AUTONOMOUS DRIVING SIMULATOR

HOW AUTONOMOUS DRIVING AFFECTS THE SAFETY OF OUR SOCIETY

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Mechanical Engineering

By
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November 1, 2021

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Ever since the creation of cars, the idea of a self driving vehicle has existed. “The first self-driving vehicles were ships” which used the forces of nature to move, and humans hoped to bring this same idea to cars (Townsend, 2020, para. 1). The luxury to reap all the benefits of the car without actually having to put in the effort and mental power to learn and operate it was a dream for many. However, the technology when cars were first introduced was not even close to being capable of such tasks, and with humans being more “invested in electric” cars, the idea of this self-driving vehicle has always just been a distant fantasy (Heller, 2019, p. 25). While the idea was pushed off to the side for many decades, the technology and software have advanced to a point where developing such a vehicle is extremely probable and some prototypes even have “million[s of] miles of fully-automated driving on public roads” along with traditional cars (Adams, 2018, para. 1). While we may not have noticed it, “advanced driver-assistance systems” have been slowly advancing each year to “help drivers park, stay in their lane or avoid objects” and companies are trying to improve these systems to a point of fully driving the car itself (Nicola, 2021, para. 1). With advancements in our vehicle’s designs, assistance systems, and software, this dream of a fully hands free self driving has become closer to a reality with each passing day.

With the rise of autonomous vehicles, the main concern from consumers is the safety of the passengers and civilians. The technical project helps propose a solution to directly combat this issue, even if the relationship is loosely coupled. “Given the vast amount of car accidents that are due to human error”, the self-driving car removes this aspect and theoretically should be safer on the roads (Müller et. al, 2020, p. 1550). However, because self-driving cars are still not widely adopted, it is hard for consumers to justify purchasing such a vehicle and putting their lives at risk without understanding the technology. This is where the driving simulator comes

into play as it allows for consumers to try the product and understand it in a real world scenario without being put in danger. The simulator also has an alternative purpose of teaching the current software in self-driving vehicles by being able to run through real scenarios thousands of times at once in order to track rates of failure and other causes that may affect the real life vehicle. Our autonomous driving simulator fulfills these two purposes, ensuring that when the eventual rollout of self-driving cars comes around, consumers will not be afraid for their safety. This project to design and create an operable driving simulator to represent autonomous driving will be conducted through the semesters of Fall 2021 and Spring 2022 which amounts to a total of 28 weeks shown in Figure 1.

