Prospectus

Remote-Sensing Infrastructure

(Technical Topic)

How does decaying and substandard transportation infrastructure affect marginalized groups such as people with disabilities and people of color in America?

(STS Topic)

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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I. Introduction

Transportation is key to the nation's quality of life and economic development. Transportation infrastructure affects congestion on roadways, traffic collisions, and the public's everyday quality of life. Both public and private infrastructure sectors need to recognize and take action to meet their responsibility to the public or risk the negative effects that would affect every aspect of an American's life. Specifically, this system could be contributing to systemic inequality in the country. To attempt to improve the transportation infrastructure of the Commonwealth, this technical project aims to identify and integrate space, air, terrestrial and maritime resources and apply them in new ways that address transportation efficiency in Virginia. If this project meets its objectives, the University of Virginia engineering undergraduate students and UIX-MITRE will provide new means to help solve transportation efficiency problems in Virginia.

This STS research paper aims to analyze how substandard and decaying urban transportation infrastructure affects the quality of life of historically marginalized groups of Americans, including people of color and people with disabilities. These marginalized groups have a higher risk of financial vulnerability which coupled with systemic discrimination in America leaves these groups with an undeserved disadvantage in almost every aspect of their daily lives. The STS portion will mainly focus on finding the correlation associated with the economic factors marginalized groups face and decaying or poorly designed urban systems causing a deficit in access to transportation and a break in their journey chain. The STS topic and technical project are tied by analyzing who in the public is most affected by transportation infrastructure and why lack of access may have a significant role in discrimination.

II. Technical Topic

There are over 57,000 miles of roadways that need to be maintained by the state of Virginia and the Virginia Department of Transportation (Kastenhofer, 2007). 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 of roadway infrastructure inspection 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 are labor intensive (Vaghefi, 2012). To improve the inspection process, the solution must include remote-sensing enhanced nondestructive evaluation through a combination of the current state-of-the-art for both 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 for cheaper cost, less labor, and with 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 (Astaneh-Asl, 2008). 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 on 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, says "Remote sensing technologies can be used to assess and monitor the condition of bridge infrastructure and improve the efficiency of inspection, repair, and rehabilitation efforts" (Vaghefi, 2012). The paper 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). Three-dimensional optics is a technology that can provide depth and height information that can't be obtained from just 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. These systems have been used for transportation infrastructure in Italy, California, and Michigan. There are several types of Uninhabited Air Vehicles (UAVs) platforms 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. Michigan used these UAVs by overlaying the images to detect cracks using an algorithm they created through ArcPy, a thermal analysis tool. The algorithm collected data by calculating the percentage of the area of the bridge that has cracks/spall. California used a UAV similar to the hexacopter that used Lidar technology to monitor areas that were environmentally sensitive during an infrastructure construction problem. Italy used optical data analysis through MATLAB to detect potholes and cracks. Drones are being sent into areas that might be dangerous for human inspectors, such as at heights or in areas with

moving heavy machinery (Danielak, 2019); while satellite systems, like InSAR, are being used to monitor the sinking of the Millenium Tower in San Francisco (Desnos, Foumelis, Engdahl, Mathieu, Palazzo, & Ramoino 2017).

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. Moreover, camera systems installed in vehicles through companies like MobilEye and Tesla could provide intel into transportation infrastructure usage and quality. 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 using a few drones or UAVs that can be sent to analyze the problematic areas in more detail.

III. STS Research

The STS research topic is on the role transportation infrastructure plays for people of color and people with disabilities. This role will be explored through actor-network theory (ANT), where decaying and poorly designed transportation infrastructure, both private and public sectors, marginalized groups, and their locations are the actors. The dynamic of the network that connects them is the focus of this research. Public transportation is dependent on the transportation infrastructure the American government provides such as railroads, highways, subways, and more. “Deteriorating infrastructure, long known to be a public safety

issue, has a cascading impact on our nation's economy, impacting business productivity, gross domestic product, employment, personal income and international competitiveness, (pg. 10)" warned the American Society of Civil Engineers, which has given US infrastructure a D+ grade (Fleming, 2016). The negative impact spreads beyond the economy and into the lives of the American people. Transportation has a tremendous effect on the quality of people's lives and lack of access may have a significant role in discrimination. This analysis is being conducted to understand in what ways historically marginalized groups, such as people of color and people with disabilities, feel the impact of that discrimination. It is important to understand that transportation infrastructure could play a role in the inequality these groups face in the US. Discrimination and polarization is also at an all-time high in America right now due to the current political environment. Equality itself is a value in American culture held at the highest levels for the nation; therefore, the lives and success of historically marginalized people should be a primary concern in this country. Creating accessibility and reducing rates of poverty for marginalized groups can increase general public health and is correlated with a stronger economy (Putnam & Feldstein, 2009). Therefore, stronger infrastructure for the country could mean a stronger nation as a whole. This STS research will attempt to identify the phenomena associated with how marginalized groups are affected by transportation frameworks and decaying infrastructure and how those frameworks may amplify the systemic discrimination in America.

