PREPAREDNESS FOR ENVIRONMENTAL SHOCKS AT THE PORT OF VIRGINIA

ENVIRONMENTAL CHALLENGES IN A SEGREGATED AREA

A Thesis Prospectus
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Bachelor of Science in Systems Engineering

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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The Port of Virginia, located in Hampton Roads along the intersection of the James and Elizabeth Rivers with the Chesapeake Bay, serves as a vital component of Virginia's economy (Port of Virginia, n.d.). Through its domestic transportation of import and export goods, export of goods produced in Virginia, and processing and distribution of Commonwealth-retained imports, the Port is responsible for 7.5% of the state's total economic output and 9.5% of the state's resident employment (Port of Virginia). As globalization and competition among seaports increases (2065 Master Plan, n.d.), the Port of Virginia will have to contend with a number of emerging scenarios that could disrupt their operations and standing, whether they are industry-related, environmentally-related, or security-related (p. 4). If the port wishes to remain competitive, it will have to plan strategically for industry changes while remaining resilient to long-term environmental factors.

According to their 2065 Master Plan (n.d.), the Port of Virginia has expressed interest in a number of sectors that would help it achieve the status of busiest seaport on the East Coast (p. 9). The goal of the group's technical work is to provide the Port with a series of recommendations based on systems analyses that are tied to certain areas of interest, mainly: autonomic processes, security technology, environmental risks, and cold ironing. My technical research and loosely coupled STS research will examine both the Port and Hampton Roads community's preparedness with respect to effects from climate change, such as sea level rise, flooding, and tropical storms. On the technical side, I will examine the how the Port best prepares itself for the future with respect to both certain and uncertain environmental shocks brought on by climate change. The loosely coupled STS research will analyze the racial disparities in Hampton Roads and how this impacts the community's disaster preparedness. The Gantt chart shown in Figure 1 displays the timetable of deliverables for both projects.