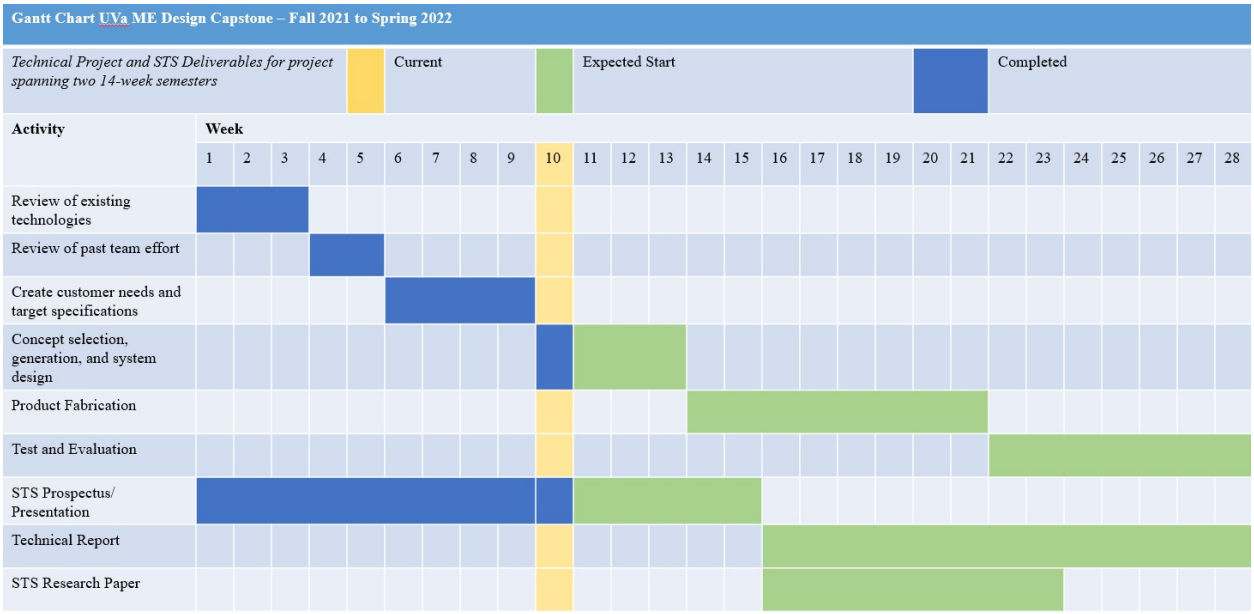

Figure 1: Gantt chart UVa driving simulator capstone project. This figure visualizes the expected timeline for the major milestones achieved via efforts on the technical project and STS project. (Lin, 2021)

AUTONOMOUS DRIVING SIMULATOR

With the rise of autonomous vehicles and new self-driving software being developed for many modern cars, there needs to be an efficient way to research the product without actually putting the vehicle on public roads. As “driverless cars are expected to be able to navigate

through messy everyday traffic without human supervision", the idea of a driving simulator tackles this issue along with solving other additional problems (Both, 2020, p. 9). A driving simulator allows for companies and researchers to test their self-driving software without actually putting a vehicle on the road. This is done by creating a simulation of the real world and creating various scenarios that the car would have to go through. Simulators are essential in the development process with companies such as Google putting their autonomous vehicles through "ten million miles every day on a virtual simulator" to test their effectiveness (Jensen, 2018, p. 582). However, driving simulators are used not only to ensure the vehicle would work as properly in a real world scenario, but also to collect data. This is done by inserting a human user into the "simulator to conduct a hazardous situation experiment" in order to collect data on human reaction time to compare to that of a vehicle (Han et. al, 2021, p. 523). This information can be leveraged to explain why self-driving cars are safer, but can also be used to teach the car's AI. For example, Tesla is tracking good drivers so that it can use "humans [to] help train its software on how to drive" with good habits (Siddiqui, 2021, para. 5).

The objective of this research is to further the research that previous groups have done for the autonomous driving simulator and advance it to become more realistic along with having more functions. It is to provide users a safe environment for them to simulate the experience of driving inside a vehicle that can be operated the same way as a traditional car as well as operated in a hand free driving manner. The driving simulator hopes to differ itself from other competitors by applying features that are more niche to the automotive world. This includes features such as a manual driving option for the users to test. The entire experience should be as immersive as possible and will replace the previous projectors with surrounding liquid crystal display (LCD) monitors inside an enclosed compartment along with a finished car interior which "includes a

driver seat, a steering wheel and accelerator/brake pedals (Shah, 2021) represented in Figure 2 . The software will be revamped in order to align with the new inputs in the interior and for the smoother outputs from the monitors. It is necessary to improve not only on the "precision mapping … and location technology" (Rowthorn, 2019, p. 38) but also focus on the communication between the vehicle's inputs and its surroundings in the simulation. Challenges that the project faces are converting the previous software used for the projectors to work with the monitors and to find a working AI that will be capable of representing the self-driving portion.

