**Prospectus**

# Pedestrian Safety Improvement Project, Rt. 301 Richmond

(Technical Report)

# Social and Technical Efficacy of Interconnected Multimodal Transport: An Integrated Commute

(STS Research Paper)

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**Technical Project: Investigating Pedestrian Safety Improvements, Rt. 301 Richmond**

**Introduction:**

The number of pedestrian injuries and fatalities keeps increasing year by year and according to the Governor's Highway Association, the numbers from 2019 are higher than they have been in the last 30 years (New Projection: 2019 Pedestrian Fatalities Highest since 1988, n.d.) (Annual Report, 2019). There is an ongoing societal responsibility to address pedestrian safety issues by considering alternative infrastructure changes, societal attitudes, and technological tools to keep vehicles and pedestrians from unwantedly crossing paths.

This project takes this broad focus on pedestrian safety improvements and focuses the lens on one corridor in Richmond, VA. The corridor, on Route 301, Jefferson Davis Highway, just south of the state's capitol, has already sustained multiple pedestrian fatalities in the current calendar year (as of August 2020). In the last year alone, two people have been struck and killed by a car on this stretch of the highway (Richmond Times-Dispatch, 2019) (NBC 12 Newsroom, 2020). From a pedestrian safety perspective, the corridor's characteristics are anything but safe: it's a high speed roadway with long distances between cross-streets which lacks pedestrian infrastructure such as sidewalks.

Another reason for our focus on this area is that it is economically disadvantaged. The median household income was $41000 compared to $70000 for all of Virginia with 32% of the population of approximately 6000 living under poverty (Bensley, n.d.). This corridor also has businesses located on both sides of traffic as well as new bus stops that are inaccessible by pedestrians unless by vehicle or by crossing the large unmarked sections. As a result, there remains a critical need to address the equity issues in terms of access to transportation and pedestrian services (Bensley, n.d.).

Under the supervision of Professor Brian Smith and Marie Audrey Nerette, with the help of Ben Doran, Kevin O'Meara, and Thomas Ruff with Timmons Group, Ryan Barnett, Hanna Custard, Christopher Hume, Andrew Taylor, and I will examine the corridor's current operating state, and then investigate improvements to alleviate pedestrian incidents as best as possible. Any improvements will be considered, from roadway geometry, design changes, signage, and operations alterations, to other Intelligent Transportation Systems (ITS) technologies and future Connected and Automated Vehicles (CAV) considerations, to softer solutions such as public information campaigns. This will result in a new roadway design (the Civil Engineering side) and a more generalized pedestrian safety experiment (the Systems Engineering side).

The project's initial steps lie in a systems framework approach. We must generalize the question at hand, determine the normative and descriptive scenarios, and generate goals before determining criteria for ranking alternative solutions. The team, an interdisciplinary team of students from the Department of Engineering Systems and Environment (ESE) and the Department of Civil and Environmental Engineering (CE), have determined the main goals of minimizing cost, optimizing the road's Level of Service (LOS) for traffic flow, minimizing pedestrian incidents, and minimizing the effects of social and political forces on safety improvement (while minimizing the effects of potential alterations on social and political forces). All of this can be achieved by designing an appropriate complete road design, similar to what is seen in Figure 2 (Snyder et al., 2013). The ranking of alternatives will then be generated based on an ordinal system to be determined at a later date through correspondence with the client

