

**The Rockslide: Dynamic Climbing Holds**

**Environmental Racism: The Black Population of Richmond Virginia and  
NO2 Pollution Exposure**

A Thesis Prospectus  
In STS 4500  
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The Faculty of the  
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Bachelor of Science in Mechanical Engineering

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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**

### ***Technical Project***

Indoor rock-climbing routes have been built using the same technology since rock climbing gyms were established. Holds, meaning plastic features designed for the climber to grab on to, are attached to the wall by screwing a bolt to a set grid of nuts that are permanently set in the wall. This system imposes inherent restrictions on the kinds of routes that can be set. First of all, holds must be placed at on the grid of nuts, limiting the variability of each move vertically and laterally. Secondly, these holds are stationary once in place and can only be moved or rotated by removing or loosening the bolt. As the sport of climbing grows, users are looking for more variability in their climbing and gyms are searching for more creative ways to provide this to its patrons. My technical project seeks to deliver variability, novelty, and creativity to climbing routes by developing a hold move linearly while carrying the weight of the user and can bolt on to any climbing wall.

### ***STS Project***

As the population of the United States grows, the number of vehicles on our cities' roadways only increases. In addition to this, a growing population demands an increased shipment of goods to meet the needs of the individual consumer and the economy at large. All of this vehicular traffic increases the amount of airborne NO<sub>2</sub>, a harmful pollutant in our cities. This is due to the fact that, "Cars, trucks, and buses are the largest sources of emissions [for NO<sub>2</sub>], followed by power plants, diesel-powered heavy construction equipment and other movable engines, and industrial boilers." ("Nitrogen Dioxide", 2020). As it stands, non-white communities are significantly more exposed to this pollutant than predominantly white communities as a result of major emission sources being more likely to be located in close

proximity to non-white communities (Kravitz-Wirtz et al, 2016). Studies show that individuals who live in neighborhoods in close proximity to high traffic roadways are at a significantly higher risk of developing asthma and respiratory system damage (Kravitz-Wirtz et al, 2018). My STS research topic is to examine the history of roadway infrastructure and neighborhood demographics in Richmond Virginia and determine if the black population in the city have suffered environmental injustice as a result of the local government's urban planning. This issue is extremely relevant to our society today because all people should be protected from the adverse effects of pollution in our cities regardless of race.

### ***Prospectus Structure***

The following section of my prospectus will explain the desired final product for my technical project, the steps and components that led to its creation, and the goals it aims to achieve. The section following that will go into further defining the technological system at the heart of my STS project. Additionally, I will identify the relevant social groups, their goals, and how they influence the system. Following this I will explain the methods and frameworks that will be used to conduct research on my topic as well as a plan for how I will conduct my research. The final section will be a list of key texts with brief descriptions of each.

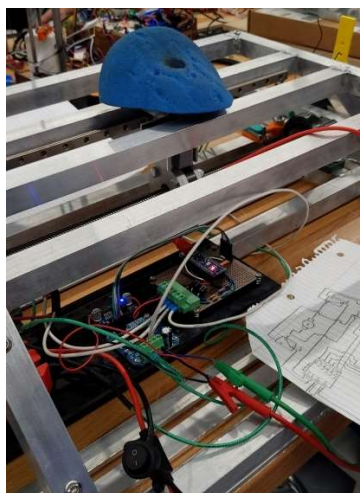
## **The Rockslide: Dynamic Climbing Holds**

The goal of my technical project is to create a climbing hold that can move linearly across the wall while the user holds on to it. This hold is designed to be completely self-contained, hiding all of the innerworkings of the product underneath an outer shell. It will also be able to mount on any indoor climbing wall. The hold is battery powered, using a standard 18V drill battery, with the ability to quickly change the battery through a removable side panel. Finally, the hold has the ability to be programmed to perform a continuous movement pattern as well as be controlled by the user through a remote interface. The implementation of all of these parts creates a hold that can be “gamified” to move while the climber attempts to stick the move to the moving hold. The motor and drivetrain are robust and powerful enough to move the climber across the wall with their weight on it, after they’ve grabbed it. Further implications of this hold are that it can be used as a tool for setting climbs, the process by which employees of the gym make a route. The hold can be mounted on the wall where the route setters can remotely move the hold to different locations to quickly determine the best position for the hold on the wall, where it can then be locked in place.

