Eliminating the Human Driver: Steering Ethical Programming for Self-Driving Vehicles

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I. INTRODUCTION

Across the globe, motor vehicle wrecks take the lives of almost 1.25 million people.[1] On average, there are 3,287 deaths each day and an additional fifty million are injured or even disabled.[2] These motor vehicle crashes are overwhelmingly caused by human error.[3] The National Highway Transportation and Safety Administration attributes ninety-four percent of crashes to human factors, mostly driver decision and driver recognition errors.[4] So, what if we eliminate the human? Just a decade ago, the thought would have sounded preposterous; however, the exponential rate of technological growth has made the once outlandish idea very possible, if not inevitable. Self-driving vehicles are on the horizon. Widespread adoption of autonomous self-driving vehicles has the potential to prevent ninety percent of car wrecks, drastically reducing the death toll resulting from vehicle crashes.[5] As expected from any type of disruptive technology,[6] the emergence of autonomous self-driving vehicles will present many legal, practical, and moral questions.

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1 *Road Safety Facts*, Association for Safe International Travel. https://www.asirt.org/safe-travel/road-safety-facts/

2 *Id.*

3 *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*, National Highway Transportation Safety Administration (NHTSA), March 2018, https://crashstats.nhtsa.dot. gov/Api/Public/ ViewPublication/812506

4 *Id.*

5 *Id.*

6 Mark Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 Calif. L. Rev. 1611 (2018).

Legally, each artificial intelligence advancement in the world of autonomous vehicles will raise questions of liability. Should the human "rider," the manufacturer, the distributor, the designers and programmers, or the mechanical engineers be held responsible for crashes that do not involve an artificial intelligence or technological malfunction? What if there is a malfunction with the technology? Everyday a new situation will present a new legal question will arise. Lawmakers should work diligently to determine the type of liability scheme best suited for this real and looming technology. To date, most scholars predict that responsibility will shift to the manufacturer as a matter of products liability law with the elimination of the human driver.[7]

Practically, the roads and those who travel them will look different from this point forward and we need to know how to navigate the new world. In addition to relieving humans from the task of driving, the development of self-driving vehicles will lead to altered dynamics of urban and suburban living and cause a migration from private vehicle ownership to commercial vehicle-sharing services.[8] But before the private ownership of automobiles is no longer necessary, the roads will be composed of a mixture of human-driven and driverless-vehicles. For owners of self-driving vehicles their work commute will be comfortable and productive. "Riders" and owners of these vehicles can sip their coffee, lean back, and let their digital

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[7] Dorthy Glancy, *A Look at the Legal Enviormant For Driverless Vehicles,* Transportation Research Board, 2016. https://onlinespubs.try.org/onlinepubs.nchrp_lrd_069.pdf

[8] *Exec. Office of the President's Council of Advisors on Science & Technology, Report to the President: Technology and the Future of Cities*, 2016, https://whitehouse.gov/sites/whitehouse.gov/files/imgaes/Blog/Pcst

assistant plan their day.[9] The problem is the roadways will not immediately transform into our science fiction image of fully automatic cars racing around town in perfect harmony. There will be a variety of vehicles from fully-automated Level 4 and 5 automobiles to regular human-operated Level 0 and 1 automobiles on the roads.

Human error will continue to be a major contributing factor in automobile accidents, regardless of this amazing new technology. Though Level 4 and 5 vehicles require little to no human input, human drivers will still be on the roads making mistakes all around the driverless vehicles. Due to human error, autonomous vehicles will be put in situations, much like a human driver, and will be forced to make hard decisions, based on their programming, to choose how to handle an impending collision. There will sometimes be no-win situations, and autonomous vehicles will have no other option but to crash in the *most efficient* way possible. The question is: Who gets to decide the "most efficient" way possible. Insert the moral dilemma?