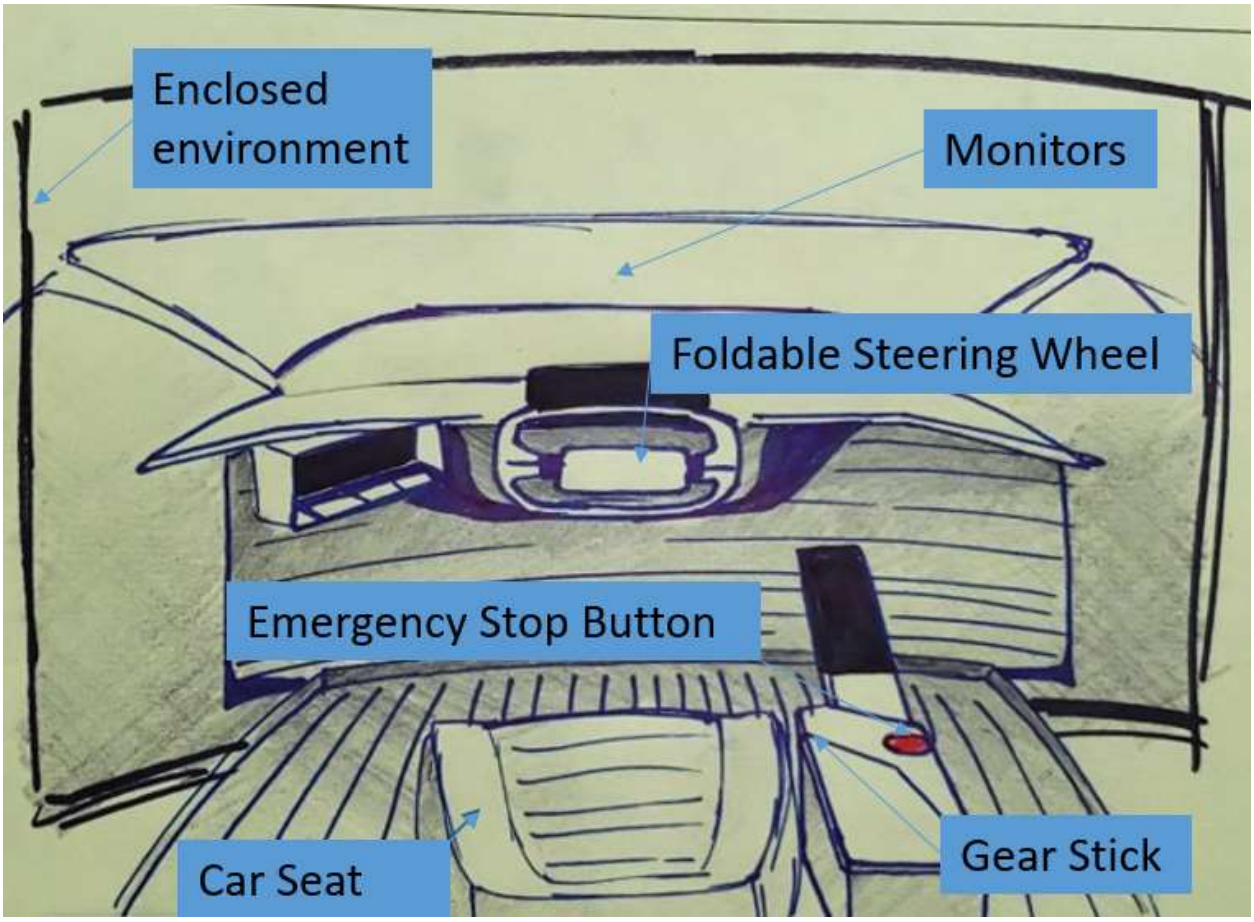

Figure 2: Proposed driving simulator. Depiction of proposed simulator consisting of an enclosure with surround monitors and car interior parts. (Adapted by Lin (2021) from Zhou et. al, 2018)

The autonomous driving simulator will be recreated along with new software and updated materials while keeping the majority of the initial design in mind and is sponsored by the DSpace. Resources dedicated to the successful completion of this project are the Observatory Mountain Engineering Research Facility laboratory space, Robot Operating System, Ubuntu, car input devices, computer, and self driving AI software. The project will be conducted under the guidance of Tomonari Furukawa, a professor in the Department of Mechanical and Aerospace Engineering at the University of Virginia, and Yuxiang Guan, a graduate student in the Department of Mechanical and Aerospace Engineering at the University of Virginia. The team members include Anne Forrest, Johnny Grant, Chet Kleppin, Andrew Lin, Mosed Saroor, Casey Welch who are each an undergraduate student currently studying mechanical engineering in their fourth year at the University of Virginia School of Engineering and Applied Science. The expected final product is a working driving simulator that allows for users to operate in the same manner as a regular car and will also have an autonomous feature for the vehicle in which users can experience a self-driving vehicle without being put into harm's way. This project will be documented in a technical report.