### ***Build Process***

Construction of the final product was completed on December 7<sup>th</sup>, 2022. The first and longest step of the build was the design process using Computer Aided Design modeling software and stress simulations to converge on a final design. Once this was finalized, the structural frame of the product was welded from aluminum tubing. After this, the linear actuator responsible for moving the hold was added. The necessary speed and torque to move a human’s weight were achieved using a high torque motor which rotates a threaded screw. The hold is mounted to a nut on the screw, which then translates the rotational movement of the screw to

linear movement of the hold. The next step was adding support to the hold, which was achieved by implementing sliding bearings attaching the supports of the frame to the underside of the hold. The necessary electronics were then implemented: a motor controller, limit switches (to stop and reverse the motor at the limits), voltage controllers (to power the system off the battery), and a microcontroller (to control all of the electrical components). A simple program telling the motor to move the hold to one end of the frame, hit the limit switch, then reverse the motor to move to the other side was written and uploaded to the microcontroller. Further work to complete the product will be adding front and side plating to cover the innerworkings of the design.



**Figure 1: The Rockslide – Frame, Hold, and Electronics**

### ***Product Aims***

This product will bring novelty and increased creativity to route setting in climbing. The challenge of sticking a move to a moving hold does not exist in climbing in the capacity that this product will achieve. Additionally, this hold will add convenience to setting, allowing route setters to try multiple iterations of hold placement quickly and easily. Finally, this hold offers the ability to level the playing field and adapt the climb to better accommodate climbers of different heights, where wingspan may be key to completing the climb.

## **Environmental Racism: The Black Population of Richmond Virginia and NO<sub>2</sub> Pollution Exposure**

For my STS research topic, I am examining how non-white neighborhoods are disproportionately exposed to NO<sub>2</sub> emissions in urban areas. Specifically, I will be examining how this environmental racism may have been a product of Richmond's urban planning by looking at the history of roadway infrastructure and neighborhood demographics. As mentioned before, motor vehicles exhaust is the largest source of NO<sub>2</sub> emission so because of that, close proximity to major roadways will be regarded as living in a high exposure zone. Furthermore, research suggests that nonwhite households are exposed to higher levels of NO<sub>2</sub> exposure and are therefore likely to be located in high exposure areas. This correlation is backed by a study published by Cambridge University which concluded, "Results based on multilevel repeated measures models indicate that Blacks and Latinos are, on average, more likely to be exposed to higher levels of NO<sub>2</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> than Whites." (Kravitz-Wirtz et al, 2016). Additionally, this is relevant because studies have linked NO<sub>2</sub> exposure to shorter survival time in lung cancer patients as well other diseases (Eckel et al, 2016)

The technology at the heart of this question is the roadway system responsible for directing the largest volume of semitrucks through the city. This roadway system is really a large interconnected technological system composed of the physical roadways, the politics that dictate where these roadways are put, and the social groups effected by said roadways. By using established STS methodologies and frameworks I hope to answer the question of whether or not the black population of Richmond Virginia a victim of environmental racism.

