EVALUATION OF VDOT SAFETY SERVICE PATROLS TO IMPROVE VDOT RESPONSE TO INCIDENTS AND CRASHES

THE ROLE OF THE AMERICAN INTERSTATE SYSTEM IN REINFORCING RESIDENTIAL SEGREGATION IN URBAN AREAS

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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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With more Americans driving than ever, the American Interstate System is a critical part of our public infrastructure (Schaper, 2017). The vision for this system began with the growth of the automobile industry in the early 1930s (United States Department of Transportation, Federal Highway Administration [FHA], 2018). In 1944, the Federal-Aid Highway Act was passed (FHA, 2018). The act authorized interstate construction, but provided no funds for the project. However, public support for highways was growing rapidly and soon the Federal-Aid Highway Act of 1956 was passed. According to Stromberg (2016), this act stipulated that the remainder of the highway system should be constructed with "90 percent of the construction cost borne by the federal government" (The design of the Interstate system section, para. 8). The passage of the law meant that city planners had virtually no obstacles in constructing new highways and the network developed rapidly (FHA, 2018). Today, the Interstate System is over 40,000 miles long and spans across the country (FHA, 2018). Although the highway network provides many benefits, the system also poses many issues for the modern American. Of these issues, traffic congestion is one of the most costly. The objective of this prospectus is to highlight modern solutions to congestion problems and socially-motivated design choices made during the Interstate System's construction that contribute to the congestion experienced today.

The technical research studies the Safety Service Patrol (SSP) program launched by the Virginia Department of Transportation (VDOT) to manage congestion on Virginia roadways. The goal of the technical project is to optimize the operations of the patrols. The tightly coupled STS research examines the use of highway systems as a political tool to enforce residential segregation. The social objectives motivating the construction of the Interstate System led to traffic patterns that contribute to the high levels of congestion that modern Americans face.

ROUTE OPTIMIZATION FOR VDOT'S SAFETY SERVICE PATROL PROGRAM

The Interstate System today is plagued by constant congestion. The average driver loses 97 hours and $1,348 a year to congestion (INRIX, 2019). In addition to being costly, Zhang and Butterman (2014) report that "vehicle emissions have become the dominant source of air pollutants" (p. 307). Increased air pollutants contribute to a variety of health and climate problems. Thus, congestion poses a major economic, environmental, and health challenge to modern America. One of the major causes of congestion is traffic incidents (Cambridge Systematics, 2005). Traffic incidents are defined as any event that impedes the standard flow of traffic including by blocking travel lanes, distracting drivers, and causing secondary accidents (Cambridge Systematics, 2005). Virginia is significantly impacted by congestion issues due to the several metropolitan areas across the state and the rapidly growing population (Virginia Population, 2019).

To combat congestion, Virginia's transportation authority established the Safety Service Patrol program in the late 1960s (Virginia Department of Transportation [VDOT], 2017). The goal of the program is "safe, quick clearance [of traffic incidents] to reduce secondary crashes, [reduced] incident duration and [improved] travel time reliability" (VDOT, 2017, slide 3). Safety patrols follow pre-determined routes along major highways in Virginia in search of traffic incidents. Patrol vehicles can either detect incidents along their route or be dispatched to an incident that was reported to authorities through another channel. These routes were created using primarily anecdotal evidence and lack support from data (Porter, 2019). By using routes that are not optimized based on incident reports, VDOT has no guarantee that they are deploying patrols to the areas that are most in need of assistance. Therefore, a more in-depth analysis of the optimal locations to route patrol vehicles is necessary.

The technical research seeks to create optimized routes for SSP vehicles. The analysis will focus on I-95 and the connecting interstates, illustrated in Figure 1 below. An optimal schedule will minimize incident duration leading to decreased congestion overall. Incident duration refers to the amount of time that the incident is impacting traffic flow (Porter, 2019). The research team consists of seven fourth-year Systems Engineering students advised by Associate Professor Michael Porter of the Department of Systems Engineering. The team will approach route optimization in two phases of analysis. In the first phase, the team will evaluate the success of the patrol routes currently in operation. In the second phase, the team will work toward a schedule for the patrol vehicles. The final recommendations will be summarized in a conference paper to be presented at the 2020 Systems and Information Engineering Design Symposium.

