Prospectus

Enterprise Risk and Resilience of Container Freight Operations at the Port of Virginia
(Technical Topic)

Weather-Related Mitigation Strategies and Technologies Used by the Federal Aviation Administration in the Presence of Hazardous Weather Conditions
(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

The Port of Virginia operates as the third largest container port in the East coast through offering a variety of services such as servicing ships that haul cargo, driving investment, creating jobs, generating revenue, and connecting Virginia to the world. Economically, the Port of Virginia has an annual impact of $88.4 billion as it creates 530,000 jobs, and invested $350 million in a project that deepened its harbor to accommodate more vessels from the Panama Canal. It is currently investing $700 million in a project to expand container operations by 40% (Porter, 2019). The Commonwealth Center for Advanced Logistics System (CCALS), a consortium of industry, government, and universities, plays a role in analyzing the Port of Virginia's strategic and operation plans and modeling terminal expansion and improvements.

As a part of CCALS, our research team investigated topics for the Port of Virginia, such as green initiative programs, alternative maritime power, cooling storage technology, and development of a technology-driven risk-management infrastructure. After meeting with the client in October 2019, it was revealed that those topics are already being researched and implemented. Dan Hendrickson, Vice President of Strategic Planning & Analytics at the Port of Virginia, saw more value in an economic development project related to crane manufacturing, since this unexplored area of research provides an expansion opportunity for the Port of Virginia. Since crane manufacturing seemed feasible to explore, research, and model, our team decided to focus specifically on how the Port of Virginia can expand into a manufacturer and serve the domestic crane market.

Domestic manufacturing of cranes is an opportunity for the Port of Virginia to grow through new investment. To provide some context on the interest in localizing crane manufacturing, the Port of Virginia currently orders specialized cranes from *Konecranes*, a

Finnish company that specializes in the manufacturing and servicing of cranes and lifting equipment (Konecranes, 2019). The Port of Virginia made a large $217 million contract order of 86 rail-mounted cranes in late 2016 from Konecranes (Harris, 2016). These cranes are all engineered and manufactured in Finland with only a few raw materials, such as steel, coming from other parts of Europe, see Figure 1. In addition, some of the largest ship-to-shore cranes the Port of Virginia ordered were manufactured by a Shanghai-based company known as *Zhenhua Heavy Industries Co.* (ZPMC) (Harris, 2017). It is evident that Konecranes and ZPMC are reliable and highly reputed crane manufacturing companies, but considering factors such as contract cost, time for delivery, and quality of delivered cranes, there is potential for minimizing cost and delivery time and improving the quality of ordered cranes.

Figure 1. Rail Mounted Gantry Crane made by Konecranes. (Konecranes, 2019)

Other ports in the United States, such as the Port of Savannah, rely on ship-to-shore cranes that can load and offload the largest ships in the East Coast and reach across 22 containers wide (gCaptain, 2018). Strategically, the Port of Virginia could become prime movers in implementing a domestic crane manufacturing facility that not only services the Port of Virginia, but other United States ports that demand cranes. Given the abundance of inputs such as steel in the United States and room for expanding manufacturing facilities within Virginia, domestic crane manufacturing could result in economic benefits through creation of local jobs, financial benefits from crane distribution to other ports for profit, and operational benefits through localized and on-demand production of cranes.

Tentative Deliverable

This capstone project will examine the demand for specific crane types, manufacturing process, necessary infrastructure, economic benefit, and alignment with the Port of Virginia 2065 masterplan to develop a detailed plan for the Port of Virginia to implement a domestic crane manufacturing facility (The Port of Virginia, 2016). Our team will investigate a benefit-case for domestic crane manufacturing and conduct research to develop an actionable strategic plan that can be delivered to the Port of Virginia. Advances in technology opens up avenues for investigating technologies to integrate within these manufacturing sites across domestic ports. One such example is automated crane technology, which has the potential to increase operational efficiency and competitive advantage as a technology-driven port. Adopting this technology will also help reduce reliance on labor unions, a threat to port operations. The creation of a new business venture through domestic crane manufacturing supports innovation, one of the core values of the Port of Virginia 2065 Masterplan. The method that primarily supports this capstone project is substantial content research on the Port of Virginia infrastructure and background information on the manufacturing process, cost, and functionality of cranes. Financial models will be used to model Return on Investment (ROI) for this expansion effort along with a detailed execution plan with steps the Port of Virginia can take to implement this localized crane facility. As this project progresses, there is potential for developing more models and conducting data analysis on relevant data the team may find related to the Port of Virginia or cranes.