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[9] Lee, Kevin, *A Day in the Life of a Lawyer in 2030*, Medium, November 2018, https://medium.com/ predict/ a-day-in-the-life-of-a-lawyer-in-2030-8890aa3f223d

II. CURRENT REALITY

Artificial intelligence that is critical to the success and operation of fully automated vehicles is developing rapidly. Some scholars and experts are predicting that there will be a widespread conversion to autonomous vehicles on the roads by 2040.[10] This progress is projected to reduce the frequency of crashes by up to eighty percent.[11] It is estimated that once ninety percent of the vehicles on the road are autonomous, there will be upwards of 20,000 less domestic fatalities each year from vehicle related crashes.[12] The potential to save countless lives and prevent injury has naturally led for "widespread deployment of this technology."[13]

After setting up the Advanced Technologies Center (ATP) in Pittsburgh, Uber released its first self-driving vehicle in September 2016.[14] The car still had a front seat "safety driver;" however, because the vehicle still requires human intervention in certain scenarios.[15] In 2017, an alliance between car-manufactures and technology companies was showcased at the Detroit Auto Show where

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10 *Cas. Actuarial Society Automated Vehicle Task Force, Restating the National Highway Transportation and Safety Administration's National Motor Vehicle Crash Causation Survey for Automated Vehicles*, https://www.casact.org/pubs/forum/14fforum/CASATVF_Restated_NMVCCS.pdf

11 *Id.*

12 Jerry Albright, *Marketplace of Change: Automobile Insurance in the Era of Autonomous Vehicles,* KPMG, 2015, https://assets.kpmg.com/conent/dam/kpmg/pdf/2016/06/id-market-place-of-change-automobile-insurance-in-the-era-of-autonomous-vehicles.pdf

13 Mark Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 Calif. L. Rev. 1611 (2018).

14 Anthony Lewandowsky & Travis Kalanick, *Pittsburgh, Your Self-Driving Uber is Arriving Now*, UBER (Sept. 14, 2016), https://newsroom.uber.com/pittsburgh-self-driving-uber

15 *Id.*

Waymo's self-driving equipment was outfitted in a Fiat Chrysler.[16] Though not yet commercially available, the Audi Traffic Jam Pilot system has Level 3 atomization technology.[17] Taking a broad view of the current technology projections, multiple companies have promised to have road-ready fully autonomous vehicles[18] within the next five years. The reality of fully automated vehicles is upon us. Science fiction fantasies are about to be realities. The technology is being developed, improved, and tested every single day. The question that must be answered now is: Who is deciding, programming, and regulating the life-and-death decisions these self-driving vehicles will be making?

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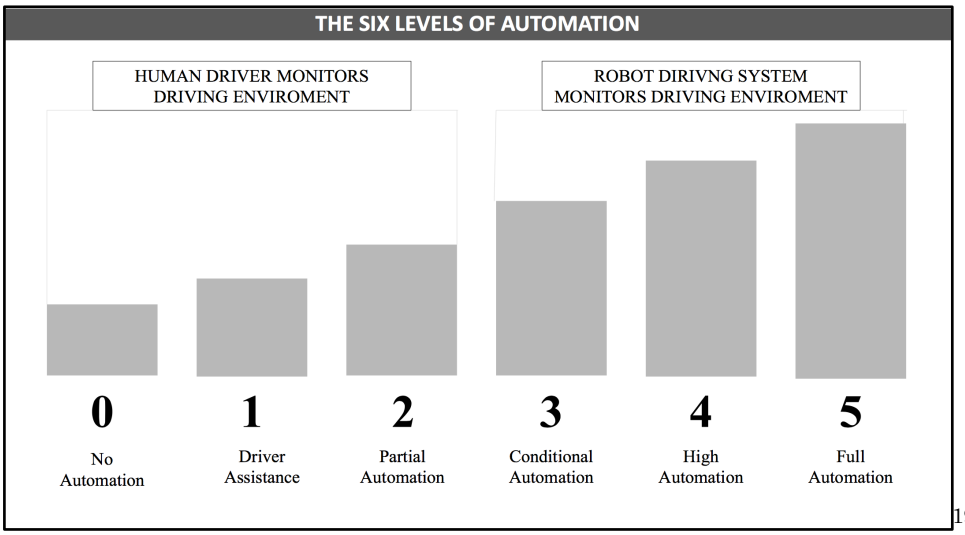
[16] Bill Vlasic, *Self-Driving Minivan Could Steer Car Industry,* New York Times, Jan. 9, 2017, at BI.

