Prospectus

Remote-Sensing Enhanced Nondestructive Evaluation of Roadway Infrastructure
(Technical Report)

The Effect of Public Transportation Policy on Low-Income and Minority Communities
(STS Research Paper)

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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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I. Introduction

There are over 57,000 miles of roadways that need to be maintained by the state of Virginia and the Virginia Department of Transportation. These roadways are crucial to transportation efficiency and the daily lives of the public. Currently, national regulations only enforce the inspection of roadways every 5 years and the inspection of bridges every 2 years (Gee, 2007). Current methods are inefficient and accomplished by only using a variety of ground-based systems. These ground-based systems also have drawbacks, including traffic buildups, lane closures, and the fact that they are labor intensive. To improve the inspection process, the technical project will investigate remote-sensing enhanced nondestructive evaluation through the combination of the state-of-the-art that includes a combination of spacecraft, aircraft, and ground-based systems.

There has always been a connection between the decaying roadway and public transportation infrastructure in America and the growing economic and social inequality. The cities and the transportation systems used in American are highly automobile centric with roads created to maximize car speed and capacity, buildings surrounded by large parking lots, and highways and freeways allowing long distances between work, home, and shopping to become the norm. This system has absolutely allowed staggering economic growth but the lack of focus on public transportation and building infrastructure to support it has produced disastrous environmental and social impacts (Fleisher, Cohen, et al., 2020). This research seeks to understand the larger economic and social implications of transportation policy on low-income and underserved communities and examine the feasibility and effectiveness of proposed solutions to these issues.

II. Technical Topic

Current methods such as Visual Inspection, Acoustical Techniques, and Infrared/Thermal Imaging of roadway infrastructure inspection are inefficient and accomplished by only using a variety of ground-based systems. These ground-based systems have many drawbacks, including traffic buildups, lane closures, and the fact that they are labor intensive (Vaghefi, 2012). Additionally, they each have limitations such as invalid assessment of interior infrastructure, inaccurate testing, and limited usage (McGuire, 2020, para. 1-3). To improve the inspection process, the solution must include remote-sensing enhanced nondestructive evaluation through the combination of the state-of-the-art that includes spacecraft and aircraft. A satellite could send data to VDOT and allow them to focus on maintaining worn roads instead of repairing broken roads. This would create a more efficient system for the state’s roadways that would cost less, require less labor, and cause fewer transportation infrastructure delays.

Maintaining transportation infrastructure is vital for the wellbeing of the state and public. The collapse of bridges is extremely dangerous as shown by the death of 13 people when I-35W collapsed in Minnesota in 2007 (Twin cities.com). Although the collapse has led to reform in how infrastructure is inspected, those methods are now dated and could be improved for more efficient and less costly methods of inspection. Research indicates that as road conditions deteriorate, there are more collisions and accidents tend to be more severe (Alhasan, 2018). By sensing all transportation infrastructure continuously, it would be possible to identify which roads are deteriorating at faster rates and put more time and effort into these problematic areas.

Research indicates there are a variety of remote sensing options available with either drones or satellites that allow for remote sensing from air and space. A paper published by Devin Harris, a Civil Engineering Professor at the University of Virginia, and other contributors discusses the wide variety of sensors that is the focus of the technical project, including Synthetic Aperture Radar (SAR), Interferometric Synthetic Aperture Radar (InSAR) on satellites, and a sensor called Light Detection and Ranging (LIDAR) on drones (Ma, 2019). Another technique to assess infrastructure from space is three-dimensional optics, which is a technology that can provide depth and height information that cannot be obtained from only one image. This can be done by overlapping two images, taken from two different angles of an object, with at least 60% overlap when combined.

As well as satellites, there are also several types of Uninhabited Air Vehicles (UAVs) that could be used for evaluation of infrastructure, such as the tethered blimp, small imaging quadcopter, a micro quadcopter, and a hexacopter. The hexacopter would be the best choice for this technical project as it needs to be able to carry more weight for the different kinds of sensors. However, it does have a short flight time of 30 minutes.

Designing a system that will be able to see all the roads of Virginia and accurately determine which roads and bridges have damage will come with various challenges. Satellites are limited in what resolution they are able to detect, so current and affordable technology might not be within reach and an outside company may be required to fund the project. Drones are also limited by Virginia laws requiring them to be manually piloted, which greatly decreases the range they can cover in a day. Camera systems installed in vehicles through companies like MobilEye and Tesla could provide intel into transportation infrastructure usage and quality, but it may be difficult to gain access to the data. The most effective solution the project team has decided upon is to design a system with an overarching satellite that collects information on all roadways daily with a few drones or UAVs that can be sent to analyze the problematic areas in more detail.

