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# THE ROAD TO THE FUTURE: A REGULATORY REGIME FOR THE RISE OF THE ROBOT CARS

DANIEL SPENCER\*

## INTRODUCTION

An Apple iCar™, a Tesla X, and a Google Waymo all meet up at a three-way intersection. Who has the right of way? Is the concept of a “right of way” even applicable when each car has already wirelessly transmitted its intended route and collectively planned for this intersection five miles ago?<sup>1</sup>

As autonomous vehicles slowly revolutionize America’s roadways, the underlying expectations and regulations must change also.<sup>2</sup> To date, these changes have been largely uncoordinated and inconsistent across the states.<sup>3</sup> Purportedly to remedy this inconsistency, the U.S. Department of Transportation (“USDOT”) has appointed numerous task forces within the Federal Highway Administration, the National Highway Traffic Safety Administration (“NHTSA”), the Federal Transit Administration, and elsewhere, but has yet to issue binding requirements.<sup>4</sup> The closest the USDOT has come to doing so is its September 12, 2017 publication *Automated Driving Systems: A Vision for Safety* suggesting industry best practices

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<sup>1</sup> See Andrew Ng & Yuanqing Lin, *Self-Driving Cars Won't Work Until We Change Our Roads—And Attitudes*, WIRED MAGAZINE (Mar. 15, 2016) (“[W]e should not expect computers to drive in the same way as humans.”).

<sup>2</sup> See *id.* (comparing the development of social expectations during the emergence of the railroad to social expectations during the emergence of autonomous vehicles).

<sup>3</sup> See NAT'L CONF. OF STATE LEGIS., *Autonomous Self-Driving Vehicles Legislation* (Nov. 11, 2016), <http://www.ncsl.org/research/transportation/autonomous-vehicles-legislation.aspx> [<https://perma.cc/YD2X-4CS3>] (comparing the states’ differing approaches to autonomous vehicle legislation).

<sup>4</sup> See Carl Andersen, *USDOT Activities in Automation, SIS49: National Road Authorities Strategies to Support the Development towards Automation*, 22ND ITS WORLD CONFERENCE (2015), [http://www.its.dot.gov/presentations/world\\_congress2015/wc2015\\_Automation.pdf](http://www.its.dot.gov/presentations/world_congress2015/wc2015_Automation.pdf) [<https://perma.cc/VQK9-GDJM>] (explaining the DOT Intelligent Transportation Systems Joint Program Office role in integrating efforts across numerous agencies and departments).

and recommending model legislation.<sup>5</sup> However, this effort falls far short of creating binding standards as NHTSA has done in other areas.<sup>6</sup> Absent binding government regulation, competing and contradicting state standards stifle innovation.<sup>7</sup> In collaboration with the automotive industry, the USDOT should standardize a binding vehicle communication protocol and promulgate a federally standardized autonomous vehicle code that is tied to state highway funding.

This Note will begin by assessing the harms and benefits of autonomous vehicle proliferation to identify the tradeoffs between negative externalities and social utility.<sup>8</sup> Where these tradeoffs are large, regulation becomes particularly appropriate.<sup>9</sup> After identifying potential problem areas, this Note will then examine potential regulatory responses to those problem areas under three alternative models of regulation: industry-driven, government-driven, or a hybrid model.<sup>10</sup> Throughout, the emergent technology of vehicle-to-infrastructure (“V2I”) and vehicle-to-vehicle (“V2V”) communication protocols will serve as exemplar technologies illustrating the harms of failing to pre-emptively consider this emergent industry’s regulatory needs. Ultimately, a case will be made for a comprehensive federal regulatory regime inspired by industry leaders and enforced uniformly by the states.

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<sup>5</sup> See generally *Automated Driving Systems: A Vision for Safety*, NHTSA (2017), [https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0\\_090617\\_v9a\\_tag.pdf](https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf) [<https://perma.cc/8LQ6-RLNZ>] (characterizing the publication as “Voluntary Guidance” intended to promote the use of “best practices”).

<sup>6</sup> Compare *id.* and 49 C.F.R. §§ 563.1, 563.6 (2006) (requiring data recorders in all vehicles, mandating commercial availability of data recording tools, and allowing for almost no exceptions).

<sup>7</sup> This is demonstrably true for the healthcare and construction industries. See, e.g., David M. Gann et al., *Do Regulations Encourage Innovation?—the Case of Energy Efficiency in Housing*, BLDG. RES. AND INFO., 284, 293–94 (Oct. 2010) (comparing “prescriptive” and “performance-based” regulation and advocating for the latter due to its enhanced “information sharing and co-operation” amongst regulators); see also Lesley H. Curtis & Kevin A. Schulman, *Overregulation of Health Care: Musings on Disruptive Innovation Theory*, 69 L. AND CONTEMP. PROBS. 195, 196 (2006) (“Rules designed to protect consumers may have the unintended consequence of preventing good-quality, lower-cost alternatives from reaching the marketplace.”).

<sup>8</sup> See R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 2 (1960) (establishing a general framework for analyzing risk-utility tradeoffs in emergent markets, using the telecom industry as an example).

<sup>9</sup> *Id.* (claiming that regulatory intervention requires analyzing social utility vs. risk “in total and at the margin”).

<sup>10</sup> INTELLIGENT TRANSP. SYS. JOINT PROGRAM OFFICE & U.S. DEP’T OF TRANSP. RESEARCH AND INNOVATIVE TECH. ADMIN., CONNECTED VEHICLE ENVIRONMENT: GOVERNANCE ROUNDTABLE PROCEEDINGS FROM JUNE 20, 2011, 196–204 [hereinafter INTELLIGENT TRANSP. SYS.] (identifying the three potential governance models).

## I. THE GENERAL SOCIAL IMPORTANCE OF REGULATING AUTONOMOUS VEHICLES

Whoever owns the means of production at the time an innovation occurs usually captures the majority of the benefits created by that innovation.<sup>11</sup> For instance, factory owners rather than factory workers profited from proliferation of industrial robots throughout the 1990s.<sup>12</sup> Looking deeper into history, print shops profited from the printing press to the detriment of their now-obsolete typesetters.<sup>13</sup> In the future, transportation and shipping companies will capture the benefits of autonomous vehicles at the expense of drivers' obsolescence.<sup>14</sup> When autonomous vehicles increase wage inequality and unemployment without a countervailing benefit, they operate to the detriment of now-obsolete drivers.<sup>15</sup> Regulations on the use of autonomous vehicles will determine a new allocation of benefits between the truck owner, the now-unemployed driver, and the truck manufacturer. The decisions (or indecision) of our regulators will permanently change the contours of the transportation industry by re-apportioning its fruits amongst the industry's participants.

Such benefit-shifting applies to the consumer use of autonomous vehicles as well. Driverless cars do not benefit the consumer transportation industry if the law forces them to operate within the same regulatory environment and the same set of societal expectations as human-piloted

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<sup>11</sup> See, e.g., Sebastian Moffett, *Technology Widens the Gap Between Rich and Poor*, WALL ST J. (May 4, 2011), <https://www.wsj.com/articles/SB10001424052748703922804576301154008155570> [[https://web.archive.org/web/\\*/](https://web.archive.org/web/*/)<https://www.wsj.com/articles/SB10001424052748703922804576301154008155570>] (relying on an OECD report to identify technological progress as a contributing factor in growing wage inequality).

<sup>12</sup> See DR. MICHAEL J. HICKS & SRIKANT DEVARAJ, THE MYTH AND THE REALITY OF MANUFACTURING IN AMERICA AT TABLE 4, BALL STATE UNIVERSITY CENTER FOR BUSINESS AND ECONOMIC RESEARCH DATA CENTER (2015), <http://projects.cberdata.org/reports/MfgReality.pdf> [<https://perma.cc/7R9P-GRLM>] (attributing 87% of manufacturing job loss to automation); see also Patrick Gillespie, *Rise of the machines: Fear robots, not China or Mexico*, CNN MONEY (Jan. 30, 2017), <http://money.cnn.com/2017/01/30/news/economy/jobs-china-mexico-automation/index.html> [<https://perma.cc/FWV4-3TRY>].

<sup>13</sup> See, e.g., Tom Scocca, *The first printed books came with a question: What do you do with these things?*, BOSTON GLOBE (Aug. 29, 2010), [http://archive.boston.com/bostonglobe/ideas/articles/2010/08/29/cover\\_story/](http://archive.boston.com/bostonglobe/ideas/articles/2010/08/29/cover_story/) [<https://perma.cc/B763-RA4A>] (examining the effect of the printing press on the emerging market for books).

<sup>14</sup> U.S. DEP'T OF LABOR, BUREAU OF LABOR STATISTICS, INDUSTRIES AT A GLANCE: TRUCK TRANSPORTATION, NAICS-484 (2016), <http://www.bls.gov/iag/tgs/iag484.htm> [<https://perma.cc/WVR3-CMSW>] (counting nearly 1.5 million Americans employed as full-time truck drivers, more than one percent of the U.S. labor force).