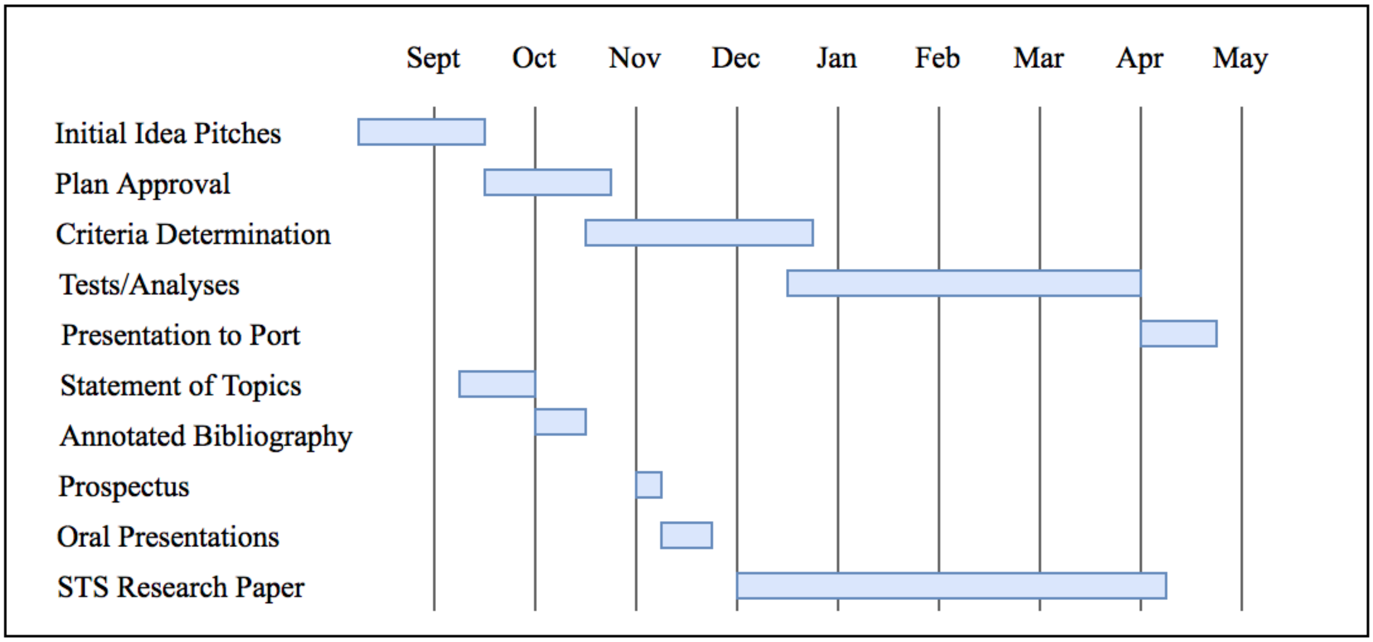

Figure 1: Gantt Chart: This chart displays the timetable for work on both the technical and STS topics. The first five entries coincide with the technical work while the remaining five coincide with STS work (Sampaio, 2020a).

PREPAREDNESS FOR ENVIRONMETAL SHOCKS AT THE PORT OF VIRGINIA

Under the direction of Professor of Engineering Systems & Environment James Lambert, Systems Engineers Derek Gimbel, Benjamin Mendel, Dillen Longo, Chris Gacek and I will provide the Port of Virginia with a glimpse into the future of the maritime port industry. Our deliverables will be a robust set of initiative recommendations for the Port of Virginia's consideration based on mutual areas of interest covering several areas: the Port's transition to becoming a smart port, adoption of emerging security technology, resilience to future environmental conditions, and possibilities with cold ironing. The recommendations to the Port will cover numerous topics, with each team member working on their own set of deliverables. Derek and I will both focus on the environmental aspect, with each of us delivering different perspectives for evaluating alternatives. My specific technical work will analyze Port preparedness with respect to certain and uncertain environmental shocks, operating on a 30-50