HOW AUTONOMOUS DRIVING AFFECTS THE SAFETY OF OUR SOCIETY

The problem of autonomous driving is not necessarily the actual vehicles and the software they use. It is the lack of trust that the public has for this technology because of their novelty. While many are excited about the positive outcomes these vehicles bring such as reduced accidents and traffic congestion, environmental benefits, etc, they also bring upon new risks related to safety, security, liability, and regulation (Anderson et al., 2016). If this concern continues, it is a possibility that these self-driving vehicles will not be able to be common among the roads. If not enough people will have the faith to become early adopters and this decades

long project will never reach takeoff depicted in Figure 3, millions of dollars and thousands of hours of research and innovation will be for naught.

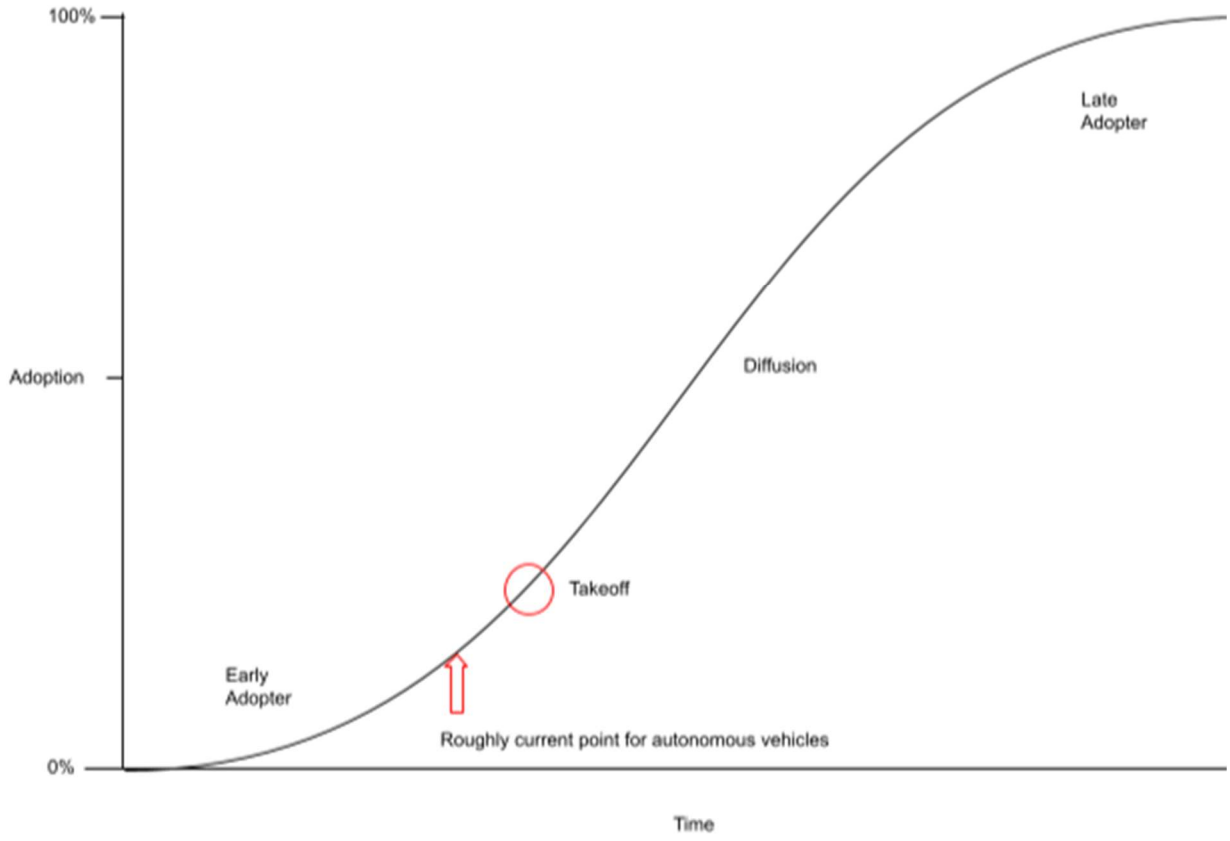

Figure 3: Diffusion curve. Depiction of diffusion curve and the current location of autonomous vehicles in the S-curve. (Adapted by Lin (2021) from Rogers et. al, 1996).

The objective of the research work is to create a functional driving simulator. This relates back to the STS research portion as creating the simulator will allow for users to take data points on just how safe their driving truly is. It can then be compared to actual self-driving vehicles which helps determine the safer option of travelling. This helps ease the general public's distrust of the reliability of these vehicles. Allowing for the simulator to take in data from humans that represent good driving habits also help the AI learn what choices to make in unpredictable scenarios. Teaching the software is essential as human drivers are “inefficient, dangerous”, and unpredictable, having roads mixed with both manual and autonomous vehicles may confuse the

computer leading to safety implications (Both, 2020, p. 103). It is also essential for companies to utilize this data and technology to further their own software as quickly as possible because the competition to build self-driving cars has spread world-wide (Townsend, 2020). Many well-known companies have started to take part in this race such as Uber, Google, Tesla, and those are just the largest in the United States. This increase in competition has resulted in many large companies improving their software at an astounding rate and without these simulators, a company may lose traction to others.

IS THE HINDRANCE THE CAR'S SAFETY OR IS IT HUMAN BEHAVIOR