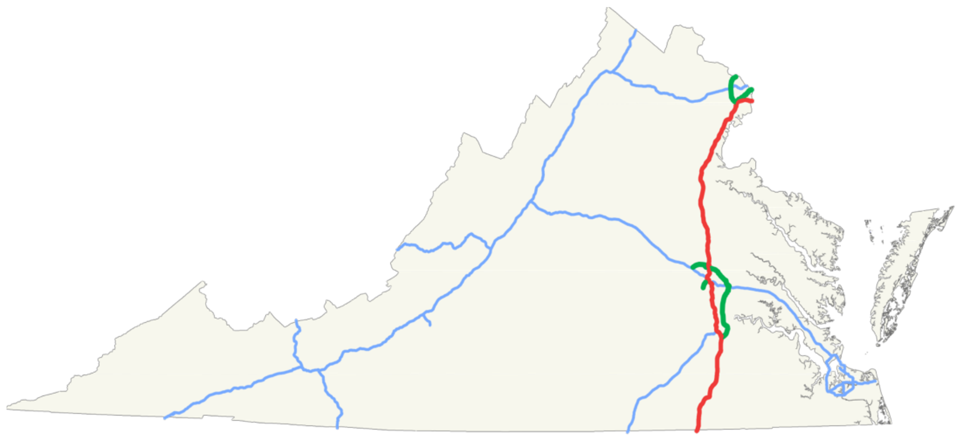

Figure 1: Interstates of Virginia: Map illustrates the interstate system in Virginia. The red indicates I-95; green indicates the connecting interstates which include I-195, I-295, I-395, and I-495; and blue indicates other interstates (Adapted by Emma Chamberlayne from 25or6to4).

By evaluating the current routes used by the patrols, the team hopes to provide evidence to department leadership and policy makers about the effectiveness of the program and to identify regions in need of increased SSP support. VDOT is considering expanding patrol coverage along I-95 and designating patrol vehicles as emergency response vehicles (Porter, 2019). Evidence supporting the program's success at minimizing congestion could help persuade lawmakers to fund these improvements. Further, an understanding of gaps in the current routes will inform the optimization analysis. The team has defined two core metrics that will be used to evaluate the routes: response time and clearance time. Response time refers to the amount of time between when authorities dispatch a patrol vehicle to an incident and when the vehicle arrives on scene. Clearance time is defined as the amount of time between when authorities are made aware of an incident to when all travel lanes are cleared for traffic. A successful route will minimize both median response time and median clearance time. Additionally, the team will investigate the times and locations of incidents and how well the current routes cover them. The team plans to present findings from this phase of analysis to VDOT no later than November 18, 2019.

In the second phase of analysis, the team will develop a model to optimally route safety patrol vehicles. The improved schedule will account for gaps in current routes and recommend new paths and operating hours in order to minimize the median response time and clearance time. The team will start by dividing the interstate system into one mile bins and calculating the risk of an incident in that bin for each hour of the day, for all days of the week. Determining the likelihood of an incident in each of these bins will allow the team to identify areas in need of safety patrol support. Then, the team will calculate the worst case travel times for each bin. Worst case travel time means a situation where an incident occurred immediately behind the patrol vehicle and the operator has to proceed to the next turnaround point in order to reach the incident and provide assistance. Combining these two sources of information, the team will build a model that routes patrol vehicles to high risk areas with minimal travel time. Patrol routes will be described by mile markers and time of operation.

The team’s objective is to deliver an optimized patrol route schedule by the end of the two-semester capstone course. The first iteration of the route schedule will be presented to Katie McCann and Daniel Truitt, VDOT personnel who manage the SSP program, by December 2, 2019. The process to develop the preliminary route schedule as well as comments from the members of the transportation agency will be summarized in an interim report which will be presented to the technical advisor and SSP team by December 12, 2019. The team will continue to iterate upon and improve the route schedule until March 2020. By April 15, 2020, the team will submit a conference paper with conclusions from the research to the Systems and Information Engineering Design Symposium and to the transportation department. The team does not anticipate a need for additional funding or resources outside of personal computers. The technical team members are: Bunny Campbell, Emma Chamberlayne, Julie Gawrylowicz, Colin Hood, Allison Hudak, Matthew Orlowsky, and Emilio Rivero.

