Prospectus

Remote-Sensing, Non-Destructive Evaluation of Roadway Infrastructure
(Technical Topic)

How the Production of Roadway Infrastructure in the United States led to the Destruction of Black Neighborhoods
(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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Introduction

You may have come across roadway infrastructure that has not been properly maintained which causes cracks, potholes, and sinkholes. This poorly maintained infrastructure, factor into the way one drives and could be the cause of accidents, late arrivals, vehicle destruction. The United States has about 600,00 roads and bridges (Vagehfi, 2012). According to, Abdulkadir Ozden (2016, p. 753), "Researchers indicate that 65% of the roadways are rated as 'less than good condition' and 25% of bridges require 'significant repair.'" More locally, there are over 57,000 miles of roadways that need to be maintained by the state of Virginia and the Virginia Department of Transportation (Virginia's Department of Transportation, 2019). 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). From an interview with Hanna Custard, Civil Engineering student at the University of Virginia, says that roads, in the US, are given a level of service, that is a letter grade ranging from A-F (Custard, 2020). Most roads have around a C average. Custard (2020) continues to say that roads are built with a 30-year design life and when this design life is up, it depends on policy makers to determine if the road needs maintenance, or if new roadway infrastructure is needed. Over a 30-year design life, inspecting roadway infrastructure every five years is not efficient in maintaining its structural integrity, which is a reason why many roads have structural flaws.

Current inspection methods of infrastructure usually require a significant amount of time and money to complete and can be improved with the use of remote-sensing technologies. The sustainability of infrastructure is challenged due to the rise of maintenance costs and reduction in public spending (Shaghlil & Khalafallah, 2018). Ryan Wall's *8 Ways Drones Are Lowering the*

Cost of Infrastructure Inspection (2020) says that current methods of inspection can cost from $500,000 to $1 million dollars, not including day operations, which varies from $2000 - $3500, or shoulder and lane closures, which varies from $500 - $2500 dollars (Wall, 2020). The implementation of remote-sensing technologies, such as drones, can provide more efficient results, while reducing costs and labor. Wall states that the use of a drone and infrastructure inspection saved about 40 percent of money compared to traditional methods (Wall, 2020). Also, the technology has "fast, reproducible, on-demand image acquisition," which provides a quicker means for providing data rather than time and labor being wasted due to current methods (Perroud 2020, para. 4-8). Other technologies such as satellites have the opportunity at being more efficient too. Hoppe (2016) analyzes the feasibility of satellites in infrastructure and says that it can act as an alternate or compliment to current methods to make the evaluation of infrastructure more efficient (Hoppe, 2016).

The project will offer a design a that has the capability of being a non-destructive, remote-sensing evaluation of roadway infrastructure, with the use of either drones, satellites, or a combination.

Remote-Sensing Technologies on Infrastructure

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 also have drawbacks, including traffic buildups, lane closures, and they are labor intensive (Vaghefi, 2012). Also, they each have limitations such as invalid assessment of the interior of the infrastructure, inaccurate testing, and limited usage (McGuire, 2020). To improve the inspection process, the solution must include remote sensing enhanced nondestructive evaluation, which can be accomplished with the use of

spacecraft and aircraft. A satellite could send data to VDOT and allow them to focus on maintaining worn roads instead of repairing broken roads. Henceforth, creating a more efficient system for the state's roadways for cheaper cost, less labor, and 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 (Vezner, 2015). 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, and other contributors 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, p. 886). 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 just be obtained from 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 which is 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 (Meyer, 2016).

Designing a system that will be able to capture images of 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 with a few drones or UAVs that can be sent to analyze the problematic areas in more detail.

Roadway infrastructure provides a safe, efficient way to travel to different destinations and they must be maintained for the feasibility of the end-users. However, this technological advancement that we all seem to know for its transportation qualities has been used to segregate and discriminate against people of color, specifically persons of African descent. The next section reviews how infrastructure planning resulted in the destruction of black neighborhoods.

Infrastructure and the Destruction of Black Neighborhoods

Since the early 1940's roadway infrastructure has been developed to account for the number of cars that people were purchasing. Alana Semuels (2016) uses an analogy in *The Role of Highways in American Poverty* that explains the reason behind the mass production of roadways. She says that policymakers thought that cities function as human bodies. The bodies had a disease, which were the amount of people buying cars. Due to the number of people who were moving and travelling to the suburbs of cities, a technological system needed to be created to transfer people from the heart to the body. Because of this, traffic was formed, and the cure was deemed to be the production of highways (Semuels, 2016). Blacks were amongst people who were unable to move to suburbs due to loans being denied, and refused jobs, which is a process called redlining. Therefore, this left part of the city overpopulated with black people. Furthermore, city makers thought that the overpopulation was a problem and, in many cities, built infrastructure through these neighborhoods, clearing people of color from them (Semuels, 2016). In this example, infrastructure can be seen as a tool of destruction. The social dimension of my project will analyze how infrastructure planning destroyed black neighborhoods.