III. STS Topic

Decisions about transportation policy and the funds directed towards it are rarely made with consideration toward low-income communities but these are the communities that are disproportionately affected by them. Car ownership in the United States is highly varied depending on socioeconomic status and race. According to Quamie (2011), 63% of households in the lowest real income quintile do not have access to a car. That number drops to less than 10% for higher income classes. Also, only 5% of white households are carless while 20% of black households, 15% of Native Hawaiian/Pacific Islander households, and 14% of Hispanic households are carless (Quamie, 2011). Yeganen (2018) found that access to jobs using public transportation instead of a personal automobile is statistically higher for low-income and non-White populations (Yeganeh, Hall, et al., 2018). Households that do not have access to a car are forced to use public transportation to reach their work, homes, and shops. Thus, the funding and maintenance of public transportation which regularly is neglected directly affects their ability to survive and thrive in their community. Beyond the decline in public transport services and increased cost of fares, the dependence on cars causes more accidents as well as increased noise pollution, nature and landscape costs, soil and water pollution, and energy dependency (Maibach, Schreyer, et al., 2008); all of these affect minority communities as well.

It is also important to examine other barriers to getting to work and shops as a resident that are exacerbated by public transportation in lower income communities. Over policing and high levels of crime in low income communities means that people are less reluctant to travel in them, especially at night. Businesses have higher insurance costs and break-ins with very little support from law enforcement. All these challenges lead to the closure of neighborhood businesses and deter new businesses from investing in the area. These gaps in key retails and service stores force residents to travel farther distances outside their neighborhood and purchase necessities. Low income families spend almost 40% of net income on transport (Clifton, & Lucas, 2004) so increasing costs of public transportation and the lack of transport to many areas present a special challenge to them. The only alternative to this is walking unreasonably long distances, disturbing work and travel patterns and inhibiting job searches.

An effective solution involves a multifaceted approach working towards tackling the root of the problem. Creating people centered streets and walkable areas will phase out car-centric places and make trips by walking or public transit easier. Compact neighborhoods where people live close to where they work, shop and play will cut down on transport times and cost. Beyond these changes, regions need to be tied together with high quality transit that is fast, frequent, and reliable and government policies need to be passed to support this shift. Lastly, on demand transportation services including e-bikes and shuttles need to be used to fill the gaps when transit is not available or provide an alternative to metros, subways, etc. (Fleisher, Cohen, & Amin, 2020). Studies have shown that those who move to neighborhoods where public transport is more available and locations are walkable are more likely to be carless by choice and opt for other modes of getting around (Klein, & Smart, 2019), showing the need for a transition to a system described. Providing redundancy in transit options using methods such as e-bikes and shuttles also allows the system to continue functioning effectively during crises. Using the example of the coronavirus pandemic, having redundant public transport systems allows those without access to cars, many of whom are essential workers, alternate ways to travel without risking overcrowded options.

There are many challenges to implementing these solutions. Current governmental structures and regulations are inherently rigid and slow to adapt to attempts to expand transport and mobility. Many of the solutions proposed would end up being the responsibility of the private sector and it is important to ensure that private companies are properly motivated and getting a return on their investments. However, the current method is unsustainable for many American people and these solutions will allow us to transition away from a car-dependent society to have a lasting impact on both social inequality and climate change.

This research seeks to understand the larger economic and social implications of transportation policy on low-income and underserved communities and examine the feasibility and effectiveness of proposed solutions to these issues. To do, it will examine the larger sociotechnical system of transportation infrastructure and policy. The technical project will focus on the technology associated with roadway infrastructure while the STS project will contextualize it within a larger system.

IV. Timeline and Expected Outcomes

The technical portion of the capstone will require a final fall semester presentation in December due to MITRE detailing our solution plan for the given problem statement. Following their critique, the class will decide whether it is feasible to continue with the three current problem teams the class is divided into or whether it would be prudent to down select to one or two. After this decision, the groups could potentially be rearranged, and a more in-depth solution plan will be created with specific parts and requirements outlined. The final deliverable will be an end-of-semester report encompassing the work done by the groups over the course of the semester and a guideline and plan for future capstone classes continuing this work.

Research on the STS topic will continue throughout the remainder of the fall semester and into the spring of 2021. A successful thesis project would examine the larger implications of policy decisions in roadway infrastructure and posit potential solutions for the issues found.

Both the technical project and the STS research paper will be completed by April 2021.

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