Historically marginalized groups experience systemic discrimination in America leading to inequality in almost every aspect of daily life, including economic factors. People of color make up about 27.6% of the United States population and over-represent the percentage of families in low income households at 52% (Milner, 2013). People of color are

more likely to be below the poverty line due to institutional obstacles, such as limited work or advancement opportunities, inadequate school systems, the effects of generational poverty and other factors. As a testament to how people of marginalized groups are most affected by most systemic phenomena in the United States, people of color are experiencing some of the harshest effects for COVID-19 this year (Pirtle, 2020). People with disabilities live with a higher risk of financial vulnerability than people without disabilities. As a group, people with disabilities appear to be particularly vulnerable financially due to: 1) reduced earning capacity often associated with functional limitations, 2) the often-substantial costs of accommodating these limitations, and 3) their high susceptibility to certain financial shocks (Batavia & Beaulaurier, 2001). These higher expenses can include personal assistance and transportation costs as these are barriers for people with disabilities using public transportation (Mitra, Palmer, Kim, Mont, & Groce 2017). For people with disabilities, any barriers in the built environment can prevent them from using public transport in the first place. For example, the lack of and poor quality footpaths, such as uneven surfaces due to cracks, were identified as a common issue. Lack of curb ramps or lighting can cause potential hazards. Furthermore, there is the idea of a journey chain which includes all the transportation and paths taken from when an individual leaves their home. If the infrastructure or environment along that journey chain creates any barriers it can be detrimental for the individual using that route (Park & Chowdhury, 2018).

Decaying infrastructure causes delays in networks such as the New York subway system which disproportionately affect people who are low income. Therefore, because people with disabilities and people of color are systemically trapped in poverty at higher rates, these transportation networks disproportionally affect marginalized people. This

hypothesis can be proven through the New York subway system. Even though subway users are riding the same trains and waiting in many of the same stations, commute experiences, including commute duration, vary widely. Using 2012-2016 data from the American Community Survey (ACS), lower-income areas and higher-income areas were plotted with their corresponding commute times, giving the conclusion that higher incomes are associated with lower commute times (Gorton & Pinkovskiy, 2018). A shorter commute is valued as more expensive because housing demand is higher in city centers where people work and want to live, hence paying higher costs for transportation efficiency. Subway riders with the longest commute times are also less able to substitute away from a troubled line because the next subway line or station may be very far away. In addition, workers traveling during off-hours are far more likely to be at the mercy of planned work for transportation infrastructure. Median household income against subway performance was plotted and concluded individuals from lower income areas must commit more time to avoid lengthy delays. As an area's household income declines, the length of extreme subway downtime spells increases. This result is a combination of the increased risk of experiencing downtime associated with a longer commute, the distribution of trains to which each block group has access, and differences in morning departure times (Gorton & Pinkovskiy, 2018).

In comparison to city centers where high-income housing pays for transportation efficiency, suburbanization has caused a "reverse commute" where bus schedules and capacity can no longer meet the needs of low-income commuters. The decaying and substandard transportation infrastructure patterns have become out of date in these areas. Transportation research that focuses on physical infrastructure like roads, bridges, and operations have elaborate testing facilities and research centers that spend many millions of

dollars annually. Although TEA-21 allocated $3.3 billion over six years for surface transportation research and development to ensure that the United States will be a world leader in these areas, only a relatively miniscule fraction of those funds is spent on research examining transportation's effect on poverty and social outcomes (Sanchez, 2008). There was also another study showing the lack of understanding the actors of location play in this system. City governments are unwilling to cater to the needs of poor communities, which as discussed earlier, often include marginalized groups. Cities refuse to use poverty mapping when planning for transportation upgrades which adds to inaccessibility and decaying transportation infrastructure in poorer areas (Grieco, 2015). These negative interactions between the actors only exacerbate the inequality and failure of the system surrounding transportation infrastructure.

This STS topic is the role that transportation infrastructure plays in inequality in the United States. The STS question is how does decaying and substandard transportation infrastructure affect marginalized groups such as people with disabilities and people of color in America. This question is significant as transportation has a tremendous effect on the quality of people's lives and lack of access may have a significant role in discrimination. To productively complete this research, a review of locations where marginalized groups are most affected by decaying transportation infrastructure will be done. This is necessary to have a working understanding of the effect that the neglected transportation infrastructure will have. Census data will be needed in order to look at poverty mapping and mapping of people of color and disabilities and compare the data to where decaying infrastructure is located. To find out which locations have decaying transportation infrastructure, I will research both rural and city infrastructure planning. To attempt to conceptualize and quantify

the negative social and economic effects caused by the failing frameworks, I will research interviews and first-hand accounts of people of color and people with disabilities who have been affected by failing infrastructure. I will continue to draw on the correlation between marginalized groups and higher poverty rates and then overlay those factors with neglected transportation systems. With these details, it should be conclusive whether or not transportation infrastructure helps to amplify the systemic discrimination in the United States.