<sup>15</sup> Moffett, *supra* note 11.

cars.<sup>16</sup> For example, a driverless car is in fact *not a driverless car at all* if regulations require an attentive driver to have her hands on the wheel at all times.<sup>17</sup> In addition to this regulation, numerous other rules have crept in to sponge up the benefits of driverless cars and erode consumer demand, including heightened insurance requirements, use restrictions, special speed limits, and other unique requirements.<sup>18</sup> Indeed, it is in the best interest of both the insurance industry<sup>19</sup> and the petroleum industry<sup>20</sup> that driverless cars do not become mainstream, and if they do, that they gain popularity slowly and under strict regulation.<sup>21</sup> With the proper amount and type of regulation, driverless cars can completely re-define transportation as we know it today, or they can remain mired in regulatory red tape.

It is important that any regulation seek to enable safety and innovation, not stifle ingenuity to further the status quo for the benefit of those with a financial interest in “business as usual.”<sup>22</sup> At some point, compliance with special regulations so erodes the benefits of the innovation that the only remaining benefits accrue to special use cases,<sup>23</sup> or to the manufacturers of the vehicles, rather than to the end user.<sup>24</sup>

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<sup>16</sup> Ng & Lin, *supra* note 1.

<sup>17</sup> NAT'L CONF. OF STATE LEGIS., *supra* note 3 (conducting a fifty-state survey and finding that most states have “hands-on” requirements for autonomous vehicle drivers).

<sup>18</sup> *Id.* (identifying state-by-state use restrictions on autonomous vehicles).

<sup>19</sup> INS. INFO. INST., *Background On: Self-Driving Cars and Insurance* (July 1, 2016), <http://www.iii.org/issue-update/self-driving-cars-and-insurance> [<https://perma.cc/82WC-P339>] (explaining the uncertain future of the insurance industry pending the potential emergence of a no-fault compensation fund, and indicating potential market shrinkage due to the increased sharing of autonomous vehicles).

<sup>20</sup> *See, e.g.*, Maria Ramos, *How Driverless Cars Will Upend Energy Markets*, OIL PRICE (June 19, 2015), <http://oilprice.com/Energy/Energy-General/How-Driverless-Cars-Will-Upend-Energy-Markets.html> [<https://perma.cc/FP6F-NPNJ>] (“[T]hese driverless cars, when they do arrive, will change our relationship with fossil fuels forever.”).

<sup>21</sup> The growing regulatory restraints and political pressures threatening to suffocate development of autonomous vehicles unsurprisingly mirrors the near death of the electric car in the mid-1990s. *See* WHO KILLED THE ELECTRIC CAR? (Sony Pictures 2006) (blaming General Motors and oil companies for delaying the widespread acceptance of electric vehicles).

<sup>22</sup> Tim Hindle, *Barriers to entry, exit, and mobility*, THE ECONOMIST (June 13, 2009), <http://www.economist.com/node/14025576> [<https://perma.cc/BQ4Q-7YSC>] (cautioning that “[b]arriers to entry can also be erected by governments,” to gain a competitive advantage against prospective market entrants).

<sup>23</sup> *See id.*; *see also* Olivia Solon, *Self-driving trucks: what's the future for America's 3.5 million truckers?*, THE GUARDIAN (June 17, 2016), <https://www.theguardian.com/technology/2016/jun/17/self-driving-trucks-impact-on-drivers-us> [<https://perma.cc/9PYB-42ZX>] (such as taxis and trucking companies that can organize and lobby for commercial-use exemptions from driving restrictions).

<sup>24</sup> *But see* Anthony Levandowski & Travis Kalaick, *Pittsburgh, your Self-Driving Uber is*

This fledgling industry currently has few standards or expectations surrounding it, making regulations especially powerful. Regulators have a unique opportunity to both maximize as well as distribute the benefits of autonomous vehicles if they act quickly. NHTSA's current inaction attains neither of these desirable policy goals.

## II. IDENTIFYING THE END-STATE GOAL

Automated braking, acceleration, and blind spot detection have become more popular since the time of writing.<sup>25</sup> Current autonomous vehicle use is limited to research and development by companies that hope to create the future of driverless cars.<sup>26</sup> As such, autonomous vehicles have only a *pending* benefit to the average consumer, and the benefit currently accrues only to the projected future profits of auto manufacturers—it has not yet arrived.<sup>27</sup> As automakers begin to monetize the results of their research and design efforts, it is the duty of the government to draw the line between safety, profit, and user experience.<sup>28</sup> Throughout the past century of automobile use in the U.S., a complex patchwork of state-by-state vehicle codes have emerged that draws the risk-utility balancing line in various places.<sup>29</sup> Some states' regulators prefer to prioritize speed and convenience

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*arriving now*, UBER BLOG (Sept. 14, 2016), <https://newsroom.uber.com/pittsburgh-self-driving-uber/> [<https://web.archive.org/web/20171116080053/https://www.uber.com/blog/pittsburgh/pittsburgh-self-driving-uber/>] (claiming self-driving cars will create jobs rather than destroy them because “self-Driving Ubers will be on the road 24 hours a day[.]” which means they will need more human maintenance).

<sup>25</sup> See *Automated Driving Systems: A Vision for Safety*, *supra* note 5, at ii, 4 (explaining the Society of Automotive Engineers' definition of “automated vehicle” as only those in categories 3–5 that do not require extensive human input).

<sup>26</sup> While it is true that Uber recently deployed an autonomous fleet, local regulations still require an attentive driver at all times and the project remains a research and development effort. See Max Chafkin, *Uber's First Self-Driving Fleet Arrives in Pittsburgh This Month*, BLOOMBERG (Aug. 18, 2016), <http://www.bloomberg.com/news/features/2016-08-18/uber-s-first-self-driving-fleet-arrives-in-pittsburgh-this-month-is06r7on> [<https://perma.cc/PA7Z-5MWZ>].

<sup>27</sup> See Joan Schneider & Julie Hall, *Why Most Product Launches Fail*, HARV. BUS. REV. (Apr. 2011) (examining common failure modes preventing companies from monetizing research and design assets).

<sup>28</sup> U.S. DEP'T OF TRANSP., ABOUT US: MISSION (2015), <https://www.transportation.gov/mission/about-us> [<https://perma.cc/KHM8-5TBY>] (“ensuring a fast, safe, efficient, accessible and convenient transportation system”).

<sup>29</sup> See, e.g., CENTERS FOR DISEASE CONTROL AND PREVENTION, PRIMARY ENFORCEMENT OF SEAT BELT LAWS, Table B.5 (Dec. 2, 2015), <https://www.cdc.gov/motorvehiclesafety/calculator/factsheet/seatbelt.html> [<https://perma.cc/FR2L-XD32>] (detailing the large discrepancies in seatbelt laws across the United States).

in exchange for astronomical vehicle casualty rates, while other states' regulators arguably overprotect and inconvenience their drivers.<sup>30</sup>

The emergence of autonomous vehicles will upset the risk-utility balance in all fifty states and provide a ripe opportunity for the federal government to standardize one approach across all the states. Absent federal government intervention to change the status quo, the regulatory regime surrounding automobile use is ill-suited to this emergent innovation, and will fail to maximize the benefit of autonomous vehicles.<sup>31</sup>

#### A. *Maximizing Benefit in the End-State Goal*

An attempt to maximize the social utility of this emerging technology must first identify the utility to be maximized. Clearly understanding the gains to be made ensures that an attempt at regulation (1) does not stifle the main purpose of the innovation, and (2) does not unduly prioritize special interests.<sup>32</sup> The benefits of autonomous vehicles are numerous, but they generally fall into one of three categories: safety, convenience, or economics.

Even the most basic driver assistance technologies dramatically improve safety.<sup>33</sup> A simple blinking light and alarm combination to warn of rapidly approaching traffic reduces collisions by an average of seven percent, and an automatic braking system reduces collisions by fifteen percent.<sup>34</sup> The NHTSA recorded 33,000 fatalities on America's roadways last year—more deaths than by suicide, by gun violence, or by drug addiction in the United States.<sup>35</sup> Even a nominal increase in roadway safety

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<sup>30</sup> See, e.g., Tyler Spraul, *Worst Drivers by State*, CAR INSURANCE COMPARISON (last visited Jan. 21, 2018), <http://www.carinsurancecomparison.com/which-states-have-the-worst-drivers/#Table2015> [<https://perma.cc/6PWM-RELT>] (using National Highway Traffic Safety Administration crash data to extrapolate the relative safety of driving in each state and identify outliers).

<sup>31</sup> Ng & Lin, *supra* note 1.

<sup>32</sup> Adam Thierer, *Why Permissionless Innovation Matters*, TECHNOLOGY LIBERATION FRONT (Apr. 4, 2014) (arguing that "experimentation with new technologies and business models should generally be permitted by default" if they are not seriously harmful); see also Adam Thierer, *Removing Roadblocks to Intelligent Vehicles and Driverless Cars*, 5 WAKE FOREST J.L. & POL'Y 339, 340 (2015) (arguing for general regulatory permissiveness in innovating driverless vehicle solutions).