RESIDENTIAL SEGREGATION AND THE AMERICAN INTERSTATE SYSTEM

With the expansion of the automobile industry and the rise of the suburbs in the late 1930s, Americans pushed for new infrastructure that would allow them to freely commute to the cities (Simek, 2016). The federal government soon backed the idea and provided funds to support the construction of the Interstate System (FHA, 2018). On the surface, the idea of a long-distance transportation network was novel. However, many city planners took advantage of the influx of funds to achieve a more ill-intentioned goal. Simek (2016) explained that the engineers of these highway networks saw them as political tools to change the urban landscape which lead to the "displacement, demolition, and economic disenfranchisement" of black communities (para. 3). The construction of the Interstate System disproportionately impacted "poor, often racially segregated" neighborhoods and was used deliberately to displace racial minorities (Simek, 2016, para. 3). In many cases, the highways were leveraged as a means to reinforce existing residential segregation or to create a newly segregated society.

BACKGROUND AND ORIGINS OF RESIDENTIAL SEGREGATION

Residential segregation is a well-established practice throughout the United States that began long before the vision for the Interstate System. Armstrong-Brown, Eng, Hammond, Zimmer, and Bowling (2016) defined residential segregation as "the physical separation of races in a residential context" (p. 2). Starting in the early 1900s, city leaders began using land use regulations to divide American cities on the basis of race. To quantify the degree of residential segregation as a result of these practices, demographers use index of dissimilarity (Logan & Stults, 2011). Index of dissimilarity refers to the spread of groups across census tracts within a city with a scale between zero and one hundred (Logan & Stults, 2011). Logan and Stultz (2011) explained that the value of index of dissimilarity can be thought of as the "percentage of one group who would have to move to achieve an even residential pattern" (p. 25). Regions with indices of dissimilarity above 60 are considered to be highly segregated (Logan & Stults, 2011). In 1910, the year the first racial zoning ordinance was passed, the national average for index of dissimilarity in urban areas was 56 (Massey, 2001). In 1940, this average rose to 78 (Massey, 2001). The increase in index of dissimilarity of 39 percent supports the claim that residential segregation became a defining feature of American cities in the early 1900s.

The deliberate separation of races has had profound impacts of the socioeconomic status and overall wellbeing of racial minorities in the United States. According to Armstrong-Brown et al. (2016), this practice often leads to "differential access to resources and societal opportunities" (p. 2). Residential segregation has in many cases led to the neglect of black communities, contributing to high concentrations of poverty in these neighborhoods (James, 1994). According to Jargowsky (2015), "a black poor person is more than three times as likely… to reside in a neighborhood with a poverty rate of 40 percent or more than a white poor person" (p. 6). This evidence supports the idea that black communities are more isolated and live in higher concentrations of poverty than white communities. Residential segregation has also contributed to fewer opportunities for upward mobility. Massey (2001) argues that "the way a group is socially incorporated into society" has significant impacts on how the group is included in the labor force (p. 392). By separating black communities from other parts of society, African Americans are often placed at a significant disadvantage when it comes to access to high-quality jobs (Massey, 2001). Additionally, the systematic separation of races contributes to decreased overall living conditions. James (1994) explains that African American neighborhoods with high concentrations of poverty experience "poor infrastructure, inferior schools, large numbers of single-parent families, and high exposure to crime and physical violence" (p. 408). These surroundings threaten the health and safety of those who live there. Further, there is evidence to suggest that residential segregation can limit outlets for physical activity which contributes to higher levels of diabetes (Armstrong-Brown et al., 2016). These findings demonstrate that residential segregation has profound negative impacts on African American neighborhoods.

Over time, city leaders have enforced residential segregation through land use regulations and later through comprehensive planning practices. Zoning and other forms of land use regulation were originally used as a tool to control the physical environment (Silver, 1997). However, zoning soon became a method for excluding racial minorities from certain regions of cities (Silver, 1997). Baltimore made history in 1910 as the first city to pass a zoning ordinance that designated residential blocks for specific races (Silver, 1997). This practice became known as racial zoning and quickly spread to the rest of the American South as well as many cities across the country. However, racial zoning was quickly challenged in court. In 1917, the Supreme Court declared zoning on the basis of race unconstitutional in the unanimous *Buchanan v. Warley* decision (Silver, 1997). While this ruling led to the end of explicit segregation by zoning ordinance, the concept of racial zoning continued in practice. Cities hired experienced urban planning professionals to develop comprehensive race-based plans that reinforced residential segregation (Silver, 1997). Purposefully planning highways in order to segregate communities became one of the methods leveraged by urban planners to replace racial zoning. The practice rose to new levels of prominence during the 1950s when the federal government began funding the majority of the Interstate System construction costs (Semuels, 2016, para. 7).