[17] Hyatt and Paukert, *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www.cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

[18] BMW, Ford Motor Co., Tesla Motors Inc., and Volkswagon have all promised this technology. Bill Vlasic, *Self-Driving Minivan Could Steer Car Industry,* New York Times, Jan. 9, 2017, at BI.

III. WHAT LEVEL 5 AUTOMATION MEANS

1. WHAT IS LEVEL 5 AUTOMATION?



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The Society of Automotive Engineers (SAE) has identified six levels of automation and set "a specific set of requirements that a vehicle must meet before it can be considered to operate at that level."[20] Across the globe, car manufacturers are pouring billions of dollars into the development and testing of self-driving vehicles.[21] The tangible picture is the vehicle itself, but the intangible lies in the programming inside the vehicle. The *brain* of the automobile.

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19 *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www. cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

20 Hyatt and Paukert, *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www.cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

21 *Id.*

Level 5 fully automated vehicles will be fitted with a powerful brain and require absolutely no human action to travel the roads.[22] Level 5 Vehicles will have no options whatsoever for human control: no pedals, steering wheels, or joysticks.[23] Theoretically, Level 5 Vehicles will be capable of complete hands-off, driverless operations under any and all circumstances, allowing riders to sit back and watch movies or play video games during their travel.[24] Though there are no Level 5 autonomous vehicles on the market,[25] Waymo is currently working on developing its Level 5 technology using a fleet of 600 Chrysler Pacifica hybrids.[26] Others manufacturers are working tirelessly to do the same. Level 5 atomization is the ultimate goal in the world of self-driving vehicles. The questions that must be answered next are: What technology is required and who is creating the powerful brain that controls a Level 5 Vehicle's decision-making?

2. WHAT TECHNOLOGY IS REQUIRED?

Building a functioning fully self-driving vehicle is complex. The vehicle is composed of software, sensors, electronics, mechanical parts, etc.[27] The technology

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22 *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www. cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

23 Hyatt and Paukert, *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www.cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

24 *Id.*

25 Hyatt and Paukert, *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www.cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

26 *Path to Autonomy: Self-Driving Car Levels 0 to 5: Just what does "Level 5 Autonomous car" mean?*, Car and Driver, October 2017. https://www.caranddriver.com/features/path-to-autonomy-self-driving-car-levels-0-to-5- explained-feature

27 Mark Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 Calif. L. Rev. 1611 (2018).

that is still in development and responsible for being a disruptive technological force is the adaptive software that will allow these vehicles to operate without a human. Indeed, self-driving vehicles have the undisputed potential and actual likelihood of reducing the number of vehicle related injuries and deaths in an unprecedented way; however, *human error* will remain a detriment even if *driver error* is greatly reduced or eliminated. The road is "more than simply a system of regulations and designs, [it] is a place where many millions of us, with only loose parameters for how to behave, are thrown together daily in a kind of massive petri dish in which all kinds of uncharted, little-understood dynamics are at work."[28] The fact that human error is responsible for the majority of vehicle is no surprise considering the vastly different behavioral dynamics of each human driver on the road. Taking driver error out of the equation on the road opens the door to a new problem: human error creating and programming the software that is the brain and decision-maker for autonomous vehicles.

Pre-determined computer software choices will replace human choice during the driving process. The "source of error" will be shifted from a human driver to the human who programmed, coded, designed, and built the self-driving vehicle.[29] Much better equipped and more intelligent than humans in almost every way, assuming proper programming and manufacturing, self-driving vehicles are

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[28] Tom Vanderbilt, *Traffic: Why We Drive the Way We Do (And What It Says About Us)*, 2008.