Naturally, human nature is not fond of change for a multitude of reasons. The loss of control and excess uncertainty are two main contributors to this effect and is why humans avoid drastic change in their lifestyle (Kanter, 2012, para. 2). These self-driving cars cause both of these issues in the human psyche which is why there is immense pushback from certain actors in society against the use of autonomous vehicles as our daily drivers. There is also a "lower trust in" autonomous vehicles, and people want them "to be 4-5 times as safe" as their vehicles currently (Liu et. al, 2020, p. 700). This is because of the previous statement as they are losing their control over the vehicle so that they want the safety to be compensated drastically. Simulators help ease the other issue that society has against these vehicles as they help represent the expectations that users may have when riding in an autonomous vehicle. The immersed experience should be able to help them understand the safety precautions that these cars have and will help convince them to switch over.

The obvious concern of safety is the physical danger these vehicles pose, but hackers having access to "vehicle records… [along with] personal information" leaks information that may not be consensual (Collingwood, 2017, p. 35). This potential attack on the digital safety that

the users have has to be addressed by the software teams of these automotive companies. While the simulator will not be able to represent our digital safety being secure, users will have to trust in the companies to keep their information safe or companies will need an alternative method to show that their software is unbreachable.

Looking into the future, will society still have this same argument over whether autonomous vehicles are safe enough for the roads, or will we expect to see the opposite question on whether traditional driving should still be allowed for the same reasons of safety concerns. Autonomous cars at the moment are already advanced enough to be able to drive on their own but it is the laws and restrictions against fully driverless cars that are preventing them from being shipped out. Müller (2020) questions if manually driven cars should eventually be outlawed as in the future, “autonomous cars are likely to be much safer than manually driven cars” (p. 1552).

Through a study on various companies' software implementations and precautions for self-driving cars, the safety factor of these vehicles will be investigated and whether or not society's concerns are met. This will be done *via* the Social Construction of Technology (SCOT) framework pioneered by Trevor Pinch and Wiebe Bijker (Bijker, Hughes, & Pinch, 1987; Bijker & Pinch, 1984; Kline & Pinch, 1999). In the SCOT model, represented by Figure 4 on page 9, each group will provide a perspective that helps inform the companies’ engineers their values and expectations. This helps create an idea and allows the engineers to be able to work towards

and create a resulting product that will take into consideration aspects of all group's concerns.