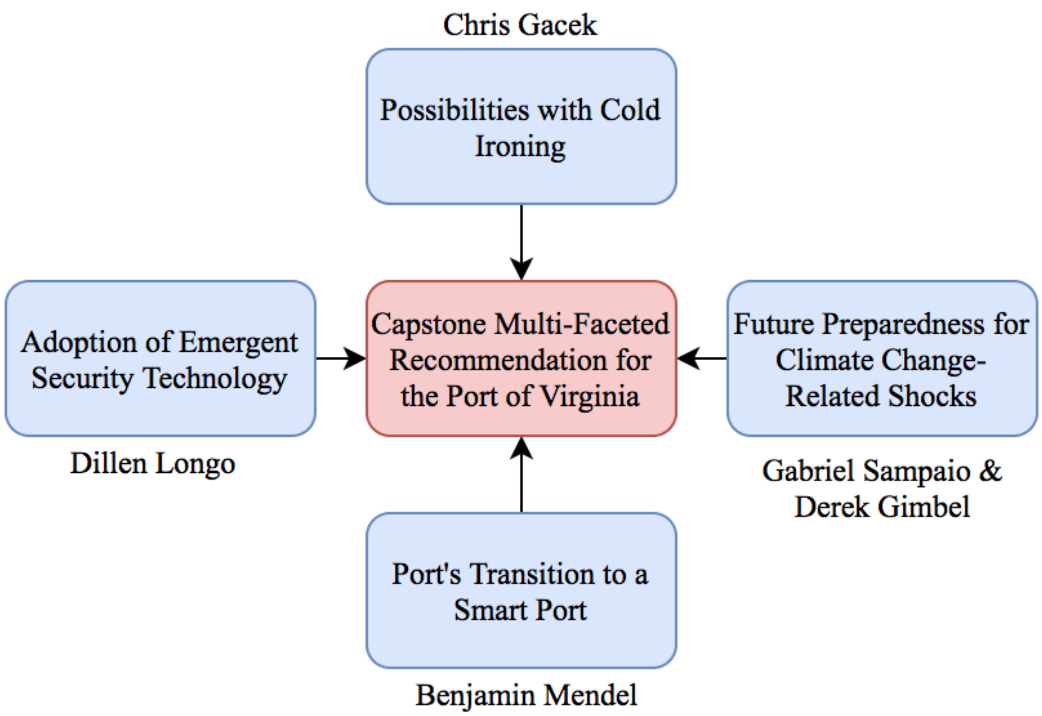

Figure 2: Relationship Diagram: Visual Representation of Contribution to Final Report for the Port of Virginia (2020b).

year and a 70-100 year timescale respectively. Figure 2 displays the breakdown of contributions.

The science regarding climate change and its effects is both undeniable and overwhelming in consensus, with over 97% of scientists believing it to be a real, quantifiable, man-made issue (Cook et al., 2016, para. 2). In a world with increasingly warmer temperatures, the strength and frequency of climate effects will be magnified, from hurricanes and rising seas to persistent flooding and land erosion (Dutter & Sammler, 2017). In essence, this means that minor storms in the future will have the capacity to inflict more damage on ports than a minor storm today. Seaports around the world will have to prepare for this inevitable future, and the Port of Virginia will likely have to take added measures due to the unique geography surrounding it. According to NASA (2017), the Hampton Roads area is steadily sinking, which exacerbates the local sea level when combined with global trends (Introduction section, para. 1). As a result, the level at Sewell's Point, which is within walking distance from the Port's Norfolk

International Terminal, is rising over twice as much as the global average, at around 4.6 millimeters per year (NOAA, n.d.).

The objective of my technical project is to conduct a comprehensive systems analysis for the Port of Virginia with respect to various environmental hazards brought on by climate change. This will culminate with a robust set of recommendations in the form of initiative investments for the Port's consideration. With regard to the analysis methods, there will be several steps, beginning with defining relevant emergent scenarios from scientific projections, identifying feasible investment levels for the Port with respect to resilience infrastructure, and deciding the most important criteria for evaluation based on their feedback. Likely scenarios will include varying levels of projected sea level rise, storm surges occurring during high-tides, and hurricanes making landfall in Hampton Roads, among others. Following these determinations, other factors will be taken into account, such as timescales, constituent activities, and schedules. Using cost-benefit analyses, quality weights, quality scores, and optimization models, I will be able to identify the most disruptive scenarios that the Port should best prepare for in the future in addition to providing a ranking of the most promising investment initiatives. According to Collier and Lambert (2018), who outlined this methodology in a report for the American Society of Civil Engineers:

> Using this future-oriented approach, the key insight is to identify those activities with highest and lowest importance, and to identify the most and lease disruptive scenarios, thus improving time management of complex projects (p. 1-2).

The final deliverable to the Port will come in the form of a report and in-person presentation that outlines my methodologies, explains findings, and provides the set of optimized recommendations based on the most disruptive scenarios identified.

ENVIRONMENTAL CHALLENGES IN A SEGREGATED AREA

Given the severity of the inevitable consequences of climate change, it is important to assess what is at stake for the local community in addition to the Port. The Hampton Roads region ranks 10th in assets at risk to damage from sea level rise (World Resources Institute, 2014). Historically, the low-lying Tidewater Region of Virginia in which Hampton Roads lies has been subject to intense nuisance-flooding and high-tide flooding. The 1933 Chesapeake-Potomac Hurricane, which ravaged multiple Mid-Atlantic states, was responsible for record-breaking 11 to 12-foot storm surges in the area that inundated thousands of residents (Samenow, 2013). Similarly, Hurricane Isabel, the costliest natural disaster in Virginia's history, produced close to 8-foot storm surges in the area in 2003 (National Weather Service, n.d., Storm Surge/Tides Section, para. 1). As mentioned in paragraph 2 of the Technical Section, the residents of Hampton Roads will have to contend with more frequent and intense flooding in the decades to come, so the need for strengthened protection measures is not remiss.

