# DEVELOPMENT OF AN AUTONOMOUS CAMPUS VEHICLE SYSTEM

## A DISCUSSION OF THE FACTORS OF AUTONOMOUS SYSTEMS LIMITING THE WIDESPREAD IMPLEMENTATION OF AUTONOMOUS VEHICLES

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By

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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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## Introduction:

*How are autonomous vehicles shaping and being shaped by our society?*

Autonomous vehicles, often hailed as the future of transportation, hold undeniable relevance in today's society. They promise to revolutionize mobility by enhancing safety, reducing traffic congestion, and offering greater accessibility to individuals with disabilities or limited mobility. Moreover, autonomous vehicles can potentially decrease carbon emissions through optimized driving patterns and efficient use of energy resources, contributing to environmental sustainability. However, alongside these advantages, several disadvantages loom on the horizon.

One significant concern about autonomous vehicles is data privacy and security, as these vehicles collect vast amounts of sensitive information about passengers' movements. Safeguarding personal data and ensuring passengers' privacy in an era of constant connectivity is paramount. In relation to this issue, autonomous vehicles employ an array of sensors and cameras, which increase the necessity for data security. Improper security could lead to issues in surveillance, which could drastically limit the acceptance of this new technology. In addition to these challenges, there are ethical dilemmas to address, such as how autonomous vehicles and artificial intelligence should prioritize passenger safety in situations where harm to pedestrians or other drivers is unavoidable. Striking the right balance between passenger safety and minimizing harm to others is a complex and multifaceted issue that necessitates careful investigation.

The confluence of technological, societal, and ethical considerations forms the heart of our research. As we delve into the specific technical and STS projects, we aim to understand not only how autonomous vehicles are being developed but also how they are influencing and being influenced by our society. Our overarching goal is to explore the ways in which autonomous vehicles can be harnessed to create a safer, more just, and equitable society.

## Technical Research Problem: Development of an Autonomous Campus Vehicle System

*How can a platooned golf cart system be implemented on Grounds to decrease transportation issues for both staff and students?*

My technical project focuses on the development of an autonomous campus vehicle system. Since this is an ongoing project, last year the team assembled two autonomous golf carts that were almost capable of driving in a process called platooning. Platooning consists of one lead car and one or more follower cars. The lead car is operated either manually or autonomously with predefined directions. As suggested by the name, the follower cars follow the lead car by mimicking the steering, acceleration, and braking of the lead car (Fakhfakh et al., 2020). Although last year’s team developed a process to allow the follower cart to replicate the

movement behaviors of the lead cart at a specified delay time, their process is not desirable as it cannot account for accumulating inconsistencies in the follower cart's path.

In order to remedy this error, my team's first goal is to implement a probabilistic distance approximation system to improve the cart's platooning. Instead of simply mimicking the lead cart's behaviors with a time delay, probabilistic distance approximation bases the follower cart's movement based on circle trajectories at a fixed point in space, thus creating uniform direction vectors between carts (Srinivasu et al., 2021). This process begins with ensuring the carts from last year are still in working order. Over time, various parts on the carts have failed, so these parts must be identified and repaired before further progress can be made. Next, we will install new LiDAR sensors to improve each cart's tracking abilities. Finally, we will install the new platooning code into each cart's computer. Our second main goal is to assemble a second follower cart. With only one functioning follower cart from last year's team, platooning is not significantly beneficial. By adding a second follower cart, our platoon will be three carts long, which will noticeably improve our system's transportation capacity. Our team's third and final goal is to integrate various new technologies into the vehicles assembled by previous teams. The first of these new technologies is adaptive cruise control. Currently, the previously assembled golf carts perform platooning maneuvers simply by mimicking the behavior of the leader cart at the same time as the leader. Adaptive cruise control allows the follower carts to alter their speed and navigation using feedback control to more effectively enable platooning (He et al., 2019). The next new technology we intend to implement is a safety message system. Once these autonomous vehicles are implemented on Grounds, there must be a way to monitor the conditions of the carts to ensure the safety of those in and around these vehicles. One way to do this is through the integration of safety messages. The carts will constantly be broadcasting updates on speed, location, and general status to either a website or a central hub. These safety messages can then be used to monitor the condition of the carts.

An autonomous campus vehicle system at the University of Virginia holds immense importance in enhancing mobility for individuals with disabilities. Those with disabilities that prevent them from walking will then be able to use the vehicles to navigate Grounds more efficiently. This innovation not only promotes inclusivity and equal access to educational resources but also fosters a more diverse and inclusive campus environment, where everyone can fully participate in the university experience.

## STS Research Problem: A Discussion of the Opposing Actors to the Widespread Implementation of Autonomous Vehicles

*How is the connection between artificial intelligence and data security hindering the development of autonomous vehicles?*

Although the benefits of our autonomous vehicles are undisputed in the situation of my technical project, there are some aspects of this technology that cause some to be opposed to the incorporation of autonomous vehicles in today's society. Notably, the autonomous driving

system creates several red-flags for users, including data security and autonomous decision making. For my STS project, I plan to focus on these data security issues caused by the autonomous driving system and how they are increasing opposition to the adoption of autonomous vehicles.