### ***Social Groups***

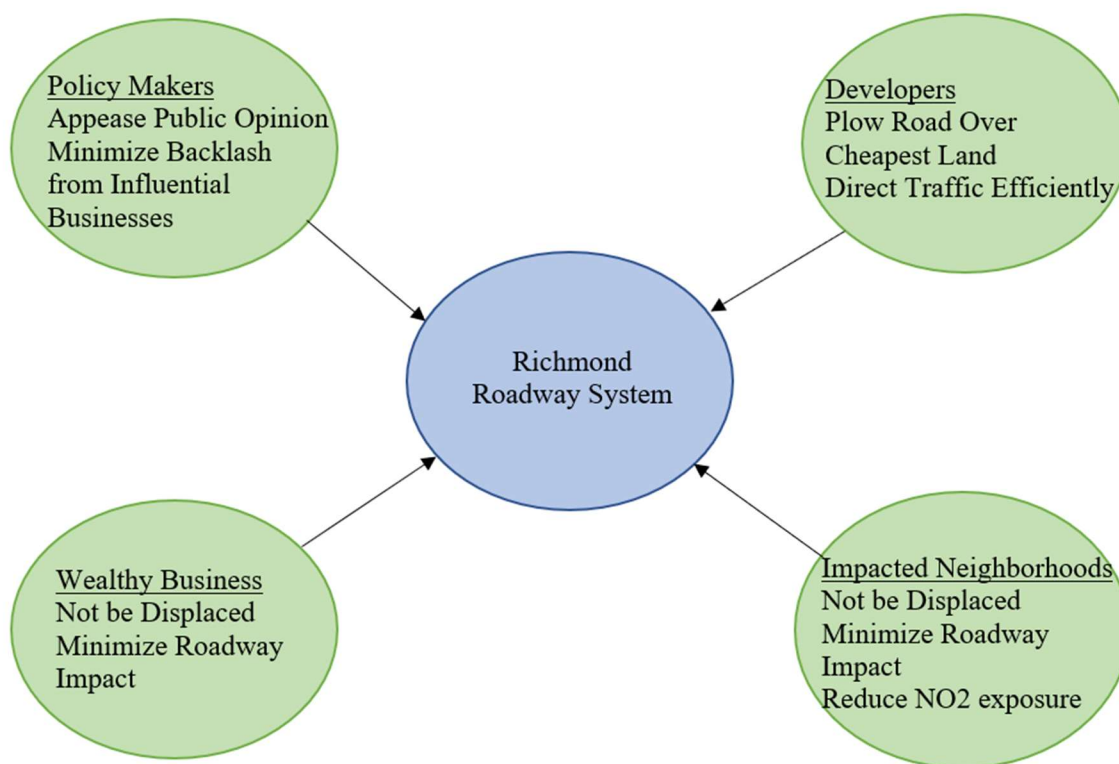
I believe there are four major social groups when it comes to the issue of environmental racism of NO<sub>2</sub> pollution from roadways. The first of which are the policy makers who decide

when it is necessary for a roadway to be built and which roadways are to be used as major arteries for directing traffic throughout the city. Secondly, the developers decide the exact location of the roadways and are responsible for buying up the necessary homes and businesses to demolish to make way for the road. Third are the wealthy business owners whose wish is to not be displaced by new roadway construction. Finally, are the residents of the predominantly black neighborhoods, making up most of Richmond's residents in the center, South, and East of the city, who are the most negatively impacted by the whole system. This claim is backed by examining the correlation between the predominantly black neighborhoods on the racial majority map of Richmond and the Vdot designated trucking routes through the city (Race Map for Richmond, VA and Racial Diversity Data, n.d.; "VDOT Designated Truck Routes and Length Restrictions", n.d.).

### ***STS Framework***

To conduct my STS research project, I will be using SCOT to examine the influence that each of the social groups has on the roadway system at the heart of my question. The first of which is the group of policy makers responsible for planning the road construction. This group is influenced by the appeals of the residents of the city and seeks to use the roadway as a way to satisfy these appeals. They are likely to do this by lobbying to place them in a way that they will receive the least amount of backlash. Additionally, they may be influenced by local business owners who may benefit or be hurt by new roadway construction. The next group, the developers, are responsible for buying the land that the roadway will be built on. The goal of the developers is to seek a way to construct the roadway as cheaply as possible and will the lowest prices homes/businesses along the proposed route to construct the road over. The third group, the wealthy business owners discourage the policy makers and developers from placing the roadway

in a way that displaces them. Finally, are the residents of the predominantly black neighborhoods of the city, who are located in closest proximity to the roadways and are the ones most negatively impacted by the NO<sub>2</sub> pollution. This group also desires to discourage the policy makers and developers from placing the roadway in a way that negatively impacts their community. All of these social groups, each having their own goals, influence the sociotechnical system as a whole and are integral components to the system.