DIFFUSION OF HIGHWAYS AS TOOLS FOR SEGREGATION

The focus of the STS research will be on the origins of highway construction as a means to create racially segregated residential communities and how this practice diffused throughout the United States. The investigation into the use of the Interstate System to enforce residential segregation will be divided into two phases. The first phase will focus on uncovering the origins of the practice and how the meaning of roadway systems was transformed. Road systems are not inherently a political tool, but as Silver (1997) indicates these forms of transportation “served as a means to erect racial barriers as early as the 1920s” (p. 200). The use of road systems to achieve a political goal supports the theory of Langdon Winner. Winner (1980) posits that there are cases “in which the invention, design, or arrangement of a specific technical device or system becomes a way of settling an issue in the affairs of a particular community” (p. 3). In this case, the Interstate System represents the technical system which was arranged in order to curb Black encroachment, contain slums, and create distinct racial communities within American cities (Silver, 1997). Using Winner’s (1980) argument as a framework, the first phase of analysis seeks to establish that the Interstate System was deliberately arranged in order to “enhance the power, authority, and privilege of some over others” rather than provide an efficient transportation network (p. 5). Through this, the initial motivations for the use of the practice could be uncovered which will help to inform the final part of the research.

The second phase of analysis will focus on how and why residential segregation through highway construction spread across the country. The core framework for this analysis will be diffusion of innovation. Diffusion of innovation studies how an innovation spreads throughout a social network (Rogers, Singhal, & Quinlan, 1996). The primary focus of diffusion of innovation research is “innovativeness, defined as the degree to which an individual or other unit is relatively earlier to adopt than are others” (Rogers et al., 1996, p. 11). Individuals can be categorized into groups based their innovativeness. According to Rogers et al. (1996), these groups are: “innovators, early adopters, early majority, late majority, and laggards” (p. 11). The plot of the cumulative number of adopters versus time typically resembles an S-curve (Rogers et al., 1996). However, the diffusion pattern with the methodologies that preceded residential segregation through highway construction was unique. This pattern can be observed in Figure 2. Within seven years, the urban landscape in a majority of American cities was defined by racial zoning. Starting with the city of Baltimore in 1910 and culminating in the Buchanan v. Warley in 1917 decision, racial zoning diffused throughout the country rapidly. The cities that adopted racial zoning before it was declared unconstitutional can be considered the innovators. After the Supreme Court decision, a few new cities adopted race-based planning. These cities can be considered the early adopters. Then, the diffusion of residential segregation largely halts. This represents a deviance from the traditional diffusion of innovation paradigm. The diffusion of racial zoning provides a foundation for the diffusion of highways as a method to enforce residential segregation. This research hopes to establish the timeline for the diffusion of this practice. Additionally, Wejnert (2002) expanded on the concept of diffusion of innovation with her framework for "integrating the array of variables defined in diffusion research to explicate their influence on an actor's decision to adopt

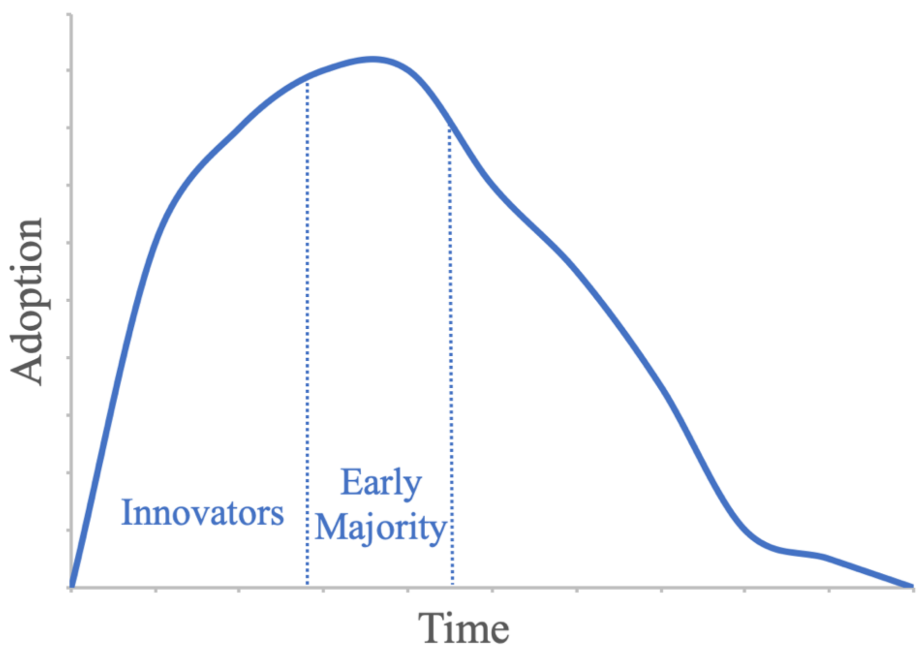

Figure 2: Diffusion of Racial Zoning: A curve representing the adoption process of racial zoning over time (Adapted by Emma Chamberlayne from Rogers et al. 1996).