IV. Timeline and Expected Outcomes

If this technical project meets its objectives, the University of Virginia Aerospace Engineering and Mechanical Engineering undergraduate students and the UIX-MITRE Space Initiative will provide new means in order to help solve transportation efficiency problems in Virginia. The following steps will hopefully be completed by the beginning of Spring 2021: engagement with key stakeholders, literature review and establishment of the state-of-the-art, refinement of the problem, development of solution requirements, identification of data streams, and a solution approaching development. After those steps are complete, the goal of designing and pitching a conference report and presentation to UIX-MITRE will be the focus of Spring of 2021. The anticipated outcome is a design to improve transportation infrastructure by creating remote-sensing evaluation options using a spacecraft or aircraft vehicle. Achieving better transportation efficiency will improve the quality of life for Commonwealth residents and improve transportation infrastructure.

The STS portion will mainly focus on finding the correlation associated with economic factors marginalized groups face and decaying or poorly designed urban systems

causing a deficit in access to transportation and a break in their journey chain. The STS topic and technical project are tied by analyzing who in the public is most affected by transportation infrastructure and why lack of access may have a significant role in discrimination. The STS paper aims at finding out how decaying and substandard transportation infrastructure affects the marginalized groups in America. This research will help in understanding the degree of effect that transportation frameworks have on discrimination and how those effects can be changed to begin dismantling systemic inequality in America.

References

Alhasan, A. (2018). Impact of Pavement Surface Condition on Roadway Departure Crash Risk in Iowa. *Infrastructures, 3*(14). https://doi.org/10.3390/infrastructures3020014

Astaneh-Asl, A. (2008, June 04). Progressive collapse of steel truss bridges, the case of I-35W collapse. In *Proceedings of 7th International Conference on Steel Bridges, Guimarães, Portugal*. www.steelbridges08.com

Batavia, A. I., & Beaulaurier, R. L. (2001). The financial vulnerability of people with disabilities: Assessing poverty risks. *J. Soc. & Soc. Welfare*, *28*, 142. https://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=2700&context=jssw#page

Danielak, M. (2019, September 16). *Drones improve safety of infrastructure inspections*. Roads Construction & Bridge Design. https://www.roadsbridges.com/drones-improve-safety-infrastructure-inspections

Desnos, Y. L., Foumelis, M., Engdahl, M., Mathieu, P. P., Palazzo, F., & Ramoino, F. (2017). Sentinel-1 mission scientific exploitation activities. In *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)* (pp. 5521-5524). IEEE. https://doi.org/10.1109/IGARSS.2017.8128254

Fleming, S. (2016). US infrastructure decay forecast to cost trillions. *Financial Times*, *10*. https://tinyurl.com/y5n3cxhc

Gee, K.W. (2017, June 06). *Highway Bridge Inspections*. U.S. Department of Transportation. https://www.transportation.gov/testimony/highway-bridge-inspections

Gorton, N., & Pinkovskiy, M. L. (2018). *Why New York City Subway Delays Don't Affect All Riders Equally* (No. 20180627). Federal Reserve Bank of New York. https://ideas.repec.org/p/fip/fednls/87262.html

Grieco, M. (2015). Poverty mapping and sustainable transport: A neglected dimension. *Research in Transportation Economics*, 51, 3-9. https://doi.org/10.1016/j.retrec.2015.07.002

Kastenhofer, I. O. (2007). What is at Stake? Examination of Virginia Department of Transportation's Land Development Functions. *Transportation research record*, *1994*(1), 43-50. https://doi.org/10.3141%2F1994-06

Ma, P. (2020, May 18). *Eyes in the sky: How satellites can monitor infrastructure health.* The Conversation. https://theconversation.com/eyes-in-the-sky-how-satellites-can-monitor-infrastructure-health-117216

Milner IV, H. R. (2013). Analyzing poverty, learning, and teaching through a critical race theory lens. *Review of Research in Education*, *37*(1), 1-53. https://doi.org/10.3102/0091732X12459720

Mitra, S., Palmer, M., Kim, H., Mont, D., & Groce, N. (2017). Extra costs of living with a disability: A review and agenda for research. *Disability and health journal*, *10*(4), 475 484. https://doi.org/10.1016/j.dhjo.2017.04.007

Park, J., & Chowdhury, S. (2018). Investigating the barriers in a typical journey by public transport users with disabilities. *Journal of transport & health*, *10*, 361-368. https://doi.org/10.1016/j.jth.2018.05.008

Pirtle, W. N. L. (2020). Racial capitalism: A fundamental cause of novel coronavirus (COVID 19) pandemic inequities in the United States. *Health Education & Behavior*. https://dx.doi.org/10.1177%2F1090198120922942

Putnam, R. D., & Feldstein, L. (2009). *Better together: Restoring the American community*. Simon and Schuster.

Sanchez, T. W. (2008). Poverty, policy, and public transportation. *Transportation Research Part A: Policy and Practice*, 42(5), 833-841. https://doi.org/10.1016/j.tra.2008.01.011

Vaghefi, K., Oats, R. C., Harris, D. K., Ahlborn, T. T. M., Brooks, C. N., Endsley, K. A., & Dobson, R. (2012). Evaluation of commercially available remote sensors for highway bridge condition assessment. *Journal of Bridge Engineering*, *17*(6), 886-895. https://ascelibrary.org/doi/abs/10.1061/(ASCE)BE.1943-5592.0000303