<sup>33</sup> *Avoiding crashes with self-driving cars*, CONSUMER REPORTS (Feb. 2014), <http://www.consumerreports.org/cro/magazine/2014/04/the-road-to-self-driving-cars/index.htm> [<https://perma.cc/X75Z-WXLF>] (last visited Jan. 21, 2018).

<sup>34</sup> *Id.*

<sup>35</sup> NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., DOT-HS-812-014, VEHICLE-TO-VEHICLE COMMUNICATIONS: READINESS OF V2V TECHNOLOGY FOR APPLICATION 263 (2014).

has a massive impact on lives saved over the course of the 1.2 billion vehicle trips made daily in the U.S.<sup>36</sup> Tesla Automotive CEO Elon Musk believes driverless vehicles are “ten times safer than manual driving.”<sup>37</sup> There are massive gains to be made in automobile safety, and every day the government delays the mass-market adoption of autonomous vehicles directly correlates with preventable loss of life.<sup>38</sup>

Although safety is perhaps the largest benefit of autonomous vehicles, their development also promises countless benefits for convenience and economic growth of cities. City planners and urban designers have already recognized that driverless cars will “change the way we [would] think about engineering cities,” allowing for a densely packed city center with minimal parking, smaller roads, and more pedestrian footpaths.<sup>39</sup> Once vehicles can drop off a passenger and then self-park while empty, the proximity of parking lots no longer matters—they can be moved to outside the city or into a surrounding industrial area.<sup>40</sup> Further, due to their precision driving, autonomous vehicles can also pack more efficiently into a given amount of parking space.<sup>41</sup> In fact, autonomous vehicles allow for up to a sixty-two percent reduction in the amount of space required for a given number of cars.<sup>42</sup>

These changes are already in motion.<sup>43</sup> Columbus, Ohio recently received a forty-million-dollar grant to redesign the city to accommodate

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<sup>36</sup> U.S. DEP’T OF TRANSP.: BUREAU OF TRANSP. STATISTICS, NATIONAL HOUSEHOLD TRAVEL SURVEY DAILY TRAVEL QUICK FACTS, [https://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/subject\\_areas/national\\_household\\_travel\\_survey/daily\\_travel.html](https://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/subject_areas/national_household_travel_survey/daily_travel.html) [https://perma.cc/4JD2-NKNW] (last visited Jan. 21, 2018).

<sup>37</sup> Cadie Thompson, *Elon Musk has finally revealed the second part of Tesla’s ‘top secret’ master plan—here it is*, BUSINESS INSIDER (July 20, 2016), <http://www.businessinsider.com/elon-musk-reveals-tesla-masterplan-2016-7> [https://perma.cc/Y3XB-WA8Y].

<sup>38</sup> See Bec Crew, *Driverless Cars Could Reduce Traffic Fatalities by Up to 90%, Says Report*, SCIENCE ALERT (Oct. 1, 2015), <https://www.sciencealert.com/driverless-cars-could-reduce-traffic-fatalities-by-up-to-90-says-report> [https://perma.cc/35TS-EFPT].

<sup>39</sup> Danielle Muoio, *4 ways driverless cars will change how we live*, BUSINESS INSIDER (Aug. 10, 2016), <http://www.businessinsider.com/peter-diamandis-how-driverless-cars-will-change-how-we-live-2016-8/#tech-companies-may-play-a-bigger-role-in-the-car-industry-than-traditional-automakers-2> [https://perma.cc/6P4R-GM8F].

<sup>40</sup> Doug Newcomb, *How Driverless Cars Spell the End of Parking as We Know It*, PC MAGAZINE (Aug. 12, 2016), <https://www.pcmag.com/commentary/346952/how-driverless-cars-spell-the-end-of-parking-as-we-know-it> [https://web.archive.org/web/\*/https://www.pcmag.com/commentary/346952/how-driverless-cars-spell-the-end-of-parking-as-we-know-it].

<sup>41</sup> *Id.*

<sup>42</sup> *Id.*

<sup>43</sup> Danielle Muoio & Sky Guold, *9 awesome innovations coming to the very first smart city in the US*, BUSINESS INSIDER (July 11, 2016), <http://www.businessinsider.com/closer-look-at-columbus-ohio-smart-city-2016-7> [https://perma.cc/59GE-DDVK].



driverless vehicles, and has done so by relocating parking lots and re-examining its pedestrian routes.<sup>44</sup> In a city environment, where cars are parked for more than ninety-five percent of the time,<sup>45</sup> a car-sharing program could reduce the number of cars needed to support a city by up to ninety-five percent.<sup>46</sup> With mass-market usage of driverless cars, population densities may safely increase, prime real estate previously relegated to parking spaces may become available for development, and the average cost of car ownership may decrease by more than ninety percent.<sup>47</sup> If regulation does not allow for these benefits to develop and accrue to the public at large, it decreases the demand for a driverless future and thus decreases the chances of that future becoming reality.

*B. Minimizing Risk in the End-State Goal*

While maximizing these benefits, a well-calibrated regulatory approach would also identify and minimize the associated harms. Disregarding the risks inherent in vehicles generally, driverless vehicles pose two additional threats: technology failure and human error.<sup>48</sup> The USDOT further classifies the human error component with three failure modes: “dependency, complacency, and over-reliance.”<sup>49</sup> A lengthy USDOT study found that more than half of drivers feel that even minimally assistive driving technology would cause them to “pay less attention to the driving environment.”<sup>50</sup>

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<sup>44</sup> *Id.*

<sup>45</sup> David Z. Morris, *Today's Cars are Parked 95% of the Time*, FORTUNE MAG. (Mar. 13, 2016), <http://fortune.com/2016/03/13/cars-parked-95-percent-of-time/> [<https://perma.cc/MVC6-U238>].

<sup>46</sup> Russ Mitchell & Tracy Lien, *Uber is about to start giving rides in self-driving cars*, LA TIMES (Aug. 18, 2016), <http://www.latimes.com/business/la-fi-uber-self-driving-cars-20160818-snap-story.html> [<https://perma.cc/PQ3A-8T83>]; see also Cadie Thompson, *Elon Musk wants to let Tesla owners make money off their cars when they're not using them*, BUSINESS INSIDER (July 21, 2016), <http://www.businessinsider.com/elon-musk-reveals-tesla-shared-fleet-2016-7> [<https://perma.cc/39LY-KDFU>]; Paul Barter, “*Cars are parked 95% of the time. Let's check!*”, REINVENTING PARKING (Feb. 22, 2013), <http://www.reinventingparking.org/2013/02/cars-are-parked-95-of-time-lets-check.html> [<https://perma.cc/4WF7-C3XS>].

<sup>47</sup> See Newcomb, *supra* note 40; see also Morris, *supra* note 45.

<sup>48</sup> See Mark Harris, *Google reports self-driving car mistakes: 272 failures and 13 near misses*, THE GUARDIAN (Jan. 12, 2016), <https://www.theguardian.com/technology/2016/jan/12/google-self-driving-cars-mistakes-data-reports/> [<https://perma.cc/Z8R5-VAS8>].

<sup>49</sup> NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., *supra* note 35, at 140.

<sup>50</sup> *Id.*

In addition to the human risks, driverless cars also pose a morass of potential technological failure modes.<sup>51</sup> Any modification to a vehicle introduces a potential new point of failure, and the changes required to make a vehicle autonomous are numerous.<sup>52</sup> Fortunately, the looming threat of moral, legal, and market sanctions that society will levy against the first automotive company at fault in a crash substantially mitigates this technology risk.<sup>53</sup> For example, after more than two million miles of testing, only one car in Google's entire autonomous fleet of vehicles has caused an accident.<sup>54</sup> The incident report indicates that a Google vehicle moving two miles per hour entered the travel path of a bus and was rear ended at less than fifteen miles per hour.<sup>55</sup> Nonetheless, the incident sparked public concern and started a media uproar, forecasting severe market sanctions for the first negligent car developer that injures a consumer.<sup>56</sup>

Some model vehicle codes further mitigate the technology risk by requiring a "showing" of capabilities before certifying vehicles as road-worthy.<sup>57</sup> Google's self-driving car has already inspired technological confidence by driving more than two million miles without significant incident.<sup>58</sup> In sum, although new technology risks may emerge, regulation and the hesitancy of the market tend to minimize them.<sup>59</sup> The most disconcerting drawbacks emerge when considering the human element, which proves more difficult to regulate away.

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<sup>51</sup> See, e.g., RICKY SALGADO & EMILIANO VELAZQUEZ, *TOPOLOGICAL COMPLEXITY FOR DRIVERLESS VEHICLES* 333 (2016) (analyzing the immense complexity in mapping even a simple route, and attempting to calculate the number of computer instructions needed to do so).

<sup>52</sup> Don Sherman, *Semi-Autonomous Cars Compared! Tesla Model S vs. BMW 750i, Infiniti Q50S, and Mercedes-Benz S65 AMG*, *CAR AND DRIVER* (Feb. 2016), <http://www.caranddriver.com/features/semi-autonomous-cars-compared-tesla-vs-bmw-mercedes-and-infiniti-feature> [<https://perma.cc/9HQ9-SW6L>] (identifying differences and points of potential failure in autonomous and regular vehicles, including "loading \$60,000 worth of navigation gear, two powerful electric motors, and shrewd software" into an otherwise everyday car).