When considering how the population is directly impacted by these environmental issues, it is useful to first consider the racial and economic disparities of the Hampton Roads community, as not everyone is affected the same. According to the U.S. Global Change Research Program (2016):

> Population growth and migration in the United States may place more people at risk of the health impacts of climate change, especially are more people are located in and around vulnerable areas, such coastal, low-lying, or flood-prone zones… Economic disparity can make it difficult for some populations to respond to dangerous weather conditions, especially when evacuation is necessary or when the aftermath requires rebuilding of homes and business not covered by home or property insurance (Demographic and Socioeconomic Trends section, para. 2).

In addition to this, the problem is magnified within America's minority communities, who have disproportionately higher poverty rates and lower income levels than White Americans (U.S.

Global Change Research Program, para. 2). Given that Hampton Roads has a minority population of roughly 40% equating to over 670,000 residents, and that poverty levels are significantly higher for African American and Hispanic families at around 15% each, one can begin to understand the severity of the problem (City of Norfolk, 2017). According to Dr. Johnny Finn of Christopher Newport University (2020), most major metropolitan areas are more racially segregated today than they were during the Reconstruction era, with Hampton Roads being no exception (About the Project section, para. 1). One of the main culprits is redlining, a historical practice which created "security maps" that rated neighborhoods according to a number of factors; this was done in order to refinance mortgages in an effort to prevent widespread foreclosures (Finn, Mapping Segregation section, para. 3). Finn explains the adverse effect on minorities:

> Neighborhoods were classified into four categories: "A" and "B" areas were the most attractive for refinancing, while "C" areas were deemed to be "transition zones" in decline and "D" areas, colored red on the map, were "characterized by detrimental influence in a pronounced degree." Race was the obvious factor in determining a neighborhood's zone: white neighborhoods were generally classified as A or B areas while black neighborhoods were almost always redlined, classified as areas in "full decline" and ineligible for refinancing. As a direct result, African Americans were prevented from protecting their homes from foreclosure, while white residents were incentivized to leave redlined neighborhoods for more homogeneously white areas backed by the Home Owners' Loan Corporation (HOLC) (2020).

Compounding the issue was a post-World War II era neighborhood composition rule which forbade public housing projects from altering the existing racial composition of their respective neighborhood (Rothstein, 2014, De Jure Residential Segregation by Federal, State, and Local Government Section, para. 1). As the vast wealth gap between White Americans and minority populations is inextricably linked to these policies, the problem poses significant threats to the community when considering preparation for natural disasters and climate change-related shocks (Rothstein, 2014). According to Pierceall (2017), many of the area's most flood-prone neighborhoods are located on low-lying land that are both lower in value and more difficult to sell (para. 15). When looking to a map of the current flood zones in of Hampton Roads, which are listed A-D in order of decreasing risk to floods and storm surges (Virginia Know Your Zone, n.d.), many of the A-rated zones coincide with historically redlined D-rated neighborhoods (Finn, n.d.). This is a topic worth further exploration when considering worsening environmental conditions that may require residents to relocate.

CURRENT INADEQUACY OF RESILIENCE INFRASTRUCTURE

At present, the infrastructure in place to protect the residents of Hampton Roads from environmental shocks, particularly those brought on by sea level rise, is inadequate. As reported by the Hampton Roads Transportation Planning Organization (HRTPO) (2014):

> Under current conditions, in the event of a hurricane it is possible that only a portion of the people living in homes in low-lying areas of Hampton Roads will be able to evacuate… Due to the number of households in low-lying areas, and given the current capacity of evacuation highways, it may take 36 hours to clear evacuation highways for a Category 3 Storm (p. 2).