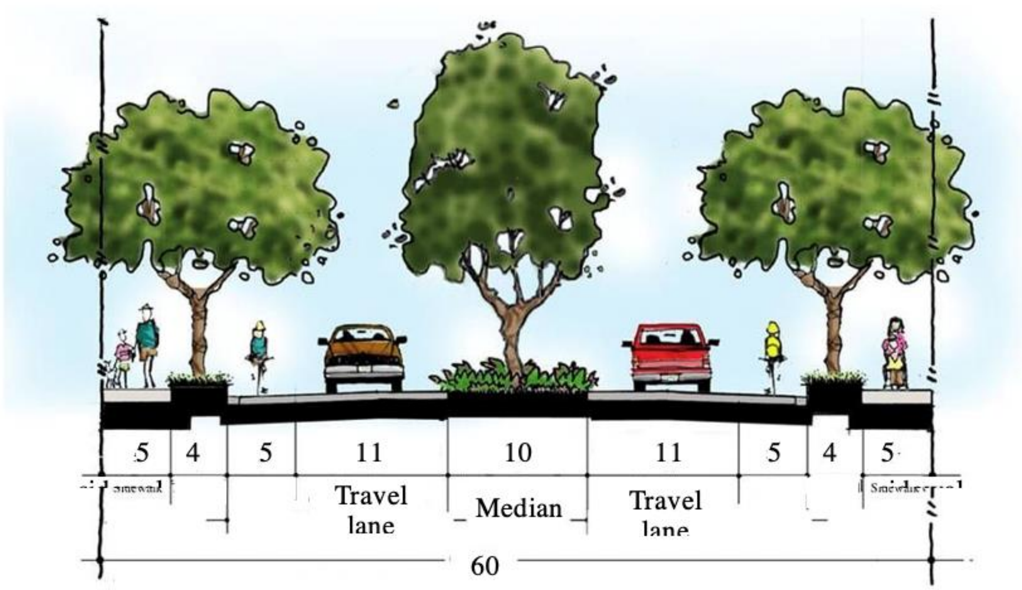


Figure 2: A visual representation of a complete streetscape including pedestrian infrastructure (Snyder et al., 2013)

(Timmons Group) and stakeholders which will allow for a clearer picture of the core value needed to make a decision.

The second stage of the project will involve research by the team on potential infrastructure improvements (CE students) and general technological adoption (ESE students). The CE students will begin developing a roadway plan in accordance with the given schematics and base map created through correspondence with the client Timmons Group; the ESE students will conduct a research experiment which attempts to determine pedestrian reaction to autonomous vehicle feedback at roadway crossings. The plan developed by the CE students is clearly applicable to the corridor in Richmond, however the experiment conducted by the ESE students is more geared towards researching the future impact of autonomous vehicles on pedestrian activity. The study conducted by the ESE students will compare pedestrian reactions in crossing the road between waiting for visual cues from a driver (a hand wave, nod, etc.) and technical cues from a mobile app when faced with crossing in front of an autonomous vehicle without a driver present. This will be tested in virtual reality to discover the connection between the pedestrian user app and the notification system, allowing the ESE students to gain insights into whether or not the notification system can be effectively used on autonomous vehicles to alert pedestrians. Again, although this study does not directly apply to the Rt. 301 Corridor in Richmond, it may drive future pedestrian infrastructure safety development and as such attempts to reach the end goal of providing roads which are both safe for pedestrians and efficient for drivers.

While the focused goal of this project is to improve pedestrian safety on a corridor of Route 301 in Richmond, as the alternatives will ideally do, such concepts will be applicable to other corridors nationwide. These improvements, if possible, may allow for other jurisdictions to draw from what was suggested and make pedestrian safety improvements themselves, allowing for the overarching goal of determining ways to improve pedestrian safety to be at least partially achieved.

**Social and Technical Efficacy of Interconnected Multimodal Transport: an Integrated Commute**

## Introduction

This paper will examine the efficacy of fully connected multimodal transport in cities through the potential evolution of related social and technical factors using the STS framework Social Construction of Technology (SCOT), and through research connected with the given technical project ("Pedestrian Safety Improvement Project"). SCOT asserts that technology does not determine human action, rather, human action shapes technological advancement. It holds that those who seek to understand the reasons for acceptance or rejection of a technology should look to the social world and its customs and development. This contrasts with technological determinism, which asserts that societies develop based upon the technologies that arise over time. The examination of the research topic based on the STS framework SCOT will be enlightened through undertaking the technical project, "Pedestrian Safety Improvement Project, Rt. 301, Richmond." The technical project aims to determine current and future methods of abating pedestrian/vehicle incidents globally through examining a corridor of Route 301 just south of Richmond, Virginia. Both geometric roadway upgrades and technological infrastructure improvements will be considered, with a research component studying possible future connected automated vehicle (CAV) technology and its impact on pedestrian safety. The development of CAV technology is intrinsically linked to improvements in multimodal transit, as the connection frameworks (vehicle to vehicle, vehicle to person, vehicle to environment) relate not only to personal vehicles, but public transit and any sort of dynamically planned transportation network. Studying these future developments will help understand the technological efficacy of interconnected multimodal transit networks. Based upon this construct of technological development through social development and through work on the technical project, this paper seeks to determine which social factors, if any at all, must adapt and advance to allow the continued technological development of interconnected multimodal transport systems.