<sup>53</sup> See Alex Davies, *Google's Self-Driving Car Caused Its First Crash*, *WIRED MAGAZINE* (Feb. 29, 2016), <https://www.wired.com/2016/02/googles-self-driving-car-may-caused-first-crash/> [<https://perma.cc/9HRL-2LKP>].

<sup>54</sup> *Id.*; Johana Bhuiyan, *After two million miles, Google's robot car now drives better than a 16-year-old*, *RECODE* (Oct. 5, 2016), <http://www.recode.net/2016/10/5/13167364/google-self-drivingcars-2-million-miles> [<https://perma.cc/UA6U-HCLR>].

<sup>55</sup> Davies, *supra* note 53.

<sup>56</sup> See *id.*

<sup>57</sup> See, e.g., NEV. ADMIN. CODE § 482A.110(3)(b) (2014) (requiring all autonomous vehicle operators to certify the vehicle has been driven safely for "not less than 10,000 miles in autonomous mode").

<sup>58</sup> Bhuiyan, *supra* note 54.

<sup>59</sup> See NEV. ADMIN. CODE § 482A.110(3)(b) (2014); Davies, *supra* note 53.

C. *Balancing Risks Against Benefits in the End-State Goal*

Regulators can best optimize the utility of this new technology through some combination of maximizing upsides while minimizing downsides.<sup>60</sup> The proper balance of risk to reward in this arena will necessarily conform to the standard risk assessment palette used by the insurance industry,<sup>61</sup> commonly known as the “Risk Cube.” In the Cube model, an actor has four options when confronting a risk: accept, reject, mitigate, or transfer the risk.<sup>62</sup> The current regulatory regime relies unduly on the “reject” and “transfer” corners of the cube.<sup>63</sup> Twenty-one states allow the lawful use of driverless cars on public roads, while the remaining twenty-nine outright “reject” their implementation and development.<sup>64</sup> Of the twenty-one that do allow the use of driverless cars, nine of them only allow such use for testing purposes by authorized entities, or under other use restrictions—functionally “rejecting” the risk.<sup>65</sup> The remaining twelve states stray away from the “reject” strategy by relying heavily on the “transfer” approach—requiring much higher insurance than that required of equivalent human-piloted cars.<sup>66</sup> Several of these twelve states, such as Alabama, Arizona, and Wisconsin, transfer the risk into the future by setting up committees to study the risk, or by making narrow exceptions to existing rules rather than enacting comprehensive legislation.<sup>67</sup>

In tilting the cube, the “accept” and “mitigate” vertices accelerate innovation while increasing risk, and the “reject” and “transfer” corners decelerate innovation while shifting risk to other sectors.<sup>68</sup> In placing their dollars in varying proportions on this risk mitigation cube, each state inevitably tilts the playing field toward the consumer, toward the industry, or toward the status quo.

An inconsistent tilt of the risk cube across the states will stifle innovation. A software programmer in Palo Alto, California, cannot properly

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<sup>60</sup> Coase, *supra* note 8.

<sup>61</sup> Norman T. Sheehan, *A Risk Based Approach to Strategy Execution*, 31 J. BUS. STRATEGY 25, 25 (2010) (summarizing the industry standard “Four-step framework to risk-based strategy execution”).

<sup>62</sup> *Id.*; See DEP’T OF DEFENSE, RISK MANAGEMENT GUIDE FOR DEFENSE ACQUISITION PROGRAMS, OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR SYST. ENG’G 85 (7th Ed. Dec. 2014) (Interim Release).

<sup>63</sup> NAT’L CONF. OF STATE LEGIS., *supra* note 3.

<sup>64</sup> *Id.*

<sup>65</sup> *Id.*

<sup>66</sup> *Id.*

<sup>67</sup> *Id.*

<sup>68</sup> DEP’T OF DEFENSE, *supra* note 62.

optimize her code for the regulatory needs of fifty different regimes all tilted to favor slightly different interests. For example, one state may prefer to prioritize emissions reduction, and in so doing, incentivize close following distances to reduce drag.<sup>69</sup> Meanwhile, another state may prefer to prioritize safety, and in so doing, incentivize increased following distances.<sup>70</sup> For legitimate policy reasons, two states can call for completely opposite vehicle protocols.<sup>71</sup> These mismatched incentives lead to inconsistent autonomous vehicle behavior, and even worse, they stall development and optimization.

This type of regulatory inconsistency across the states has already infiltrated other vehicle code provisions as well. As one example among many, California's stringent emissions systems requirements render many cars "49-state" cars that are not eligible for registration in California.<sup>72</sup> Like the inconsistent emergence of seatbelt laws,<sup>73</sup> and like Florida and Nevada's already-differing approaches to regulation,<sup>74</sup> the growth of autonomous vehicles will create competing incentives that conceal priorities. It is precisely this misbalance and inconsistency that so interferes with innovation as to require centralized, federal action.

### III. COMMUNICATION PROTOCOLS AS A MICROCOSM OF THE END-STATE GOAL

After establishing the nationwide risks and benefits in this emergent industry and prioritizing them along a risk continuum based on the risk cube, federal regulators must assess the tools with which they can reach down to the local level to mold the desired outcome.<sup>75</sup>

Federal regulators shoulder a weighty task in assessing nationwide risk and implementing policy controls on such a large scale. A smaller-scale

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<sup>69</sup> Clara Moskowitz, *Hypermiling: Driving Tricks Stretch Miles Per Gallon*, LIVESCIENCE (July 24, 2017) (extolling the aerodynamic efficiency benefits of close following distances).

<sup>70</sup> TRAVELERS INSURANCE, *3-Second Rule for Safe Following Distance*, <https://www.travelers.com/resources/auto/travel/3-second-rule-for-safe-following-distance.aspx> [<https://perma.cc/5R4U-AKQK>] (last visited Jan. 21, 2018) (extolling the safety benefits of large following distances).

<sup>71</sup> Compare Moskowitz, *supra* note 69, and TRAVELERS INSURANCE, *supra* note 70.

<sup>72</sup> CAL. DEP'T OF MOTOR VEHICLES, BUYING AND SELLING: FAQs IN CALIFORNIA, <http://www.dmv.org/ca-california/buy-sell/buying-selling-faqs.php> [<https://perma.cc/9SCK-RT5J>] (last visited Jan. 21, 2018) ("Many vehicles are only certified to meet lesser federal emission standards, called '49-State' certified.").

<sup>73</sup> CENTERS FOR DISEASE CONTROL AND PREVENTION, *supra* note 29.

<sup>74</sup> NAT'L CONF. OF STATE LEG., *supra* note 3.

<sup>75</sup> Section V.A, *infra*, addresses the constitutional implications of federal intrusion into this traditionally state-regulated sphere.

example will better illustrate the competing interests at stake and illuminate how federal regulators may best implement their policy decisions uniformly at the state level.<sup>76</sup>

Currently, the technological development surrounding V2V communications and V2I communications poses the greatest emerging regulatory conundrum as the technologies threaten to privatize traffic control.<sup>77</sup> To be sure, V2V and V2I communications are far from the only considerations in a regulatory regime, but they are emblematic of the challenges faced by the industry and will lead to a greater understanding of the unique issues raised by the industry.

#### A. *Vehicle-to-Vehicle Communication Considerations*

As the name indicates, V2V communications “transmit basic safety information between vehicles,” such as road conditions, upcoming obstacles, traffic information, and emergency response data.<sup>78</sup> Waze, Google Maps, and Apple Maps are all primitive forms of this technology: they use aggregated data on devices in motion to predict traffic conditions.<sup>79</sup> Each of these software programs estimates slowdowns and traffic jams by calculating the average speed and number of devices on a roadway.<sup>80</sup> V2V promises to do the same, but with no human to interpret the data, and with a much more robust stream of information.<sup>81</sup> In addition to assessing traffic conditions, V2V will allow vehicles to negotiate rights of way and passing speeds independent of road infrastructure or human intervention.<sup>82</sup> With widespread adoption of V2V communication, driverless vehicles will broadcast information about traffic hazards, road conditions, weather conditions, blind corners, slowdowns, emergencies, and many other factors to increase safety and convenience on the road.<sup>83</sup>

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<sup>76</sup> Ryan Beene, *V2V Hits Critical Stage: Technology is ‘at the 1-yard line’ but faces political obstacles*, AUTOMOTIVE NEWS (May 15, 2016) (“[The] V2V mandate is viewed by policy experts as the most important step for connected-car deployment.”).

<sup>77</sup> *Id.* (“[T]he cable TV industry, plus Google, Qualcomm and a coalition of other groups, urged the FCC to open the 5.9-gigahertz band of the radio spectrum.”).

<sup>78</sup> NAT’L HIGHWAY TRAFFIC SAFETY ADMIN., *supra* note 35, at xiii.