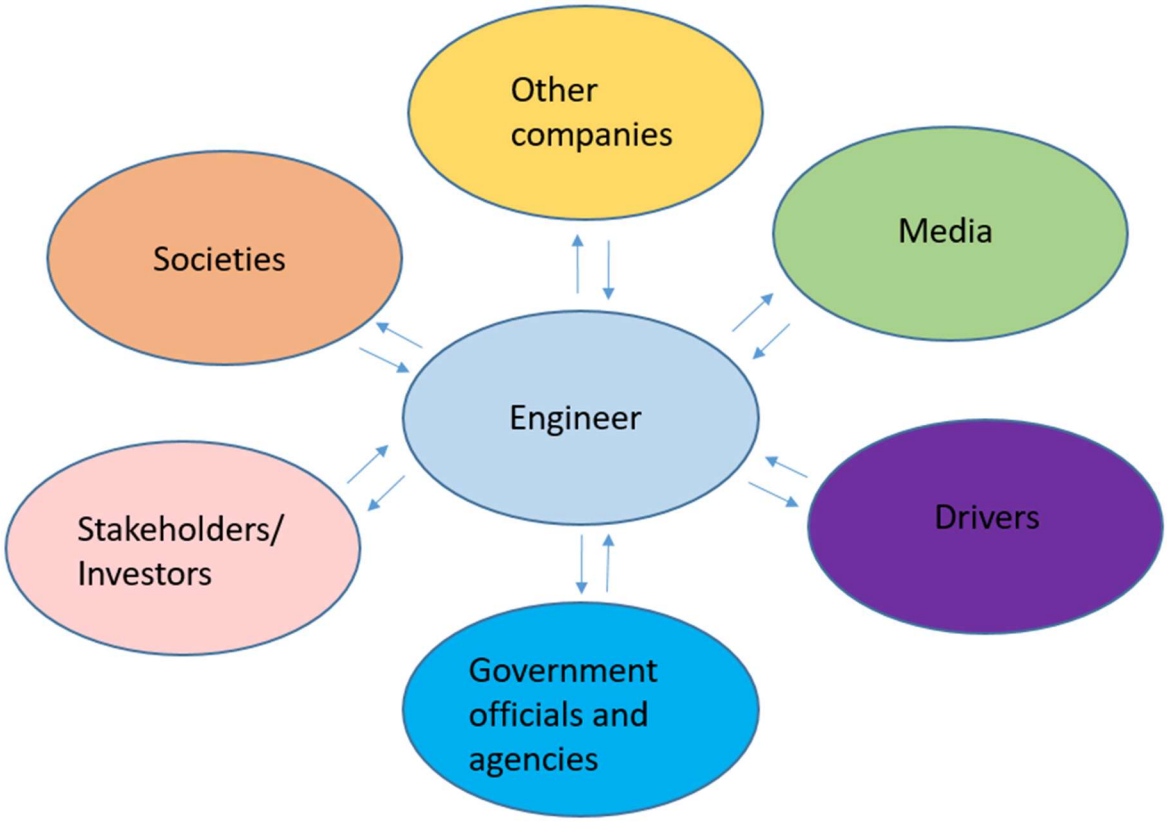

Figure 4: Autonomous driving SCOT model. The engineer negotiates between each social group to enable the incorporation of each group's values and goals. (Lin, 2021)

This research project will be in the form of a scholarly article which outlines the relationship between autonomous driving and the safety of society. It will attempt to demonstrate the lengths that companies take in order to ensure the safety of autonomous driving products as it affects all parts of society. By taking into consideration the values and expectations that various groups have for the design of these vehicles, a final product that will satisfy most of their concerns will be created. While there is much that the companies can do for the consumer in creating such a product that will be fool-proof, it is the customer's responsibility to be willing to try out the final products. By establishing whether it is the consumers' ignorance or the

companies lack of effort, it will be determined which group, if any, are the handicap that is preventing this product from reaching takeoff for diffusion.

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