**Multimodal Transport: what is it?**

Multimodal transport refers to "connectivity of more than one mode to a line haul in an urban area" (Kumar, Parida, Swami). If one commutes to work using multiple modes of transport, such as riding a bike to a train station and then taking the subway downtown, they are engaging in multimodal transport. One could think of a multimodal transit system in a major city constituted with walking, biking, cars, light rail, metro rail, heavy rail, buses, scooters, and (soon) eVTOL (electric Vertical TakeOff and Landing systems). As cities grow, and existing infrastructure fails to support transportation demand, new transportation modes organically form. Cities which once relied on spread out vehicle travel now may rely on buses, subway systems, and bicycles more so than before due to heightened population density and condensed roadways. These improvements, more likely than not, may have risen for different reasons and were developed using different initiatives. In some cases, different entities provide travel in the same city. What if a city which utilizes ridesharing, scooters, buses, subways, and bicycles, all provided from different entities public and private, employed a central planning system which connected all of these parts into one? This paper seeks to understand the conditions in which transportation development drives *towards* this concept, not necessarily *to* it, with a focus on the efficiency of the networks themselves and the benefits increased efficiency could bring to society. Continuous improvement of current commuting systems towards this concept of multi-mobility in large urban areas holds importance primarily due to two factors: the need for efficiency, and the global climate crisis.

## City Growth and Efficiency Concerns

More than half the world's population lives in cities, and projections indicate that urban areas will account for 60% of the global population by 2040 (Goetz, 2019). As cities continue to expand, their urban transportation systems atrophy immensely. Studying over 200 cities from 38 countries, it was found that over half of them registered 100 hours lost in congestion per driver per year; in the United States congestion costs in 2018 were estimated to be $87 Billion (Goetz, 2019). From an economic perspective, "the primary characteristics governing the qualitative interaction potential of metropolitans or large cities are the land use and transportation system taken in combination," (Kumar, Parida, Swami, 2013) meaning the economic prosperity of a metropolitan area, to an extent, relies on the potential of its transportation system. Hence, as cities grow the efficiency of their urban transportation system – the roadways and public transit systems that their citizens rely on – is paramount.

How may the problem of inefficient urban traffic be rectified? Making sure that public transit systems are as efficient as possible. Multimodal networks are the most efficient, as demand is spread across "nodes" (biking, buses, rideshare, etc.) reducing reliance on any one method of transport as roads become more congested with personal vehicle traffic, alternate modes provide a greater utility to the commuter. *Fully integrated* multimodal transit systems would find a way to connect all such "nodes" together into one platform, allowing for centralized trip planning, automation, and optimized routes for the user. One could imagine using the same app to plan a trip from home to work, allowing central payment for a bike to the train station, the train itself, and a rideshare from the train station in the same platform, which utilizes all possible "nodes" to produce an optimally quick and cheap trip. Such platforms do not vastly exist for *commuting* already, however strides have been made in the logistics industry. "Globalization requires firms to produce and deliver goods faster to customers; corporations must manage their supply chains and integrate their logistics systems more effectively." (Rondinelli, Berry, 2000) On a macro scale, global trade has forced companies to maximize efficiency (shipping using large automated warehouses, trucks, planes, ships, vans, etc). On a smaller (not small, but smaller!) scale, one could allude to the same concept but for large cities; globalization has forced companies shipping things overseas to rely on several modes of transportation, while city growth will force commuters to rely on multiple forms of transportation to get to work as fast as possible at the lowest cost. As cities grow, their current designs fail to keep up with the increase in vehicle traffic – vehicle traffic further increases pollution as well, harming the collective quality of life and adding further burden to the global climate crisis.

**Climate Change and Multimodal Transit**

The ongoing global climate crisis is one of the most socially significant crises of the 21$^{st}$ century. With many scientists warning of "existential threats" to humanity due to the crisis, it has become a single-issue voting topic for many Americans, and a talking point on both sides of the American political spectrum. With a general global attitude towards mitigating the effects of the crisis, there remain groups adamantly denying its effects. Therein lies a societal struggle back and forth between making sweeping (and costly) changes to end the crisis, and maintaining the global status quo and reducing expenditure. Increasing transportation efficiency – and thus, the development of multimodal transport systems – lies in the middle of this struggle. The transportation sector is responsible for roughly 70% of American petroleum use, which greatly increase harmful greenhouse gas emissions, and the 'movement of people' (as opposed to goods) makes up 70% of the transportation sector's total energy use and greenhouse gas emissions.