<sup>79</sup> NCTA: THE INTERNET & TELEVISION ASSOCIATION, *How Google Tracks Traffic* (July 3, 2013), <https://www.ncta.com/platform/broadband-internet/how-google-tracks-traffic/> [<https://perma.cc/M22H-M5RT>].

<sup>80</sup> *Id.*

<sup>81</sup> NAT’L HIGHWAY TRAFFIC SAFETY ADMIN., VEHICLE-TO-VEHICLE COMMUNICATIONS (2016), <https://icsw.nhtsa.gov/safecar/v2v/> [<https://perma.cc/S493-N3XW>].

<sup>82</sup> U.S. DEP’T OF TRANSP., FACT SHEET, VEHICLE-TO-VEHICLE COMMUNICATION TECHNOLOGY (2014).

<sup>83</sup> *Id.*

### B. *Vehicle-to-Infrastructure Communication Considerations*

Similar to V2V communication, V2I communication enables signaling between vehicles and road infrastructure such as stoplights, variable direction signage, speed limit signs, or road markings.<sup>84</sup> As is already implemented manually in many urban areas, V2I communication will enable low-capacity multi-lane roads to automatically switch directions of travel in response to fluctuating traffic conditions.<sup>85</sup> V2I also allows for variable speed limits depending on road conditions, time of day, or other factors.<sup>86</sup> As one example among many, school zones don't need a twenty-five-mile-per-hour speed limit at midnight, yet many jurisdictions enforce the rule around the clock.<sup>87</sup> Such adaptive road infrastructure enabled by V2I will vastly improve optimization of traffic flows by fine-tuning all aspects of the road-going experience.<sup>88</sup>

## IV. MAXIMIZING BENEFITS BY SELECTING AN APPROPRIATE REGULATORY MODEL

Regulators can maximize the benefits of nascent technologies, such as V2I and V2V, by selecting an appropriate regulatory model. As discussed earlier, regulators must select from three potential regulatory models: the private model, the public model, or the hybrid approach. Each involves varying degrees of industry and government participation. Looking to other industries and other areas of government, the U.S. government has historically adopted a wide variety of approaches. The following sections examine the competing merits of the private, public, and hybrid approaches in the context of autonomous vehicles, ultimately recommending a hybrid approach for its ease of administration and inherent fairness.

NHTSA has already begun to contemplate its role in the autonomous vehicle revolution. A 2011 government roundtable, attended by

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<sup>84</sup> Luigi Glielmo, *Grand Challenges for Control: Vehicle-to-Vehicle/Vehicle-to-Infrastructure Control*, INST. OF ELECTRICAL ENGINEERS CONTROL SYST. SOC'Y, <http://www.ieeecss.org/sites/ieeecss.org/files/documents/IoCT-Part4-13VehicleToVehicle-HR.pdf> [<https://perma.cc/YBB4-9WKN>] (last visited Jan. 21, 2018).

<sup>85</sup> *Id.*

<sup>86</sup> *Id.*

<sup>87</sup> Gary Richards, *Roadshow: Confusion over 25 mph speed limit near schools*, MERCURY NEWS, Feb. 13, 2015, <http://www.mercurynews.com/2015/02/13/roadshow-confusion-over-25-mph-speed-limit-near-schools/> [<https://perma.cc/Z4FE-KNBU>].

<sup>88</sup> See generally NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., *supra* note 81.

USDOT representatives discussed various industry trends and potential regulatory models.<sup>89</sup> NHTSA understands there is a question of regulatory posturing that must be answered.<sup>90</sup> At the roundtable, officials evaluated the pure public model of regulation as used in the healthcare industry's complex tapestry of interwoven regulatory layers.<sup>91</sup> NHTSA has referenced the current state of healthcare's regulatory affairs in its policy memoranda, and regards it as a cautionary tale.<sup>92</sup> As an intermediate approach, the Telecom industry enjoys a large amount of independence in setting districts and regulating coverage areas, while still attracting a moderate amount of government oversight.<sup>93</sup> NHTSA has begun the process of looking for wisdom in other industries, but has not yet reached a conclusion.

A. *The Private Model of V2I and V2V Regulation*

In the private model of regulation, the government trusts the industry to self-regulate. This works well for lawyers, and poorly for investment banks.<sup>94</sup> In the V2I and V2V context, a private regulatory model would leave industry leadership free to determine the contours of the communication standard: whether signals are sent on radar, LIDAR, infrared, or some other platform; the wavelength on which the signal is sent; and the standards by which the signal is encoded.<sup>95</sup>

Standards selection has been a historic struggle in the tech world. For instance, Apple pays large royalty fees to Sony Ericsson for its use of the 2G, 3G, and 4G internet communication protocols—a standard cell phone feature.<sup>96</sup> The same monopolization phenomenon has occurred with

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<sup>89</sup> INTELLIGENT TRANSP. SYS., *supra* note 10, at 6 (examining “existing governance models within the public sector and/or industry” for inspiration).

<sup>90</sup> *Id.* at 6.

<sup>91</sup> *Id.*

<sup>92</sup> *Id.* at 11 (“[t]he organization over-engineered the standards and lost sight of the goals of improving health.”).

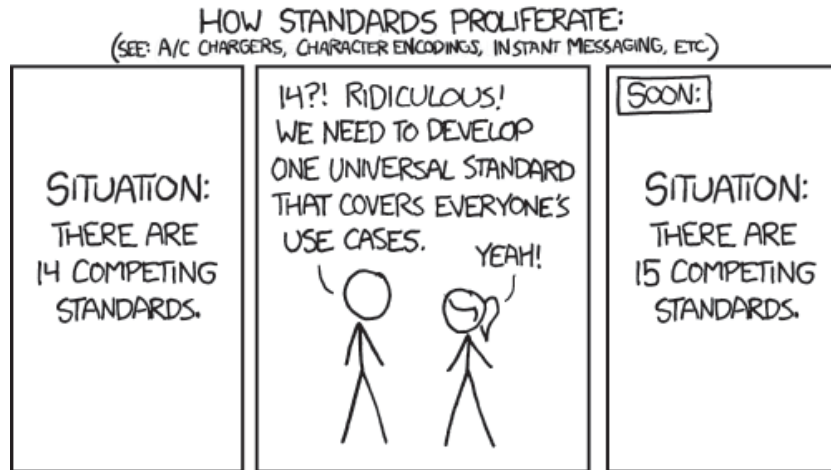
<sup>93</sup> See generally Nicholas Economides, *Telecommunications Regulation: An Introduction*, NYU STERN (2005), [http://www.stern.nyu.edu/networks/Economides\\_Telecommunications\\_Regulation.pdf](http://www.stern.nyu.edu/networks/Economides_Telecommunications_Regulation.pdf) [<https://perma.cc/A7P7-T4CN>] (offering a succinct summary of the current state of regulatory affairs in the telecom industry).

<sup>94</sup> James E. Moliterno, *The Trouble With Lawyer Regulation*, 62 EMORY L.J. 101, 103 (2013) (discussing the different cultures of regulation between lawyers and bankers and examining how culture affects ability to self-govern).

<sup>95</sup> See Glielmo, *supra* note 84, at 2 (indicating Europe has settled on wireless LAN as a protocol, but stating that American systems are “not yet compatible” with one another).

<sup>96</sup> Peter Sayer, *Apple to pay Ericsson patent royalties on iPhones and iPads*, INFOWORLD (Dec. 21, 2015), <http://www.infoworld.com/article/3017534/intellectual-property/apple-to-pay-ericsson-patent-royalties-on-iphones-and-ipads.html> [<https://perma.cc/V9C5-8ENN>].

Apple's lightning ports,<sup>97</sup> the Blu-ray disk format,<sup>98</sup> and many other technological standards. The evidence is clear: the establisher of a technology standard gains perpetual royalties from those that did not establish the standard. This incentivizes holdouts and forestalls the emergence of a clear standard, because the last company to give in gains a monopoly over its competitors. Thus, in the private model of governance, a clear standard may never emerge, and if one does, it will disproportionately favor the last holdout and cause bullying or in-fighting in the industry. Especially considering the public's interest in a clear, royalty-free standard, the industry requires at least some modicum of federal intervention.



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The royalty-seeking holdout problem becomes especially onerous when considering the unique challenges facing driverless vehicle technology. For example, in establishing a V2V communication protocol, the industry must be able to guarantee that when an Apple iCar, a Google Waymo,

<sup>97</sup> Jordan Kahn, *Apple will soon let third-party products use its Lightning port, opening up new possibilities for accessories*, 9TO5MAC (Nov. 18, 2014), <https://9to5mac.com/2014/11/18/apple-mfi-summit-third-party-products-lightning-port-new-accessories/> [<https://perma.cc/3YNV-SD6T>].

<sup>98</sup> Chen An Huang et al., *Sony's Blu-Ray Strategy*, MCAFEE, <http://www.mcafee.cc/Classes/BEM106/Papers/2007/Bluray.pdf> [<https://perma.cc/7DY7-DEUM>] (last visited Jan. 21, 2018) ("Only the largest manufacturers have bargaining power.").