**Figure 2: SCOT Web Graphic**

### ***Research Methodologies***

To conduct the research for my STS project, I will be using a historical methodology. I will be looking at historical housing trends and prices, the relative expensiveness of the land the major roadways were built on, the policy leading up to the construction of major roadways, and the changes in the highest trafficked roads through the city. I will also be synthesizing



conclusions based on previous research investigating how non-white communities are disproportionately exposed to NO<sub>2</sub> pollution in cities, racial majority maps of neighborhoods throughout the city, maps of traffic density through the city, and designated trucking routes throughout the city. This approach should yield a comprehensive enough set of data to conclude if the black population of the city is a victim of environmental injustice as a result of urban planning.

Next semester moving into conducting the research for my topic I hope to start by identifying legislative records pertaining to the construction of the major roadways through Richmond. After identifying the location and time of construction it will be necessary to investigate the demographics of the neighborhoods in close proximity to these roadways to see how this might have changed, or not changed, as an effect of construction. This alongside NO<sub>2</sub> emission mapping I believe will provide a good basis to conduct my research around.

### Key Texts

- 1) Kravitz-Wirtz, N., Crowder, K., Hajat, A., & Sass, V. (2016). THE LONG-TERM DYNAMICS OF RACIAL/ETHNIC INEQUALITY IN NEIGHBORHOOD AIR POLLUTION EXPOSURE, 1990-2009. *Du Bois Review: Social Science Research on Race*, 13(2), 237-259. Retrieved from <https://www-webofscience-com.proxy01.its.virginia.edu/wos/woscc/full-record/WOS:000387546200003>

This is a long-term study from 1990 to 2009 proving that non-white neighborhoods are much more likely to have higher levels of NO<sub>2</sub> pollution than predominantly white neighborhoods. They did this by comparing measured NO<sub>2</sub> levels with census data in urban areas throughout the US. This study also links roadways as a major emission source and their proximity to black neighborhoods as a product of cheaper/low-income housing sites. This supports the exact correlation that presumably is present in Richmond.

- 2) Kravitz-Wirtz, N., Teixeira, S., Hajat, A., Woo, B., Crowder, K., & Takeuchi, D. (2018). Early-Life Air Pollution Exposure, Neighborhood Poverty, and Childhood Asthma in the United States, 1990–2014. *International Journal of Environmental Research and Public Health*, 15(6), 1114. MDPI AG. Retrieved from <https://www-webofscience-com.proxy01.its.virginia.edu/wos/woscc/full-record/WOS:000436496900065>

This is a study linking different racial and socioeconomic backgrounds to adverse health effects from NO<sub>2</sub> pollution across multiple generations. The study links traffic related emission to NO<sub>2</sub> exposure and the development of asthma in children who live in high-risk areas. They also identify the degree of lung damage as a function of neighborhood poverty and racial/socioeconomic disparities. This study will be a strong source in my paper as it identifies the real effects of NO<sub>2</sub> on lung health and proves that lower income neighborhoods are at a higher risk.

- 3) Race Map for Richmond, VA and Racial Diversity Data. BestNeighborhood.org. (n.d.). Retrieved from <https://bestneighborhood.org/race-in-richmond-va/>

This source is a map of the predominant race/ethnicity by neighborhood of Richmond Virginia. There is a clear division of racial majority between white and black neighborhoods with the majority black neighborhoods being located to the northeast, east, and south of the city center. This will be used to establish a correlation to neighborhood roadway proximity in my paper.

- 4) Eckel, SP et al. (2016). Air pollution affects lung cancer survival. *Thorax*, 71. Retrieved from <https://doi.org/10.1136/thoraxjnl-2015-207927>

This is a study with over 350,000 patients conducted from 1988-2009 investigating how lung cancer patients are affected by air pollution. The findings conclude that airborne pollutants, including NO<sub>2</sub>, reduced the survival time of the patients who were exposed to higher levels of pollutants. This study also recognizes the disparity in exposure levels between urban and rural environments as it excluded patients living in rural areas. This is useful to support the dangers and effects of NO<sub>2</sub> exposure.

## Bibliography

- 1) *Nitrogen Dioxide*. American Lung Association. (2020, February 12). Retrieved from <https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/nitrogen-dioxide>
  
- 2) *VDOT Designated Truck Routes and Length Restrictions*. ArcGIS web application. (n.d.). Retrieved from <https://vdot.maps.arcgis.com/apps/webappviewer/index.html?id=4803162ce73d458a9b8f6d9cb51aa470>