There are several reasons why the autonomous driving systems in these vehicles have led to the opposition to the widespread use of autonomous vehicles in today's society. Firstly, due to the need for an assortment of sensors and cameras, there are concerns over privacy within and around these vehicles (Xie et al., 2022). Secondly, there are significant concerns surrounding data security and safety, as autonomous vehicles collect vast amounts of personal information, leaving room for potential breaches and misuse (Szűcs & Hézer, 2022). Lastly, the ethical dilemmas posed by self-driving cars, particularly in scenarios where choices must be made about protecting passengers or pedestrians, highlight the complex moral challenges these vehicles introduce (Bannerjee, 2021). These multifaceted concerns underscore the need for careful regulation, ethical frameworks, and comprehensive societal discussions before fully embracing autonomous vehicles in our transportation landscape.

## Background:

The rapid advancement of autonomous vehicles holds promise for revolutionizing transportation, yet several pervasive issues have emerged as formidable hurdles in their development. The most relevant elements to this sociotechnical system include the actual autonomous vehicles, the users of these vehicles, other individuals who interact with these vehicles in public, and the governing bodies that regulate autonomous vehicles. This study delves into the controversy surrounding the compromised security of autonomous vehicle data, the potential invasion of privacy through the extensive use of cameras, and the ethical ramifications of artificial intelligence-driven decision-making in critical situations. Key elements include the intricate networks of sensors, communication systems, and artificial intelligence algorithms governing autonomous vehicles. Understanding this sociotechnical ecosystem is crucial to navigating the complexities impeding the integration of autonomous vehicles into our society. As we explore these challenges, special attention will be devoted to the specific social groups affected, ensuring a comprehensive investigation that can inform effective solutions for the sustainable advancement of autonomous vehicle technology.

## Literature Review:

The current landscape of autonomous vehicle research reflects a high-potential field, yet critical challenges persist, necessitating a comprehensive investigation. Existing scholarship underscores the intricate relationship between technology and societal implications, offering insights into the need for an in-depth analysis of data security, camera privacy, and artificial intelligence decision-making within autonomous vehicles.

By analyzing the vulnerability of autonomous vehicles to data leaks, literature emphasizes the urgency of fortifying the security of these technologies against potential breaches (Nayak et al., 2021). Furthermore, significant analysis of the algorithms steering autonomous vehicles is necessary to determine their decision-making behavior in difficult, time-sensitive situations (Wang et al., 2020). The literature also suggests the potential encroachment of privacy through the extensive use of cameras in autonomous vehicles. Additionally, the delicate balance between innovation and privacy concerns is being tested as the necessity for sensors and cameras in autonomous vehicles leads to the potential for user surveillance (Xie et al., 2022).

While these sources offer valuable insights, the dynamic nature of autonomous vehicle technology necessitates a focused exploration to bridge gaps in the current understanding. The literature review thus establishes a compelling case for this investigation, asserting the need to address these critical issues hindering the seamless integration of autonomous vehicles into our sociotechnical landscape.

## Theoretical Framework:

This study adopts a theoretical framework rooted in Algorithmic Governance and Surveillance Studies within the broader field of STS. Algorithmic Governance explores how algorithms and artificial intelligence systems shape and govern sociotechnical systems (Katzenbach & Ulbricht, 2019). In the context of autonomous vehicles, this framework allows for an examination of how artificial intelligence decision-making influences the development and operation of autonomous vehicles, especially concerning data security and privacy. Complementing this, Surveillance Studies provide a lens to analyze the pervasive use of cameras in autonomous vehicles and the implications for privacy. This perspective helps unravel the sociotechnical aspects of surveillance technologies integrated into autonomous vehicles and their impact on the social groups involved.

By intertwining these concepts, the research aims to scrutinize the interplay between artificial intelligence decision-making, data security, and surveillance in the context of autonomous vehicles. This theoretical framework provides a nuanced understanding of the sociotechnical landscape, emphasizing the roles of artificial intelligence and data surveillance in shaping the development and societal integration of autonomous vehicles.

## Investigation Methods:

To address my research question, I will focus on analyzing case studies related to the autonomous vehicle issues that I have previously mentioned. The case studies will delve into specific instances of autonomous vehicle operation that highlight the current drawbacks of this technology. This includes cases that explore issues with data security, camera privacy, and critical autonomous vehicle decision-making incidents.

Additionally, I will analyze current regulations concerning autonomous vehicles to look for mentions of data security and autonomous vehicle operation. By identifying the valid

regulations that govern the autonomous vehicle industry, I will be able to further investigate the factors of these vehicles that I am discussing in this paper.

## Conclusion:

In conclusion, this research endeavors to unravel the sociotechnical dynamics surrounding autonomous vehicles. Through an exploration of data security, camera privacy, and artificial intelligence decision-making, the study aims to contribute valuable insights into the challenges hindering autonomous vehicle development. The goal is to establish a nuanced understanding of how artificial intelligence and surveillance technologies shape and are shaped by societal expectations and concerns. This STS lens not only offers a comprehensive examination of the current landscape but also lays the groundwork for subsequent technical research. Through my team's technical project, we will have the experience of developing an autonomous vehicle system, thus gaining more insight into the complexities of such a system. Ultimately, this research will contribute to a safer, fairer, and equitable integration of autonomous vehicles into society, considering the complex web of interests and motivations that shape our technological landscape.

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