<sup>99</sup> *Standards*, XKCD, <https://xkcd.com/927/> [<https://perma.cc/XC22-9PFA>] (last visited Jan. 21, 2018) (explaining the proliferation of standards and competitive pursuit of monopoly) (Graphic used with artist's permission).



and a Tesla all meet up at a three-way intersection, that all the parties involved are speaking the same language and can navigate the turn without incident.<sup>100</sup> Whichever tech giant holds out the longest will compel use of their technology as the standard.<sup>101</sup> This impedes innovation and is exactly the high-speed game of chicken that regulation should seek to alleviate.

Likewise, V2I systems are not immune from the fight for technological superiority. The best present-day analogue for V2I infrastructure is the drive-through wireless toll-road payment program used by fast-pass, ez-pass, and their equivalents.<sup>102</sup> The system relies on dash-mounted passes that are government-issued, government-standardized, and used on government-maintained infrastructure.<sup>103</sup> Even so, these passes still fail on occasion, and any failure rate above zero is too high for V2I communication events that impact public safety.<sup>104</sup> A situation with competing standards is not conducive to reliability.<sup>105</sup> In addition to toll payment methods, these infrastructure-interface issues are also apparent in our present reality in other ways.<sup>106</sup> For example, luxury car owners frequently have difficulty programming vehicle-based infrared garage door openers to function with their particular garage door.<sup>107</sup> Enabling third-party infrastructure to seamlessly interface with a different third-party vehicle is incredibly difficult absent some measure of paternalism.<sup>108</sup> In the V2I case, some measure of governmental interference is unavoidable, as the infrastructure itself is inherently government-owned and -operated.<sup>109</sup> This rules out the private model entirely.

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<sup>100</sup> See Glielmo, *supra* note 84, at 2.

<sup>101</sup> ANNE LAYNE-FARRAR, COMPETITION POLICY INTERNATIONAL'S NORTH AMERICA COLUMN, WHY PATENT HOLDOUT IS NOT JUST A FANCY NAME FOR PLAIN OLD PATENT INFRINGEMENT 4 (2016) (“[h]oldout can be a very attractive strategy for standards implementers.”).

<sup>102</sup> See, e.g., PA. TURNPIKE, *How Does E-ZPass Work?*, [https://www.paturnpike.com/toll/how\\_it\\_works.aspx](https://www.paturnpike.com/toll/how_it_works.aspx) [<https://perma.cc/ZCD2-54EE>].

<sup>103</sup> *Id.*

<sup>104</sup> *E-ZPass Consumer Reviews and Complaints*, CONSUMER AFFAIRS, [https://www.consumeraffairs.com/utilities/ez\\_pass.html](https://www.consumeraffairs.com/utilities/ez_pass.html) [<https://perma.cc/7FN5-MA5M>] (last visited Jan. 21, 2018) (listing several dozen complaints about malfunctioning EZpasses).

<sup>105</sup> Glielmo, *supra* note 84, at 2.

<sup>106</sup> See, e.g., Acura Technical Service Bulletin 04-036, *Homelink® System—Won't Learn Garage Door Opener Code* (Jan. 2005).

<sup>107</sup> *Id.*

<sup>108</sup> See, e.g., 47 C.F.R. § 2.106 (2002) (relying on the FCC's regulatory enforcement authority to allocate radio wave frequencies amongst broadcasters).

<sup>109</sup> But see Steve H. Hanke, *In Praise of Private Infrastructure*, CATO INST. (Apr. 2008), <https://www.cato.org/publications/commentary/praise-private-infrastructure> [<https://perma.cc/Z8ZG-2KGU>] (examining ways to circumvent the “natural monopoly character” of privately owned infrastructure—but this potential future is not yet our reality).

In addition to holdout and standardization problems, the private governance model brings even worse economic problems in the form of hidden costs. The private model of regulation creates strange implications for variable licensing fees. For example, luxury car brands with a lower volume of sales have fewer units over which to amortize their costs, so a fixed licensing fee upfront will cost more per unit for a low-volume vehicle manufacturer than a high-volume vehicle manufacturer.<sup>110</sup> Thus, a low-volume brand like Mercedes will pay more per car to license technology than will a high-volume brand like Honda.<sup>111</sup> Luxury brands in general tend to overpay for their patent and licensing fees as compared to mass-market brands.<sup>112</sup> In effect, this will cause some consumers to pay more to access infrastructure and other consumers to pay less. Normatively, this may not be a negative consequence—perhaps some would like to see the wealthy pay more for the use of common infrastructure. Disregarding normative claims to balancing class divides, this is a negative externality for at least two reasons.

First, disparate royalty fees function as a hidden tax on vehicle manufacturers that lack bargaining power against the owner of the technology standard. This is only exacerbated by the fact that the government will have no view into the hidden costs of its infrastructure. If installing a “smart light” at an intersection will incur a licensing fee for the users of enabled vehicles, the government is blind to the amount of the functional tax it levies on those companies that did not develop the technology standard and instead must license it.

Such a government-enforced monopoly may seem far-fetched; however, the rudiments of an analogous system are already present in Firm Fixed Price federal government contracts whose terms require the use of a *specific* software product.<sup>113</sup> In most cases, the cost of the contract-mandated product skyrockets as the government contractor loses all leverage

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<sup>110</sup> Jason Lancaster, *What Makes Luxury Cars So Expensive?*, HUFFINGTON POST (Mar. 19, 2015), [http://www.huffingtonpost.com/quora/what-makes-luxury-cars-so\\_b\\_6904266.html](http://www.huffingtonpost.com/quora/what-makes-luxury-cars-so_b_6904266.html) [<https://perma.cc/3EUP-EK89>] (“The more exclusive (fewer models sold) the car, the more the automaker has to charge each buyer for their design, development, and assembly costs.”).

<sup>111</sup> *Id.*

<sup>112</sup> Bruce M. Tharp, *Product Licensing 101: So Let’s Talk Money*, CORE77 (Sep. 11, 2012) (“[m]ass retailers are often the key to a nice royalty check.”).

<sup>113</sup> THE U.S. DEPT OF JUSTICE, COMPETITION AND MONOPOLY: SINGLE FIRM CONDUCT UNDER SECTION 2 OF THE SHERMAN ACT 132 (June 25, 2015), *available at* [https://www.justice.gov/sites/default/files/atr/legacy/2008/09/12/236681\\_chapter8.pdf](https://www.justice.gov/sites/default/files/atr/legacy/2008/09/12/236681_chapter8.pdf) [<https://perma.cc/V6RG-JZJ3>] (“Higher entry barriers make it easier for existing firms to exploit whatever power they have to raise prices above the competitive level.”).

against the software provider.<sup>114</sup> In effect, the government has given a monopoly to the third-party software supplier in both cases.

Second, the profits of this system will accrue only to the largest bully that holds out the longest.<sup>115</sup> Promising a government-enforced monopoly to whoever can beat the industry into accepting a single standard is a recipe for stagnation, or at least non-cooperation.<sup>116</sup> These market and game-theory forces combine to eliminate the private model of regulation from serious consideration as a viable approach.

The failures of the private model of regulation have also borne out in the emergent industries of the past as well. During the internet's growth phase in the early 1990s, the federal government took a complete hands-off, private approach.<sup>117</sup> This pure private model resulted in the private sector's creation of ICANN, the Internet Corporation for Assigned Names and Numbers, to keep some semblance of order.<sup>118</sup> Despite inventing the internet and contributing greatly to its early growth, the U.S. Federal Government still has only limited jurisdiction over even the most egregious of internet crimes.<sup>119</sup> Establishment of an unregulated quasigovernmental organization, such as ICANN, over which the government has effectively zero control hardly proves an aspirational model for the prudent governance of autonomous vehicles.<sup>120</sup>

### B. *The Public Model of V2I and V2V Regulation*

With the elimination of the private regulatory model, two models remain: the public model, or the public-private hybrid model. Both involve some modicum of government interference in the research and development

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<sup>114</sup> *Id.*

<sup>115</sup> LAYNE-FARRAR, *supra* note 101.

<sup>116</sup> *Id.*

<sup>117</sup> Avik Roy, *Thanks To Bill Clinton, We Don't Regulate the Internet Like a Public Utility*, FORBES (Mar. 17, 2014), <http://www.forbes.com/sites/realspin/2014/03/17/thanks-to-bill-clinton-we-don't-regulate-the-internet-like-a-public-utility/#58f805fd34bb> [<https://perma.cc/QJ8U-XD5E>] (stating that the early U.S. internet regulatory efforts required "trusting market forces and technological innovation to the maximum extent").

<sup>118</sup> *See generally* ICANN, <https://www.icann.org/> [<https://perma.cc/N88F-NX2V>] (last visited Jan. 21, 2018) ("The Internet Corporation for Assigned Names and Numbers is the private sector, non-profit corporation created in 1998 to assume responsibility for . . . system management.").

<sup>119</sup> INTELLIGENT TRANSP. SYS., *supra* note 10, at 15 ("The Internet as a whole is not necessarily a good model for Connected Vehicles . . .").