In addition to lacking efficient evacuation plans, a number of other measures are also subject to failure during flooding, including seawalls and sewage systems. According to the Hampton Roads Sanitation District (HRSD), the sewage system has the capacity to treat 249 million gallons per day for the entire region (Sanitary Sewer Overflows FAQ, n.d., para. 1). They explain that the system is designed to only handle sewage – each locality has its own separate system for storm water management – and is frequently overwhelmed during storms causing routine flooding of streets and properties in low-lying areas (HRSD, n.d.). In order for Hampton Roads to create a strengthened, more equitable resilience plan for the future, the responsible stakeholders – mainly local governments, the Virginia Department of Transportation (VDOT), the Hampton Roads Planning District Commission (HRPDC) and the HRTPO – must properly balance the needs of the entire population. Figure 3 displays the general steps to constructing a hazard mitigation plan, as outlined by the HRPDC.

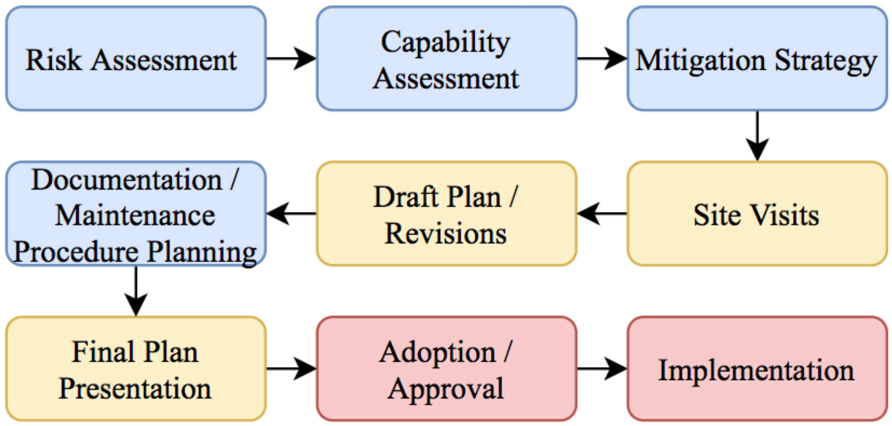

Figure 3: Flow Chart: Generalized steps for implementation of resilience projects. *Note*. Adapted from Hampton Roads Hazard Mitigation Plan (2017, Planning Process Section, p. 3). Blue boxes indicate documents, yellow boxes indicate in-person meetings, and red boxes indicate implementations (Sampaio, 2020c).

Any foundational change that occurs in the region will be dependent on collaboration between multiple stakeholders. For this reason, the Actor-Network Theory (ANT) model, as described by Jolivet and Haskanen (2010), is especially useful for framing the relationships between populations in Norfolk, the projected environmental shocks related to climate change, and the agencies responsible for implementing risk measures. According to Jolivet and Heiskanen:

> One major interest of this approach for our issue is that framing and overflowing can be conceived as a participation process based on analyzing power relations and controversies. Issues of framing would thus concern who is allowed to participate, how their voices are heard, how the various positions are negotiated, and how the project plan is adapted to the views expressed (Section 2.3, para. 3).

Actor-Network Theory is particularly useful in this case because it examines a microcosm of the issue, Hampton Roads' relative sea level rise, with respect to a larger global trend (Jolivet & Heiskanen, 2010). In addition to this, the model will help to provide a voice for the underrepresented populations and analyze the power dynamics at play. Lastly, as ANT helps illustrate the moving parts of complex projects, it will aid with the analysis of the non-local stakeholders who have an impact, such as state and federal agencies, in addition to the actors who may be underrepresented. The dynamic flow chart shown in Figure 4 displays a visualization of the preliminary interactions of the region using ANT.