[29] Mark Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 Calif. L. Rev. 1611 (2018).

superior "drivers;" however, nothing is perfect. There will still be failures and malfunctions.

Self-driving vehicles need high-level artificial intelligence software and humans who are able to develop it. Level 1 Vehicles have adaptive cruise control and lane-keeping technology.[30] Technology already incorporated into Level 2 and 3 Vehicles include: automatic acceleration, steering, and braking control; active lane-keep assistance; adaptive cruise control, automatic emergency breaking; full vehicle control of operations during certain portions of a trip; and advanced sensor packages.[31] Level 4 and 5 Vehicles, which are not commercially available, require much more advanced technology and programing.

Level 5 Vehicles will operate without any involvement from a human driver or rider. The vehicle will be programmed to drive without assistance. The technology required to produce this type of vehicle requires complex coding and programming, but underneath the code is the decision on **what** to code. With an almost infinite number of scenarios that may occur on the road, there are numerous challenges. Not only does the software have to account for as many scenarios as possible, it has to actually have a programmed decision to implement in each given situation. Additionally, the software must have some type of "fail-

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[30] The Kia Stinger GT with adaptive cruise control and lane-keeping tech makes it a Level 1 car. Hyatt and Paukert, *Self-driving cars: A level-by-level explainer of autonomous vehicles,* Road Show, March 2018, https://www. cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/

[31] The Cadillac's CT6's Super Cruise system qualifies it for Level 2 classification. Additionally, Mercedes-Benz Distronic Plus, Nissan ProPilot Assist, and Tesla Autopilot are all Level 2 worthy advanced driver assistance systems. *Id.*

safe" response for the unanticipated or unlearned scenarios. The amount of choices the self-driving vehicle can and should make expands the moment a decision is made during a human-driven vehicle interaction. Once the other human driver also reacts, the self-driving vehicle must make another decision, then another. Engineers have to "program over 250 million lines of code on the hardware in the vehicle, they also need to navigate all the programs, tools, and platforms to develop, deploy, optimize, and manage the autonomous vehicle software and hardware."[32] Though a superior and safer vessel, there will still continue to be automobile wrecks that no amount of programming can account for as long as humans remain behind the wheel of other vehicles on the road. In a completely driverless-world, programming could reach almost perfection if the programming is universal across all vehicles.

3. WHO IS DEVELOPING THE TECHNOLOGY?

To understand **who** is responsible for developing the software that tells the autonomous vehicle how to drive and make choices, it is critical to understand the information, skills, and educational background of these engineers. Self-driving vehicle engineers are a new category of engineer. Based on a broad survey of thirty-one companies that are engaged in the development of autonomous vehicles, there are three skills that every self-driving vehicle engineer must have.[33] First is

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[32] Marks, Jason, *What Software Do Autonomous Vehicle Engineers Use? Part 1/2*, Medium, June 2018, https://medium.com/@olley_io/what-software-do-autonomous-vehicle-engineers-use-part-1-2-275631071199

knowledge and expertise in the general-purpose object-oriented programming language, C + +.[34] Second, engineers must be conformable with Linux, the open source operating system of choice in the industry.[35] Third, engineers must be well-versed and skilled using Python, a high-level programming language.[36] Robot Operating System (ROS), MATLAB, Simulink, and Git are also utilized by engineers in developing self-driving vehicles. "ROS is an ecosystem of software libraries for robot development" and is necessary to develop autonomous vehicles.[37] MATLAB and Simulink are two software platforms for control system design.[38] MATLAB is a numerical and proprietary programming language, and Simulink is a block-diagram-based graphical programming interface that allows users to create simulations and models.[39] Finally, Git is software used for version control and source code management for autonomous vehicle companies.[40]

In addition to the base-knowledge, engineers have to be skilled at dozens of other specific and specialized programs. The engineers for self-driving vehicles are unquestionably intelligence, experienced, and technologically savvy. While extremely intelligent, these engineers not elected officials. CEOs of the companies