<sup>120</sup> *Id.*

of the technology. The nature of that interference will shape the growth of the industry and merits its own discussion.

A closer examination reveals that the public model can exist only in theory. Regulators must be apprised of the current state of the rapidly changing technology, and they can learn only from the industry. A recent Bloomberg report indicates that Silicon Valley currently spends twice as much lobbying money as Wall Street.<sup>121</sup> Even worse, the Google Transparency Project reveals that the Obama administration hired 258 advisers and analysts from Google alone.<sup>122</sup> Lobbying efforts in the legislative branch tend to be subtler and harder to track, but campaign contributions from the technology sector have increased more than forty percent in the past eight years.<sup>123</sup> When private sector actors hold office or sway the legislature to adopt favorable changes, they remove the potential for pure government regulation. In this political system, there can be no such thing as action not directed by the industry. This leaves one viable regulatory approach: the hybrid model.

### C. *The Hybrid Model of V2I and V2V Regulation*

Up to this point, it is clear that regulation should seek to enhance the benefits of driverless vehicles while minimizing the downside risk by selecting an optimal option, or mixture of options, from the risk cube. Policymakers would be wise to look to past emergent markets and study the mixtures of private influence, public influence, and industry influence on the regulatory bodies that grew up with the industries.<sup>124</sup> To USDOT's credit, focus groups engaged in roundtable discussions to seek wisdom from the past growth of other industries prior to issuing its 2017 guidance on driverless vehicles.<sup>125</sup> As discussed earlier, allowing a regulatory

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<sup>121</sup> Saleha Mohsin, *Silicon Valley Cozies Up to Washington, Outspending Wall Street 2-1*, BLOOMBERG (Oct. 18, 2016), <https://www.bloomberg.com/news/articles/2016-10-18/outspending-wall-street-2-to-1-silicon-valley-takes-washington> [<https://perma.cc/H4PF-AFCA>].

<sup>122</sup> GOOGLE TRANSPARENCY PROJECT, *Google's Revolving Door (US)*, <https://googletransparencyproject.org/articles/googles-revolving-door-us> [<https://perma.cc/WX7L-M589>] (last visited Jan. 21, 2018).

<sup>123</sup> David Sirota, *Election 2016: Silicon Valley Becomes Major Money Force in Politics*, INT'L BUS. TIMES (July 16, 2015), <http://www.ibtimes.com/election-2016-silicon-valley-becomes-major-money-force-politics-2010988> [<https://perma.cc/YU3D-JLZW>].

<sup>124</sup> INTELLIGENT TRANSP. SYS., *supra* note 10, at 1 (stating the mix of industries NHTSA looks to for "best practices.").

<sup>125</sup> *Id.* ("[t]here is expertise in the area of governance for other industries.").

machine to grow organically and unpruned over time will only result in holdouts, unpredictable licensing fees, and economic waste.<sup>126</sup> In contrast to the organic, private-sector approach, USDOT is examining approaches such as the management of the telecom growth phase in the mid-1900s.<sup>127</sup> These massive telecom companies grew in a segmented, planned way due to the need for taxpayer-funded infrastructure.<sup>128</sup> In this approach, the federal government (and sometimes state governments) granted charters to corporations to provide services and build infrastructure in compliance with government-provided specifications using taxpayer money.<sup>129</sup> The idea of private, for-profit businesses commingling goals with the government seems to be a promising analogy for the construction and operation of V2I technology.<sup>130</sup> The government retains authority and control, but does not need to engage in the day-to-day management and operation of cables and towers—or for autonomous vehicles, stoplights and tech-enabled roadways.<sup>131</sup>

As with its cross-industry research into regulatory posture,<sup>132</sup> NHTSA has also conducted research on potential model legislation to accept or consider.<sup>133</sup> Michigan, the country's nucleus of automotive innovation, has rapidly become the most autonomous-vehicle-friendly state in the union.<sup>134</sup> The University of Michigan has established a driverless vehicle proving grounds, and has successfully lobbied the state to relax regulations on autonomous vehicles, allowing the car-manufacturing powerhouse to attract more manufacturing and research and development jobs.<sup>135</sup> Specific features of Michigan's regulatory regime are difficult to

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<sup>126</sup> See *infra* Introduction.

<sup>127</sup> INTELLIGENT TRANSP. SYS., *supra* note 10, at 7.

<sup>128</sup> U.S. DEP'T OF THE TREASURY OFFICE OF ECON. POL'Y, EXPANDING OUR NATION'S INFRASTRUCTURE THROUGH INNOVATIVE FINANCING 2 (2014) (stating "Our nation needs to continually modernize and maintain our infrastructure," and emphasizing that businesses "need reliable power and broadband.").

<sup>129</sup> *Id.*

<sup>130</sup> Hanke, *supra* note 109.

<sup>131</sup> *Id.*

<sup>132</sup> INTELLIGENT TRANSP. SYS., *supra* note 10, at 1.

<sup>133</sup> Alex Davies, *The Feds Just Got Real About Self-Driving Cars (It's About Time)*, WIRED (Sept. 9, 2016.), <https://www.wired.com/2016/09/feds-just-got-real-self-driving-cars-time/> [<https://perma.cc/Z2ZH-Y3BL>].

<sup>134</sup> See Kirsten Korosec, *Michigan Just Passed the Most Permissive Self-Driving Car Laws in the Country*, FORTUNE (Dec. 9, 2016), <http://fortune.com/2016/12/09/michigan-self-driving-cars> [<https://perma.cc/PR4W-VK5U>].

<sup>135</sup> Neal E. Boudette, *Michigan's New Motor City: Ann Arbor as a Driverless-Car Hub*, N.Y. TIMES (July 9, 2017), <https://www.nytimes.com/2017/07/09/business/driverless-car>

analyze—because they are relatively new.<sup>136</sup> Michigan’s Vehicle Code was amended in December 2016 to include the content of Michigan Senate Bills 0995–0998, which, among other things, provide for “Research or testing of automated motor vehicle[s], technology allowing motor vehicle[s] to operate without human operator, or any automated driving system . . . .”<sup>137</sup> However, in the short term, the hybrid approach may require allowing industry to take the lead, as private industry can experiment more quickly and with less risk than the government.

## V. THE POWER TO REGULATE

Determining an appropriate regulatory posture and a well-planned approach means little without sufficient authority and funding to implement the plan. The following sections establish federal regulators’ power to act, and identify potential sources and amounts of funding.

### A. *Constitutionality Considerations*

Federal intrusion into state vehicle codes implicates constitutional and states’ rights issues that merit discussion. The federal government has mandated vehicle regulations in the past, such as the Nixon-era Emergency Highway Energy Conservation Act creating a national speed limit of fifty-five miles per hour,<sup>138</sup> or the Energy Policy and Conservation Act’s Corporate Average Fuel Economy (“CAFE”) standards mandating fleet fuel economy minimums.<sup>139</sup> These regulations are typically predicated on Congress’s commerce clause power, and current constitutional jurisprudence accords Congress with a large amount of deference when regulating channels of interstate commerce (such as highways)<sup>140</sup> and instrumentalities of interstate commerce (such as cars).<sup>141</sup> Indeed, the Ninth Circuit has

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-autonomous-university-michigan.html [https://web.archive.org/web/\*/https://www.nytimes.com/2017/07/09/business/driverless-car-autonomous-university-michigan.html].

<sup>136</sup> Melissa Burden, *Snyder Signs New Michigan Self-Driving Vehicles Law*, THE DETROIT NEWS (Dec. 9, 2016), <http://www.detroitnews.com/story/business/autos/2016/12/09/autonomous-car-law/95199544/> [https://perma.cc/5GL5-MQU5].

<sup>137</sup> Michigan Vehicle Code, MCL 257.665.

<sup>138</sup> Emergency Highway Energy Conservation Act of 1974, Pub. L. No. 93-239, 87 Stat. 1046.

<sup>139</sup> 49 U.S.C. § 32902 (2007).

<sup>140</sup> *See, e.g.*, *Houston, E. & W. Tex. R. Co. v. United States*, 234 U.S. 342, 345 (1914).

<sup>141</sup> *Hammer v. Dagenhart*, 247 U.S. 251, 272 (1918) (“Over interstate transportation, or its incidents, the regulatory power of Congress is ample.”).

weighed in on the permissibility of federal regulation of emission standards and has found no overreach.<sup>142</sup> A similar finding is likely in the regulation of autonomous vehicle standards.