Timeline for Analysis and Deliverable

When working on this long-term project of evaluating and designing a plan for the Port of Virginia, it is important to outline milestones that will be achieved throughout the year. Before the next client site visit in Norfolk, Virginia around the middle of November, our team will have background research completed on the crane manufacturing and distribution process. By early spring, our team will have an in-depth financial model to facilitate a cost-benefit analysis and evaluate ROI for implementing a domestic crane manufacturing facility. Along with this model, our team will evaluate metrics such as projected number of jobs created, profit generated, number of cranes produced, and ranking of the Port of Virginia compared to other United States ports. By the end of April 2020, our team will have a completed conference paper for the Systems and Information Engineering Design Symposium (SIEDS) conference sponsored by the Institute of Electrical and Electronics Engineers (IEEE). Lastly, our team will meet with the client at the end of the project to discuss the completed model and findings from the year-long research. Please refer to Table 1 below to see a timetable of milestones for our project.

8/28/19 – 9/4/19	**9/4/19 – 10/10/19**	**10/10/19– 11/15/19**	**11/15/19– 2/15/20**	**11/15/19– 4/15/20**	**2/15/20– 3/30/20**	**3/1/20– 4/15/20**	**4/15/20– 4/30/20**
Project introduction	Initial research	Crane background research	Initial model building	Continue supporting research	Final model and analysis completion	SIEDS paper	Finalize client deliverables

Table 1. Timetable for capstone project. (Created by Iyer, 2019)

Weather-Related Issues in Aviation

While my technical topic focuses on a strategic plan to drive expansion efforts at the Port of Virginia, I will shift my focus to aviation rather than the maritime transport industry. Hundreds of thousands of airplanes fly in the United States (US) National Airspace (NAS) each day and cross different terrains and weather conditions. The Federal Aviation Administration (FAA) is the government agency that regulates the NAS, ensuring it is safe for airplanes to fly in. One of the primary goals of the FAA is to "provide the safest, most efficient aerospace system in the world" (FAA, 2019). However, the presence of inclement weather creates hazardous conditions in the NAS, which is one of the largest cause of flight delays. These weather conditions cause approximately 70% of all delays with an hourly delay cost of $1400 - $4500 for a given airline (Jones & Takemoto, 2018).

Historically, one of the deadliest disasters in aviation was the collision of two Boeing 747 aircrafts, Pan Am Flight #1736 and KLM Flight #4805, at Tenerife North Airport in the Canary Islands in 1977 due to dense fog conditions (Burt, 2014). The result of this accident was 583 fatalities that could have been avoided through integration of advanced technology and mitigation strategies for aircraft operations in extreme weather conditions. Even in the past decade, one notable aircraft disaster was the crash of Air France Flight #477 into the Atlantic Ocean on June 1, 2009. This crash caused 228 deaths since ice crystals blocked the plane's pitot tubes, a necessary system for determining air speed (CNN Wire Staff, 2012).

The Air Transport Association has actually forecasted a total of 8.2 billion airline passengers in 2037, with a 3.5% compounded annual growth rate for the industry (Garcia, 2018). This is concerning, especially if 68% of extreme weather events stemmed from some form of human-caused climate change (Mcsweeney, Pearce, & Pidock, 2019). To understand how risk of weather impact on the NAS is mitigated for such events, this research will explore the weather-related technologies and strategies the Federal Aviation Administration uses.

Connections to Human, Social, and Technology

The FAA's NextGen program, which aims to improve air transportation to make flying safer, efficient, and predictable, is developing new weather-related tools within the Air Traffic Control System that affect all the actors present in the system. Some human-human interactions include pilots communicating with controllers, pilots communicating with passengers, and even flight crew communicating with passengers. The introduction of these new technologies introduces a non-human interaction as pilots and controllers have to interface with a tool through a technical medium. This research will focus on how the technology facilitates interactions to avoid weather impacts on the aircraft, while considering a social dimension behind the technical design.