Automobiles and light trucks, combined with passenger air travel, account for almost *99%* of passenger-miles, and those three modes cumulatively make up roughly 92% of transportation energy use (National Research Council, 2010). This implies that in order to reduce greenhouse gas emissions, the American public should strive to move away from the current transportation status quo. In fact, according to the National Research Council the four main ways to reduce transportation-related greenhouse gas emissions are to:

1. **Reduce the total volume of transportation activity**
2. **Shift transportation activity to modes that emit fewer GHGs**
3. Reduce the amount of energy required to produce a unit of transport
4. Reduce the GHG emissions associated with each energy use

Multimodal transport, especially a centrally sourced transportation system, could show great promise in supporting those first two ways to reduce greenhouse gas emissions. There has been a decrease over time in the amount of people traveling in each personal vehicle – from 1.9 people in 1977 to 1.6 people in 2001 (National Research Council, 2010). Increasing the average vehicle occupancy could lead to reductions in total vehicle miles traveled, and thus greenhouse gas emissions. Currently, commuting only accounts for roughly a quarter of passenger trips, so carpooling strategies have limited potential; however, new connected ridesharing technologies and dynamic routing with more efficient vehicles may be used to disincentivize emissions-laden personal vehicle use in a multimodal system.

Regarding the second step, to shift transportation modes, the most widely discussed option with regards to the movement of people is “inducing people to substitute some of their driving with public transportation service, bicycling, and walking,” which are key tenets of multimodal transportation systems. The American Federal Transit Administration (FTA) in 2010 stated that “public transportation can reduce greenhouse gas emissions by providing a low emissions alternative to driving, facilitating compact land use, reducing the need to travel long distances, minimizing the carbon footprint of transit operations and construction.” In the same report, their research claims that transportation accounts for 29% of the United States’ greenhouse gas emissions, with personal vehicle transport making up 57% of that 29% (public transit makes up 10%). The true benefit of public transport in a multimodal system, however, “requires that the services be heavily used.” In most places currently, load factors are not high enough to make public transit services more energy efficient. Deviating from the current fixed route system which relies on passenger demand in specific areas, and moving towards a dynamic multimodal system which automatically plans the most efficient routes, may allow public transit to become the greenhouse gas emission reducer it has the potential to be. While more efficient public transport would not solely fix the global climate crisis, even in the United States alone, it is a significant piece to the overall puzzle. Thus, a more efficient, smarter, and cost-effective public transit system may prove beneficial in the fight against climate change.

Fixing the United States’ climate and expansion crises is clearly not as simple as replacing personal vehicles with efficient public transport in large cities. The technology to ensure efficiency would need to be put in place (bus systems are only emissions efficient when they have sufficient passenger loads, for example), and those living in cities would need to accept and use such systems. This paper will seek to understand the social pressures pushing towards and against such developments, and how technologies may develop or stagnate along with them.

**STS Framework: Social Construction of Technology**

Social Construction of Technology (SCOT) is a theory within the field of science and technology studies which argues, in contrast to technological determinism, that technology does not determine human action and development, rather human action and development shapes technological development. SCOT was developed as a response to technological determinism, and is known sometimes as technological constructivism. SCOT's assertions regarding technological development through social pressures are heavily paralleled by this paper's topic, focusing on the development of interconnected multimodal transport due to society's pressure for fixes for the climate crisis and need for efficient transport in growing metropolitan areas. The four key tenets of SCOT are as follows: interpretive flexibility, relevant social groups, closure and stabilizations, and wider context.

Interpretive flexibility in SCOT refers to the fact that each technological artifact and development may have vastly different meanings, interpretations, or repercussions for various social groups. A striking example relative to this paper is that of the contrast between public transit development for corporations and for governments local and federal. Corporations, seeing a potential for greater profitability, will seek to lobby advancements to comply with *their* full efficiency standards – theirs being speed and cost effectiveness. In the interest of saving money, companies with stakes in transit development may seek to cut development costs to trade off with speed – saving them money, but possibly leaving the most *energy efficient* solutions off the table. Governments, in contrast, may respond to constituent desires for reduced climate change effects, and require transportation developments to comply with some sort of global emissions standards. This forces a conflict to arise between corporations and constituent desires; while corporations may view transit efficiency as a cost saving measure, governments and their constituents may view it as a necessary *cost* to alleviate the effects of global warming, thus demonstrating interpretive flexibility.