Infrastructure has more than a technological purpose and affects a specific social group negatively. There are many documented instances which proves that infrastructure is typically built-in low-income areas, typically where the population of black Americans are high, segregating them from higher income neighborhoods, and destroying their sense of community. A specific instance of segregation occurs in Detroit's 8 Mile neighborhood in the 1940's where a wall was built to segregate black Americans from a white neighborhood (Miller, 2018). Capturing the audience with a personal story of an 8-mile community native from Detroit, Teresa Moon, Miller outlines how she had no clue of the purpose of the wall built in her community. As she got older, she realized it was built in the 1940's in order to segregate two communities of different race. An occurrence of when infrastructure destroyed a neighborhood is seen in the mid 1950's when President Eisenhower enforced the road building campaign.

The plan, as outlined by President Eisenhower, would urbanize rural areas due to the increase of roadways, and would provide jobs in construction and manufacturing, therefore acting as a needed tool. However, African Americans were negatively affected by these implementations of the Interstate Highway System because typically the roadways built, were built through black communities, destroying that sense of community (Karas, 2015). Riots broke out in Tennessee once it was announced that interstates would be built in the city of Memphis, while destroying a park in the process. Protestors were able to convince the city's policy makers to not destroy the park and therefore, they decided to build through black neighborhoods, therefore destroying a sense of community and safe haven for blacks. One can see that this technology has deep social aspect because it has the power in governing what happens to a community, which can be further analyzed under the framework of techno-politics.

I will be analyzing the destruction of black neighborhoods caused by infrastructure under the framework of techno-politics because I would like to highlight prior literature in showing how technology has politics, and how it can govern social groups. In *Does Artifacts Have Politics,* Winner (1980) argues that artifacts have politics by giving two case studies as evidence. He says that artifacts can either be designed in order to solve a problem in a community, or that they require, in order to survive, political relationships. Winner supports these claims with two case studies, and one focuses on the design of bridges that resulted in the exclusion of minority groups from recreational areas. Winner draws from Robert A. Caro's biography of Robert Moses and offers evidence of Moses' social class bias and racial prejudice and how that informed the bridge design. Moses specifically built highways and bridges in hopes of prohibiting blacks and poor people from enjoying the benefits from recreational areas in Long Island, New York. Winner says that architectures and other planning of cities and public areas can provide many examples as to how physical arrangements can contain implicit or explicit political purpose (Winner, 1980, p.124). Winners claims and perspective on technology can be seen in other examples such as the Detroit Mile Neighborhood, or the black neighborhoods in Tennessee. These examples show how technology exert political will and control segments of the populace differently through the design of technological infrastructure.

Research Question and Methods

The research question that will be investigating is: How has the production of roadway infrastructure in the United States led to the destruction of black neighborhoods.? This problem is important because it shows how the black citizens of the United States have been oppressed and discriminated against no matter the circumstances. Growing up as a Black man in the United

States, I think that it's a duty to address the pain and suffering of the ones who resemble me. It is important to gather numerical data in order to make this argument valid in hopes for change.

I will conduct interviews and analyze case studies in order to support my research question. One case study that I would like to exam is the destruction of Vinegar Hill, a predominantly black community in Charlottesville Virginia. In 1965, the city of Charlottesville decided to destroy this community, as it was located in between the University of Virginia, and downtown (Smith, 2017). With this destruction, came the development of more roadways and better-developed homes. I will conduct an interview with Kathy Johnson Harris, a former resident of this community, and use her story to strengthen my claims. Thus, I will have a mapping/geographical analysis depicting the neighborhoods in Charlottesville by race, which will show that Vinegar Hill has little to no Black residents, proving that roadway infrastructure displaces Black communities.

Conclusion

There are concerns regarding both technologies such as, state laws, cost, and imaging accuracy. However, the project objective will be to design one of these technologies in hopes of making a more efficient evaluation of infrastructure. By providing detailed data of deficiencies in infrastructure in a shorter, and cheaper manner to VDOT will impact the society by reducing lane closures and traffic congestion. There is a concern that construction workers would be put out of a career if this idea was to be mass produced. However, ground evaluations are necessary in some cases for more detailed analyses. Overall, policies and regulations concerning autonomy would need to be established before these technologies are considered a solution.

My team and I expect for our technology to be able to provide around the same quality and quantity of data of current evaluation methods in a more efficient way. We expect that the

chosen technology be able to cover the state of Virginia. I expect to be able to provide data that will show the prejudices seen in infrastructure. Data would be provided showing that there tends to be a high concentration of black Americans living in the neighborhoods where infrastructure goes through. In conclusion, a technical and social analysis will be conducted on infrastructure proving that the current evaluations methods of infrastructure are inefficient and that they displace black Americans in society.

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