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[34] Marks, Jason, *What Software Do Autonomous Vehicle Engineers Use? Part 1/2*, Medium, June 2018, https://medium.com/@olley_io/what-software-do-autonomous-vehicle-engineers-use-part-1-2-275631071199

[35] *Id.*

[36] *Id.*

[37] *Id.*

[38] *Id.*

[39] *Id.*

[40] Marks, Jason, *What Software Do Autonomous Vehicle Engineers Use? Part 2/2*, Medium, June 2018, https://medium.com/@olley_io/what-software-do-autonomous-vehicle-engineers-use-part-1-2-275631071199

developing autonomous vehicles are not elected officials. They were not chosen by America, but could still be responsible for making life-and-death decisions. We know these engineers are programming the self-driving vehicle's responses and behavior, but who is responsible for *determining* the programmed responses of these autonomous vehicles? Are the programmers making the choice? Their supervisors? The CEO of the company? The legislature? A federal agency? The problem is that there is no clear answer. With no guidelines for making these programming assessments, the next question is: Who **should** be determining the standard for self-driving vehicle's pre-programmed decision-making code?

IV. LOOMING REALITY

Scholars have already begun wrestling with autonomous vehicle hypotheticals that will be all too real before long. "Imagine a robot car with no one behind the wheel hitting another driverless car. Who's at fault? The answer: No one knows."[41] Who will be prioritized by the vehicle's programming? No one knows.

1. COLLISION: DRIVERLESS VEHICLE AND HUMAN OPERATED VEHICLE

Generally speaking, the majority of crashes that will occur once autonomous vehicles are commercially available will be between a driverless vehicle and a human operated vehicle. The question for liability purposes will turn on whether there is an actual malfunction with the autonomous vehicle, either mechanically or technologically. The question from an ethical standpoint, is how the vehicle will choose to act in the event the vehicle has no technological malfunction, but instead executes its programmed decision and there is still a resulting injury, damage, or death.

2. COLLISION: TWO DRIVERLESS VEHICLES

Once the roadways become more integrated with autonomous vehicles, as previously stated, there will be a massive reduction in automobile wrecks. If every autonomous vehicle is programmed to make decisions in

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[41] Keith Naughton & Margaret Cronin Fisk, *Driverless Cars Give Lawyers Bottomless List of Defendants*, Ins. J., Dec. 2015. https://insurancejournel.com/news/national/2015/12/22/392781.htm

conformity, the roads will be safer than ever. Autonomous vehicles will be able make decisions with absolute knowledge of how the other actor in the situation will respond as well. However, there are no standards or uniform procedures for programming autonomous vehicles, and there are numerous companies working to produce autonomous vehicles. The result of inconsistent programming, while not as uncertain or concerning as human driver choices, will be less than perfect. The unknown component that is associated with human error is still present. Each individual autonomous vehicle produced by a different manufacturer will be faced with the identical unknown choice of the other autonomous vehicle as it was with a human-operated vehicle.

In addition to the actual programming decisions, there are several ethical considerations. Broadly, should there be universal standards for autonomous vehicle decisions? Would that would mean collaboration between manufacturers on heavily-guarded technology research and development? Who should set these standards? Would a government agency, a committee or collation of manufacturers, a vast collection of engineers, a group of scholars, or Congress be the best to develop these universal standards? Finally, even if universal decision-making policies and standards are created, who should be the final say on right or wrong? Who should be the final say on who lives and dies?