an innovation" (p. 297). Figure 3 illustrates the core variables that make up Wejnert's framework. Wejnert's emphasis on both collective and individual actors will heavily inform the

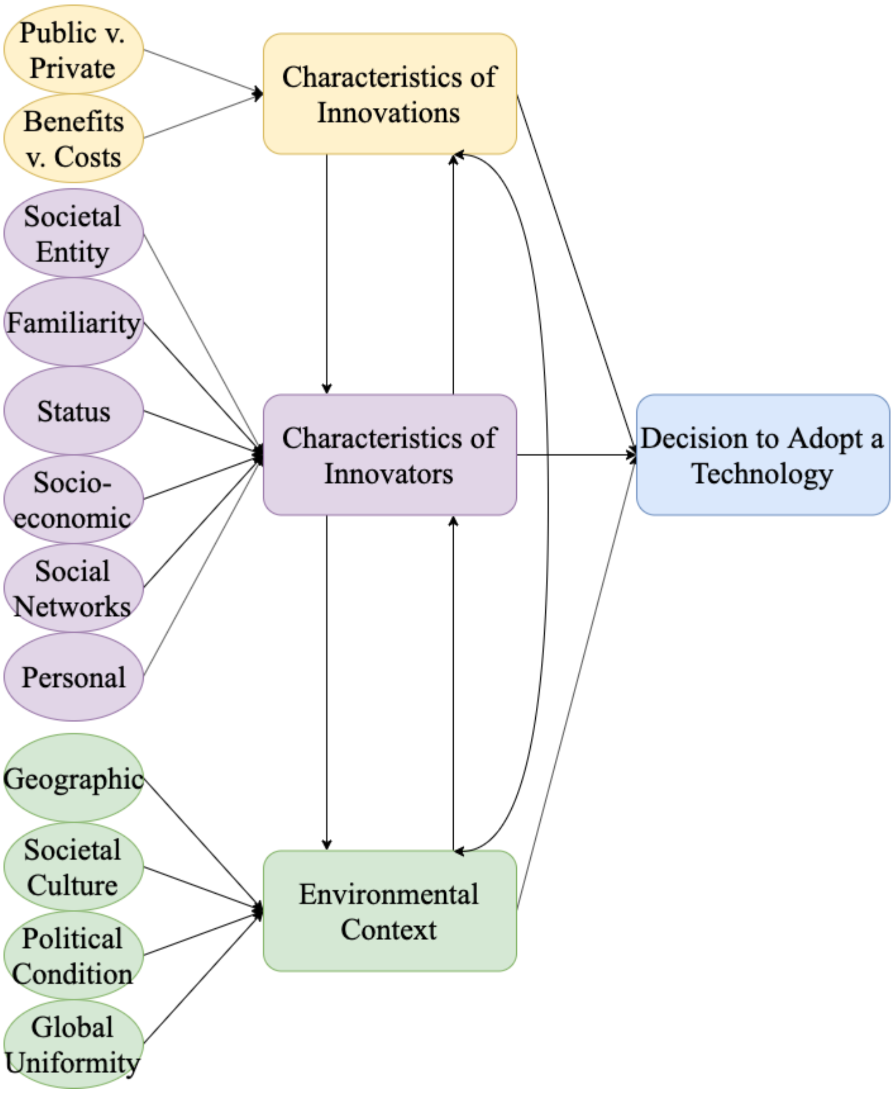

Figure 3: Variables Influencing Diffusion: A graphic representation of the variables discussed in Wejnert's conceptual framework (Adapted by Emma Chamberlayne from Wejnert 2002).

STS research as the adoption of residential segregation through the construction of the highway system took place at both the collective level, in terms of cities where the system was built, and the individual level, in terms of the city planners who implemented the plans.

The findings of the two phases of analysis will culminate in a scholarly article to be completed by April 2020. These findings could also provide new insights into modern movements to reverse the impacts of the construction of the Interstate System. By understanding how the Interstate System came to be wielded as a political tool and the reasons why it rose to such prominence, those who seek to reverse the negative effects can use this analysis as a foundation for more productive discussions by acknowledging the complicated legacy.

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