Let us look at the use of the Air Traffic Management (ATM) Tool as an exemplary FAA technology that facilitates interactions between humans and nonhumans. The ATM Tool is a combination of a variety of departure management tools that aids in decision support during convective weather conditions (Webber, Evans, Moser, & Newell, 2007). This tool facilitates interactions between FAA and Human-Traffic Flow and interactions between pilots and FAA ground operations. These interactions provide user feedback and lead to further technology enhancements that benefit pilots and controllers. While this technology facilitates interaction among key stakeholders, there are some other implications in using this tool.

One of the critical requirements for pilots operating an aircraft is to maintain Situational Awareness (SA), as this impacts their ability to perform tasks in a focused way (Endsley, 1997). A change in the operating environment for pilots leads to potential operator overload since pilots have to monitor the performance of the technology. While these tools guide decision making and optimize task efficiency, NextGen must still design technologies to ensure they do not negatively impact the work of operators. Research conducted will evaluate some of these extensively used weather-related technologies along with the social implications of their use on pilots and controllers.

Application of Actor Network Theory and Social Construction of Technology

To frame my research, my analysis will rely on the application of *Actor Network Theory* by Bruno Latour and the *Social Construction of Technology* by Trevor J. Pinch and Wiebe Bijker. Latour argued that the development of technologies leads to achieving certain values and political goals as they shape the everyday lives of human beings (Latour, 1992). Given the development of newer technologies, Actor Network Theory will facilitate the analysis of how actors have to adapt to the introduction of new technology. Drawing specifically from Latour's discussion of Actor Network Theory, my research will focus on the delegation of technology to nonhumans, or delegation of responsibility to weather-related automated tools and technologies. This is because the development of weather-related Decision Support Tools now transitions the decision-making process from other actors in the network, such as pilots and air traffic controllers, to the technology itself. A program of action, as Latour defined, is a set of instructions that can be substituted by an analyst for any artifact. This leads to the delegation of different components in a program of action to both humans and nonhumans. The main program of action in the NAS, given the presence of hazardous weather conditions, is for aircrafts to avoid these weather systems. An antiprogram, on the other hand, is an aircraft traveling through a dangerous weather system. The weather-related technologies and tools are additional layers that support the program of action, ensuring aircrafts make well informed decisions and circumvent dangerous conditions, of course at the price of researching and investing in these technologies. However, paying the price could result in positive impacts measured by number of flight accidents avoided, amount of flight delay time reduced, and number of flight plan conflicts avoided. While this delegation shows system-wide impact, it should be acknowledged that actors still have to adapt to this technology-driven systematic change. Thus, Actor Network Theory provides an umbrella for evaluating actor adaptation and system impact.

The Social Construction of Technology (SCOT) supports Actor Network Theory through emphasizing how technology has a meaning defined by different social groups based on uses, meaning, and designs (Bijker & Pinch, 2008). Within the ATM system itself, there are several social groups such as passengers, pilots, and operators who helped shape the evolution of aviation. The roles of these social groups change through the introduction and presence of weather-related technologies, with some change in reflected attitude towards their usage. As NextGen initiatives become increasingly technologically-driven, new social groups could emerge, such as a faction that is against automated decision tools and another faction in support of researching and developing weather-related tools. Thus, SCOT frames the analysis of key groups directly and indirectly impacted by the FAA's use of weather-related technology.