V. ETHICAL CONSIDERATIONS

Humans are inherently flawed beings; however, over time we have developed governing systems and set certain parameters for what is "right and wrong" based mostly on what is deemed socially acceptable, or not. In America, we elect officials from the local to the national level to make decisions that we hope will be in our best interest. Not only are these officials elected, but also restricted in their power by many procedural safeguards. As a society we have determined certain things to be "wrong" and outlawed them. Distinguishing between right and wrong is generally based on some sort of ethical or moral belief. The Oxford English Dictionary defines *ethics* as the "moral principles that govern a person's behaviors or the conducting of an activity."[42] *Morals* are defined as "the principles of right and wrong."[43] As Americans, we would probably like to believe that life-and-death programming decisions that govern the choices made by self-driving vehicle software would be made in an ethical way. Knowledge of whether those decisions are being made ethically is uncertain. Additionally, there is the concern about who determines what *is* ethical. There is no universal rule book on what is considered right and wrong, and with such a myriad of challenging programming decisions to be made, how can the average American purchase a self-driving vehicle and trust the vehicle has their best interest at heart?

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42 https://en.oxforddictionaries.com/definition/ethics

43 https://en.oxforddictionaries.com/definition/moral

1. WHY ETHICS MATTER.

The power inherent in self-driving vehicle's programmed decision-making structure cannot be overlooked. There are subjective and objective concerns to consider as an autonomous vehicle buyer, a manufacturer, a liability attorney, and as a member of the general public.

From the perspective of a potential owner of a self-driving vehicle, the first question is likely, "Who is the priority?" Subjectively, one would probably expect and hope that after this expensive investment into an autonomous vehicle that it would be programmed to save their own life at all costs. On the flip side, as a fellow driver on the road operating a regular vehicle, one would hope that they are protected as well. For example, a man and wife with two children in their non-automated vehicle would hope or expect the self-driving vehicle's programming would be designed to generally protect human life, meaning the autonomous vehicle with one passenger would not be prioritized if the vehicle could make a decision that may harm or kill the owner of the autonomous vehicle in exchange for saving the couple and both their children. Ethics matter because the decisions automated vehicles are going to have the responsibility of making come at a price. The question ultimately is: Who will pay that price?

Autonomous vehicle programming is faced with the common "trolley problem," an ethical dilemma involving choice between one or more actions, that

all carry a cost.[44] The trolley problem hypotheticals have been asked for decades with varying responses. Everyone has their own view of what is right and wrong in these complicated and life-ending decisions, as well as differing logical reasoning to come to the ultimate conclusion on who to kill. For instance, consider the following scenario and decide: Which is worse? There is an unexpected obstacle in the road ahead. Impact is inevitable without the autonomous vehicle serving either left or right. There are three choices the vehicle can make. One, stay straight and risk seriously injuring or killing the single passenger and owner of the autonomous vehicle. Two, swerve left and collide with a minivan potentially killing a mother and her two nine-month old twins. Three, swerve right and collide with a luxury sedan potentially killing an elderly couple on the way to fiftieth anniversary dinner. Someone, somewhere has to make the choice about who to save and who to kill. Someone has to choose whose life is more valuable or whether the number of lives to be saved creates a higher priority. Once someone has made these life-changing choices, an engineer has to either program those behaviors into the vehicle or develop artificial intelligence to learn and make the decision itself.[45] The scary truth is we have no idea who will eventually make these ethical choices.

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[44] Anderson, Carl, *What Do We Know About Autonomous Vehicles?*, Medium, March 2018. https://medium.com/s/story/autonomous-vehicles-what-we-know-9466482f7c2a

[45] *Id.*

VI. CONCLUSION

"Human self-understanding is still developing from the far-reaching consequences of information and computer technology."[46] There is no clear answer or solution to what we should do. As humans we will learn and evolve indefinitely. Mistakes will be made, but those mistakes will come at a high price in the autonomous vehicle world. These self-driving vehicles have great power, but those who choose how to program that power hold the lives of countless people in their hands. We, as Americans, must decide who we want to give that power to.

[46] Lee, Kevin, *A Preface to the Philosophy of Legal Information*, 20 SMU Sci & Tech. L. Rev., Fall 2017, https://ssrn.com/abstract=2937433; See also, Luciano Floridi, *Open Problems in the Philosophy of Information,* 35 Metaphilosophically 554, 555 (2004).