The second tenet of SCOT, the relevant social group, focuses on how different groups with different interpretations arise through their interpretations. Tied in with interpretive flexibility, it is necessary to examine all stakeholders in technological development to determine their goals for the technology. Alongside corporations and governments lie constituents, commuters, development companies, climate scientists, engineers, journalists, and even those completely disconnected from the specific urban ecosystem in question – the effects of climate change, for example, are global, so some in different *countries* may feel strongly about technological developments in such an arena. Each relevant social group has a different goal they want to achieve from either developing or not developing such technologies – governments to respond to constituents in terms of increased transportation demand or climate change concern, corporations to profitability, commuters to cost and ease of use, development companies to profits, climate scientists to respond to climate change, engineers to develop new technologies, journalists to spout a narrative, and those who feel strongly about climate change to (in their mind) work to end it at all costs. Advancements in public transit will require debate and conversation amongst all relevant social groups until a consensus is reached on what development should occur.

The third primary tenet of SCOT is closure and stabilization, the process in which controversies may arise when there are different interpretations of the same artifact (interpretive flexibility). This tenet would focus on how relevant social groups would interact in the development phase due to their different interpretations – taking the government vs.

corporations' angle for example, certain government agencies may attempt to pass laws requiring emissions standards for transit, while corporations may lobby against it due to higher costs.

The fourth and final tenet of SCOT is wider context, necessitating investigation of the broader global order which would push societies towards these technological advancements. Societal pressure to alleviate the effects of climate change may be somewhat derived from doomsday scenarios from scientists warning about existential crises occurring, for example. It is important to understand the context and reasoning behind different groups' interpretations of new technology before examining their interactions between each other in the development phase of such new technologies.

**STS Research Paper Plan**

The STS research paper will intend to investigate the feasibility and necessity of interconnected multimodal transport in isolated urban spaces. The feasibility of such systems will rely on the SCOT frameworks' suggestion of whether or not social pressures will drive such developments, as the systems will rely on the possibility for technological advancement which is only possible, due to the large scale, with societal support. The necessity of such systems will heavily rely on the relevant social groups' interpretive flexibility of them, heavily drawing from SCOT. Would society deem something like this necessary enough to commit a significant amount of tax funding? More specifically, does the impending impact of climate change – or other driving forces – justify a significant investment of time, effort, and capital by corporations, governments, and constituents into planning and developing the necessary technologies for interconnected multimodal transport? I will investigate these questions by looking at current multimodal systems and their impact on the localities they serve, as well as public opinion surrounding them and their development. It will also be important to research the potential technologies involved, and whether or not it is realistic for them to be developed. Research regarding multimodal transit's impact on city growth will be conducting using literature such as "Transport challenges in rapidly growing cities: Is there a magic bullet?" (Goetz, 2019) and "Performance Evaluation of Multimodal Transportation Systems" (Kumar, et. al. 2013) while study of multimodal transit's effects on climate change will be done using literature such as "Advancing the Science of Climate Change" (National Research Council, 2010). Researching and understanding past societal reaction to transportation and climate change-abating technologies will be critical to understanding the responses by relevant social groups to a concept like multimodal transport. Technological information will ideally be derived from correspondence with technical advisor Brian Smith from the department of Engineering Systems and Environment, and through discussions with industry contacts at Kimley-Horn and Associates and possibly Timmons Group.

**Conclusion**

With societies continuing to rapidly grow and move to urban, high pollution areas, and industrial emissions increasing in turn, a major problem in the 21st century will focus on ways to maximize efficiency of urban transportation networks in terms of both speed of commute and lack of greenhouse gas emissions. This paper will intend to investigate the potential social factors driving technological advancement in the multimodal transport arena, focusing on the problems society will face with regards to increased urbanization and climate change distress, and efficient multimodal transit's potential ability to decrease the negative affects stemming from these issues. Research regarding the potential for increased urban transportation efficiency could point towards technologies which may be adopted by state, local, or federal governments if pressured to reduce greenhouse gas emissions to combat the effects of climate change, or could provide assurance that transportation networks are moving in the right direction in terms of commute efficiency (or not in the right direction), providing insight to stakeholders looking to improve transit systems in major cities. It is possible that research will lead to the understanding that interconnected multimodal transit will have great benefits when it comes to urbanization and greenhouse gas emissions, or that the technology is simply too far from perfection and too expensive to implement, suggesting the necessity for short term or alternative measures to combat these sociotechnical issues. It is also possible that findings will be inconclusive, and the technologies are too infantile to comprehend their effects.

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