To summarize, the primary framework this research will use is Actor Network Theory, focusing on the delegation of technology to nonhumans for weather-related Decision Support Tools. The Social Construction of Technology will focus on the role and emergence of social groups or actors that are a byproduct of technological development. Together, these frameworks help address the following question: *What are weather-related technologies and strategies the Federal Aviation Administration uses in the presence of hazardous weather conditions?*

Research Methods

Research on this topic will examine how the Air Traffic System uses technology and other tools to handle extreme weather conditions ranging from natural disasters to common storm systems. Two primary methods to supplement this research are evidence from *prior literature* and *content analysis* to inform *case studies.* Through initial research conducted, I found a variety of scholarly articles and reports discussing ATM Decision Support during convective weather and the realistic integration of weather information into ATM. The sources include reports issued by the Lincoln Laboratory Journal, the MITRE Corporation, and the Massachusetts Institute of Technology Department of Aeronautics & Astronautics. These sources provide sufficient detail on the technical aspects of technologies and algorithms that support ATM. For example, the Lincoln Laboratory Journal on Air Traffic Management Decision Support discusses the importance of the Route-Availability Planning Tool (RAPT), a tool to guide aircraft takeoff during harsh weather conditions, and the use of objective models such as the *Optimal Scheduling Algorithm* that generates flight plans for the aircraft (Webber, Evans, Moser, & Newell, 2007). I can use the literature to introduce a useful tool or model, describe the functionality, and analyze the impact from using it. The next step is using evidence from literature to analyze the technical details.

While evidence from literature and other sources provide the details on the technologies and algorithms, content analysis of case studies will be a method used to connect the technical aspects of a specific technology or tool with the need and motivation for it. I specifically want to investigate aircraft accidents caused by disruptions in weather systems that influenced the development and adoption of certain technologies. This will provide understanding of how these technologies and tools are shaped and how research supports further technological development. One source of case studies is the National Transportation Safety Board (NTSB), where I can analyze data on past weather-related incidents. Other case studies can be found in aviation-related scholarly articles that contain analysis of a given accident or failure. The case studies I am interested in studying identify microbursts as the root cause of accidents, as they have caused a majority of weather-related accidents. For background, microbursts are short-lived downdrafts that are present during thunderstorms through the creation of forceful and dangerous wind shear (Williams, 2019). One accident related to microbursts is the downfall of Pan Am Flight #759 on July 9, 1982, resulting in 153 fatalities. Another accident related to microbursts is the downfall of Delta Airlines Flight #191 that crashed in Dallas on August 2, 1985 with 134 total deaths. One decade later, microbursts also caused the crash of USAir Flight #1016 on July 2, 1994 at Charlotte-Douglas International Airport (Smith, 2019).

In summary, the analysis of case studies will first provide a background for weather-related accidents and motivation for this research. Then, the use of evidence from prior literature will highlight important technologies and algorithms that developed from the accidents analyzed in the case studies. Lastly, these tools will be analyzed in how they are delegated to different actors and have impacted their role in ensuring that aircrafts are safe in dangerous weather conditions.

Conclusion

My research for the Spring 2020 semester will focus on the Federal Aviation Administration's use of weather-related technologies and strategies in hazardous weather conditions. This research will answer my question of what specific FAA technologies and algorithms are used, how their use reduces probability of aircraft accidents, and their impacts on actors interacting with the technologies and tools, such as pilots and air traffic controllers. The research paper will connect these findings to broader societal implications of technologies guiding aviation systems and actor response to these developments.

My research will be divided up evenly over the course of this academic year. The month of January will be dedicated to finding relevant articles and journals in order to conduct content analysis of weather-related technologies and strategies. February will consist of reading through these articles, finding similarities in types of technologies and algorithms used, and grouping them accordingly. March will involve analyzing case studies and data from the National Transportation Safety Board to discover the motivation for developing these technologies. Over the course of my research, I will synthesize my findings into a well-supported thesis outlining my findings and the large-scale impacts of weather-related technologies and tools on mitigating impact from dangerous weather conditions. I have summarized the breakdown of milestones and the deliverable through a timetable shown in Table 2 below.

1/15/20 – 2/15/20	**2/15/20 – 3/15/20**	**2/15/20 – 4/30/20**	**3/15/20 – 4/15/20**	**4/30/20**
Find articles journals, and case studies on weather-related technology	Start classifying technology and algorithms found	Write the thesis paper integrating all of my research and analysis	Find and analyze case studies of historic aircraft disasters due to hazardous weather	Thesis is completed and submitted for approval

Table 2. Timetable for STS project. (Created by Iyer, 2019)

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