### *B. Funding Considerations*

#### 1. The Availability of Funding

Congress surely has the power to regulate autonomous vehicles, but funding is another matter.<sup>143</sup> Historically, funds expended by the USDOT to maintain federal highways and fund the NHTSA have been raised through federal gasoline taxes accumulating in the national Highway Trust Fund.<sup>144</sup> Special assessments and discrete projects have been funded from this account in the past, such as the Leaking Underground Storage Tank Trust Fund.<sup>145</sup> Due to reorganization of the trust fund accounts and a disbursement from the General Fund to repair infrastructure, the Highway Trust Fund started Fiscal Year 2017 at a 470 percent premium above standard operating levels.<sup>146</sup> Given the current high level of infrastructure funding in combination with the well-established mechanisms for special projects, Congress and the USDOT should have little trouble allocating funding for the creation of an autonomous vehicle regulatory regime.<sup>147</sup>

#### 2. The Amount of Funding Required

However, ability to allocate funding does not alone advance the USDOT mission.<sup>148</sup> To effect true change through V2I technology, USDOT must allocate sufficient funding to retrofit or otherwise update a substantial amount of the country's road infrastructure.<sup>149</sup> Although stoplights are not the only infrastructure in need of modernization, they are among

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<sup>142</sup> *Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1172 (9th Cir. 2008) (recognizing and upholding NHTSA power to enforce emission standards).

<sup>143</sup> See Federal-Aid Highways Act, 23 U.S.C. §§ 101–81 (1956) (providing funding mechanisms for highway maintenance and construction).

<sup>144</sup> *Id.*

<sup>145</sup> 42 U.S.C. § 9608 (1986).

<sup>146</sup> U.S. DEP'T OF TRANSP. FED. HIGHWAY ADMIN., STATUS OF THE HIGHWAY TRUST FUND (2017), <http://www.fhwa.dot.gov/highwaytrustfund/> [<https://perma.cc/795H-D6B2>].

<sup>147</sup> *Id.*

<sup>148</sup> Federal-Aid Highways Act, 23 U.S.C. §§ 101(a)(3) (1956) (recognizing the need for “integrated strategies” to optimize “cross-jurisdictional systems”).

<sup>149</sup> Congress has recognized this as a policy goal. See *id.* § 101(b)(3)(H) (directing the Secretary of Transportation to “meet the needs of the 21st Century”).

the most easily researched and understood elements of roadway infrastructure and serve as an apt example to estimate the potential costs of required improvements.

According to a 2012 report by the National Transportation Operations Coalition, the U.S. has 311,000 stoplights on its roadways, constituting an \$83.7 billion public investment.<sup>150</sup> Currently, states, counties, and localities fund the purchase, installation, and maintenance of these assets.<sup>151</sup> These local funding sources spend approximately \$3,000 per year per stoplight on maintenance and upgrades.<sup>152</sup> It is not feasible for the federal government to retrofit and assume operation and maintenance of all 311,000 of these stoplights.<sup>153</sup> However, update efforts need not focus on all stoplights all at once. In fact, 72,000 of our country's stoplights are already "coordinated traffic signals," meaning they report back to a central computing system in the city and are programmable.<sup>154</sup> To enable V2I communication, these already "smart" stoplights would only require minimal retrofitting to add a sensor capable of communicating via the protocols decided by regulators and the industry. Even better, these "smart" lights tend to be concentrated in urban areas—areas most likely to benefit from V2I-enabled infrastructure.<sup>155</sup>

Targeting these 72,000 "smart" lights for initial upgrade, potential costs become markedly more manageable. Purchase, siting, and installation of a typical traffic signal costs approximately \$150,000.<sup>156</sup> This means that these 72,000 lights represent a public investment of a little less than \$11 billion.<sup>157</sup> Although seemingly a large figure, USDOT's 2016

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<sup>150</sup> NAT'L TRANSP. OPERATIONS COAL., NATIONAL SIGNAL REPORT CARD TECHNICAL REPORT 3 (2012), <http://library.ite.org/pub/e265477a-2354-d714-5147-870dfac0e294> [<https://perma.cc/5T8Q-XQ7U>].

<sup>151</sup> *Id.* ("Traffic signals are owned and operated by State, county, and local transportation and public works agencies.").

<sup>152</sup> *Id.* at 9, Table 5.

<sup>153</sup> See U.S. DEP'T OF TRANSP. OFFICE OF THE ASSISTANT SEC'Y FOR RESEARCH AND TECH., FROM THE NATIONAL TRAFFIC SIGNAL REPORT CARD: COSTS TO UPDATE SIGNAL TIMING IS \$3,000 PER INTERSECTION (2005), <http://www.itscosts.its.dot.gov/ITS/benecost.nsf/ID/215F723DB93D293C8525725F00786FD8?OpenDocument&Query=CApp> [<https://perma.cc/MY25-AG97>] (stating that one technician can maintain thirty to forty stoplights, creating a need for eight thousand full-time employees to maintain the nation's stoplights).

<sup>154</sup> NAT'L TRANSP. OPERATIONS COAL., *supra* note 150, at Table 1.

<sup>155</sup> *Id.* at 31 (using coordinated lights to maximize "performance in metropolitan areas").

<sup>156</sup> See, e.g., INST. OF TRANSP. ENGINEERS GEORGIA SECTION TECHNICAL COMM. GRP., TRAFFIC SIGNALS PUBLIC INFORMATION DOCUMENT 9 (2011), <http://www.dot.ga.gov/DriveSmart/SafetyOperation/Documents/TrafficSignals/Public%20Information/TrafficSignals-PID.pdf> [<https://perma.cc/ZU6F-VHWP>].

<sup>157</sup> \$150,000 x 72,000 = \$10.8 billion.



transportation projects dwarf such an expenditure.<sup>158</sup> Furthermore, retrofitting and updating these targeted lights would not require the expensive siting, surveying, and environmental approvals necessary to initially install the larger hardware components, so retrofit costs are likely far less than the current investment.

The USDOT estimates the current national average cost of a stoplight control computer at approximately \$10,000, plus \$3,000 for installation and programming.<sup>159</sup> This estimate is per intersection, so three- and four-way intersections further reduce the per-unit cost.<sup>160</sup> Thus, at the most, the total public investment in the control systems for all targeted 72,000 stop lights is \$936 million.<sup>161</sup> Such an investment is small enough to be a rounding error on the USDOT's 2017 budget of \$98.1 billion.<sup>162</sup> Although the technology for V2I has yet to reach mass-market production scale, costs are likely to mirror existing solutions, as computer technology has fallen substantially in recent years and a V2I controller only differs from a standard "smart" controller by the addition of a few sensors.<sup>163</sup> Starting with a targeted set of urban stoplights and then eventually moving to more advanced V2I infrastructure, such as speed limit signalers or road direction switching, seems a plausible phased rollout for the future road ahead.<sup>164</sup>

## CONCLUSION

The advent of autonomous vehicles promises to bring many benefits to society at large, but successful integration and use of this technology

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<sup>158</sup> See, e.g., Eric Jaffe, *The Big U.S. Transportation Projects to Watch in 2016*, CITYLAB (Dec. 22, 2015), <http://www.citylab.com/commute/2015/12/us-infrastructure-projects-2016-transportation/421431/> [<https://perma.cc/A5NN-YW3G>] (discussing a \$20 billion railway project in New Jersey, a \$17 billion Panama Canal expansion, and other similarly sized projects).

<sup>159</sup> U.S. DEP'T OF TRANSP. OFFICE OF THE ASSISTANT SEC'Y FOR RESEARCH AND TECH., *supra* note 153.

<sup>160</sup> *Id.*

<sup>161</sup>  $72,000 \times \$13,000 = \$936$  million.

<sup>162</sup> U.S. DEP'T OF TRANSP., BUDGET HIGHLIGHTS 7 (2017), [https://www.transportation.gov/sites/dot.gov/files/docs/DOT\\_BH2017\\_508%5B2%5D.pdf](https://www.transportation.gov/sites/dot.gov/files/docs/DOT_BH2017_508%5B2%5D.pdf) [<https://perma.cc/RUN3-DVLN>].

<sup>163</sup> Matt Rosoff, *Every type of tech product has gotten cheaper over the last two decades*, BUSINESS INSIDER (Oct. 14, 2015), <http://www.businessinsider.com/historical-price-trends-for-tech-products-2015-10> [<https://perma.cc/E2BX-ABRS>] (noting an almost 100% decrease in the cost of computer hardware since 1997).

<sup>164</sup> U.S. DEP'T OF TRANSP. OFFICE OF THE ASSISTANT SEC'Y FOR RESEARCH AND TECH., *supra* note 153 (scheduling rolling updates to refresh all traffic controller computers every ten years and indirectly providing the maximum time for which all stoplights in the U.S. are upgraded to V2I technology once widely adopted).

lies in the hands of regulators who have the power to either enhance or destroy these advances. If properly implemented and not stifled with excessive regulation, autonomous vehicles promise to redesign our cities, produce large gains for the economy, and prevent millions of fatal accidents.

To fully realize these benefits, policymakers must carefully weigh the risks and rewards of this new technology before acting. Once thoroughly informed as to all risks, regulators must select a regulatory model with which to address the risks. Using this model, regulators must position all risks at the desired position on the risk cube, deciding whether to accept, reject, mitigate, or transfer each risk inherent in the rise of autonomous vehicles. For the purposes of consistency, a federally standardized autonomous vehicle code will provide the best tool by which regulators may administer the policies they deem proper. When three driverless cars come to an autonomous intersection, they will pass through safely, but it is up to the regulators to determine how that happens, and who profits the most.

