims for defects addressed by regulatory standards that apply to robotic automobiles. However, explicit language establishing such a broad preemptive effect would

335. *See, e.g.*, Hubbard, *supra* note 19, at 480–83 (discussing opposition to "tort reform" proposals to limit liability to victims).

336. *See, e.g.*, Marchant & Lindor, *supra* note 277, at 1338–39 (discussing federal preemption of state tort law through the Federal Motor Vehicle Safety Standard (FMVSS)).

337. Geier v. Am. Honda Motor Co., 529 U.S. 861, 866 (2000).

338. Williamson v. Mazda Motor of Am., Inc., 131 S. Ct. 1131, 1134 (2011). The FMVSS involved in *Williamson* and in *Geier* was "promulgated pursuant to the National Traffic and Motor Vehicle Safety Act of 1966." *Id.*

probably face tremendous political opposition in Congress. Part of this opposition would be motivated by a concern for "agency capture" by the regulated industry.[339] This concern results from the asymmetry in power between the industry—focused, well-funded repeat players in the regulatory process[340]—and consumer interests represented by loose ad hoc coalitions that are primarily composed of poorly funded nonprofits.

CONCLUSION

The legal schemes for regulating the development and use of robots and for allocating the costs of injuries from robots have successfully balanced innovation and safety in a fair, efficient manner for decades.[341] This is not surprising; they are designed to achieve such a balance. Where sophisticated robots are involved, many have expressed concerns about the ability of the legal system to achieve this balance and argue that too many victims will not be compensated or that innovation will be hindered. Relying on these arguments, they urge fundamental changes in the current system. These criticisms and proposals, in effect, abandon the concern for balance and focus on either the concern for compensation or for innovation. As a result, they show little concern for the other side of the balance. In addition, these critics often rely on unreasonable expectations for tort law. For example, those concerned with compensation for victims fail to appreciate the limits on the ability of a corrective-justice liability scheme to serve as an insurance type compensation mechanism. Criticisms of the effects of the tort system on innovation tend to ignore the need for balance or the need to develop a substantive critique of the ability of the current system to achieve a proper balance. As a result, critics of the impact of regulatory and liability systems fail to consider innovation that has occurred in the past and the current widespread rapid developments in robotics, both of which suggest a lack of undue impact on innovation. Such criticisms are not sufficient to justify abandoning a system that has provided, and will continue to provide, a fair and efficient balance of innovation and safety in robotic machines.

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339. *See, e.g.*, Hubbard, *supra* note 19, at 455–56 (comparing institutional characteristics of courts and administrative agencies and discussing agency "capture").

340. *See id.* at 455.

341. *See, e.g.*, *supra* Subsection II.A.2.e, Section II.B. *See generally* Kyle Graham, *Of Frightened Horses and Autonomous Vehicles: Tort Law and Its Assimilation of Innovations*, 52 SANTA CLARA L. REV. 1241 (2012) (reviewing experience of tort system's handling of new technology, indicating some optimism about the ability of the system to handle autonomous cars, and expressing uncertainty about any predictions); Andrew P. Garza, Note, *"Look Ma, No Hands!": Wrinkles and Wrecks in the Age of Autonomous Vehicles*, 46 NEW ENG. L. REV. 581 (2012) (discussing the development of safety devices for vehicles such as seat belts and segueing into details about Google's autonomous car, its implementation, and manufacturer and liability concerns related to these innovations).