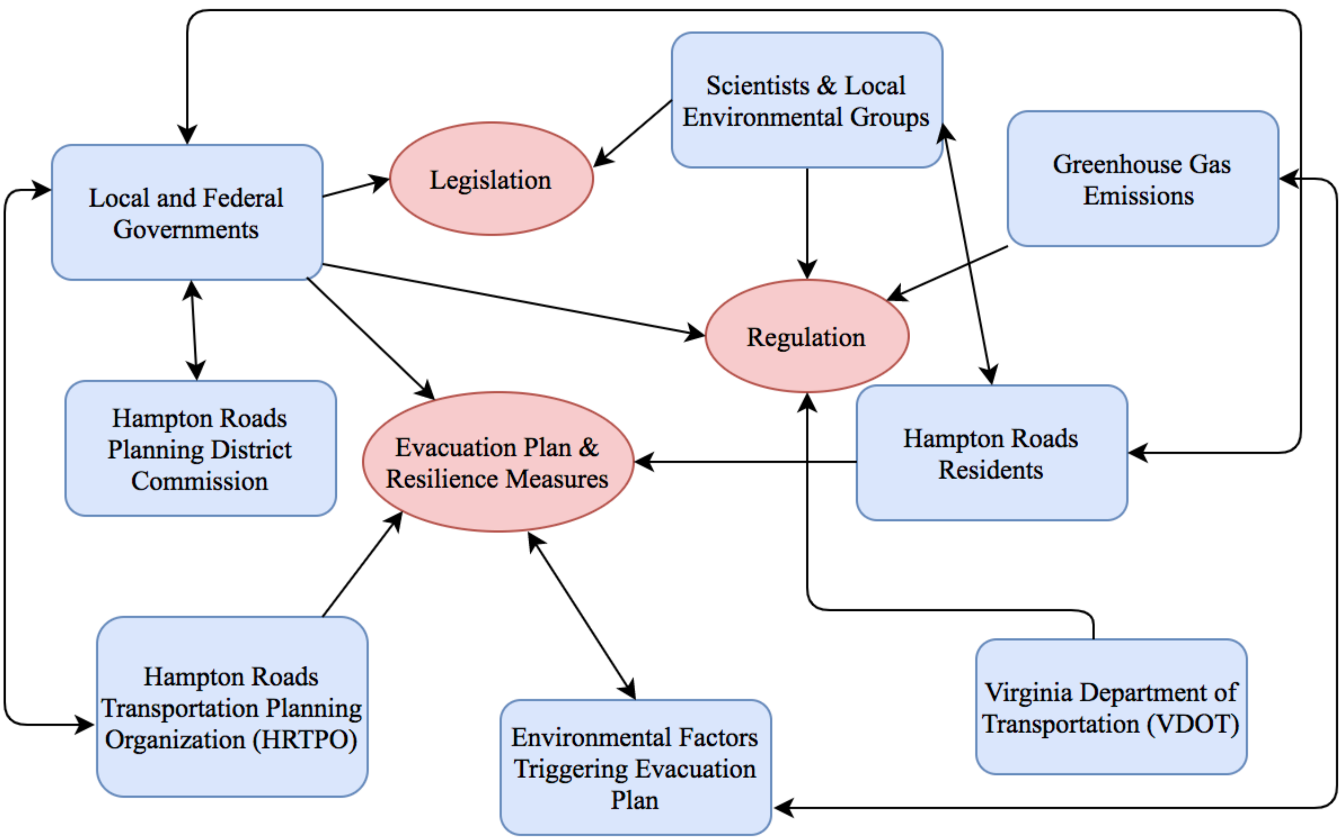

Figure 4: Dynamic Flow Chart: This chart displays a preliminary visualization of the regional interactions with respect to climate initiatives using ANT. Blue boxes indicate actors and red boxes indicate initiatives, and arrows indicate relationships (Sampaio, 2020d).

My STS research project will culminate in a research paper that provides historical precedence for modern-day segregation in the Hampton Roads region, the impact this segregation has on disaster preparedness in the region, and potential solutions using ANT and comparative analysis with other regions in the United States. The aim is to gain a deeper understanding of the indirect and direct causal factors at play within the region that have led to inadequate responses with regard to disaster planning.

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