



# EVACUATION OF TRANSPORTATION NETWORK PERFORMANCE UNDER EVACUATION SCENARIOS

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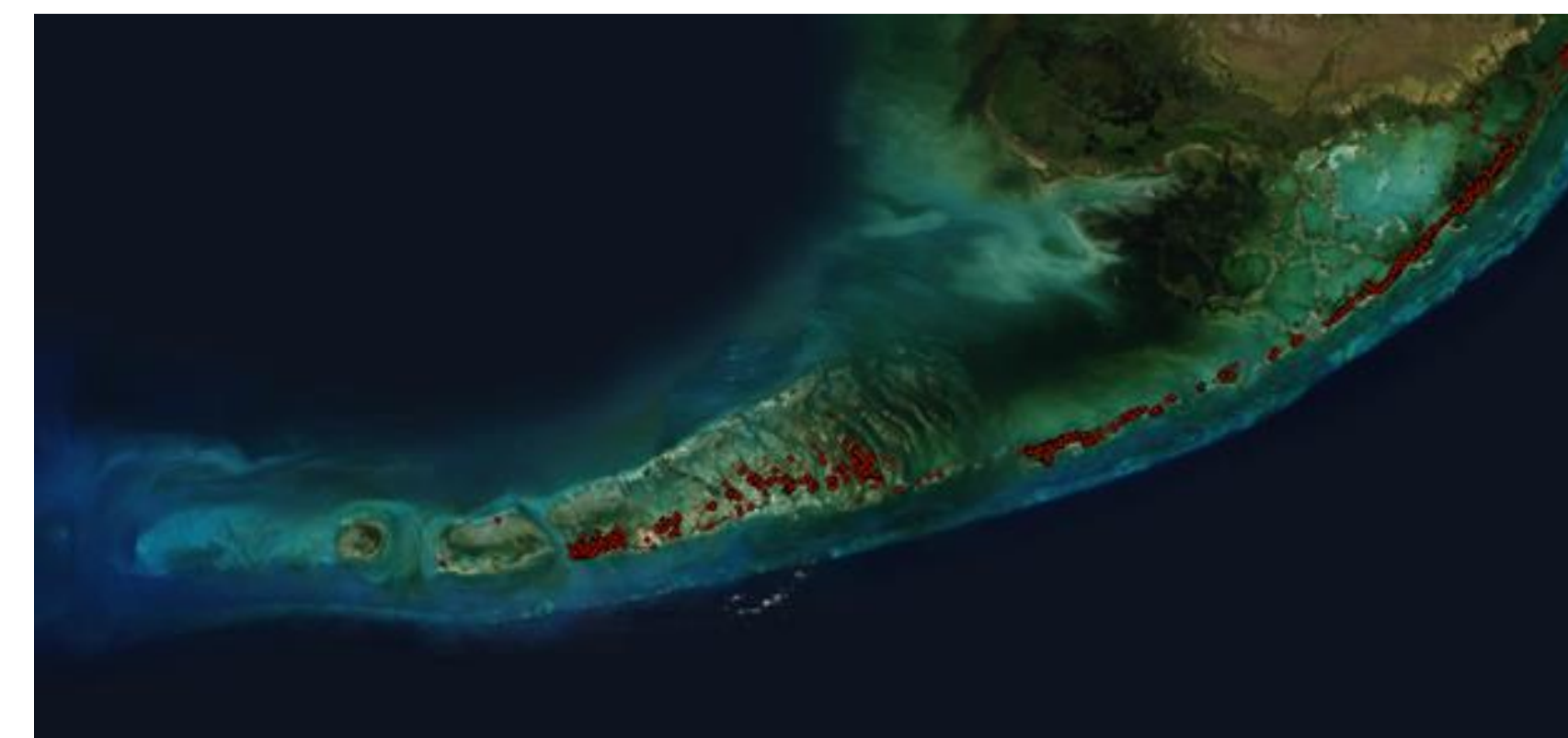
## INTRODUCTION

Every year, it is expected that \$54 billion is lost due to destruction caused by hurricanes and the flooding that often accompanies these storms (Congress of the United States, 2019). In 2019, 82,697,827 people were affected by hurricanes in the United States and its territories (US Census Bureau, 2019). These storms not only have a financial impact, but these citizens of these coastal areas spend a significant amount of time preparing for these storms, evacuating to be out of harm's way, waiting the storm out and for utilities to be restored, returning to their home, and finally cleaning up and repairing the damages. This process can take more than a week depending on storm speed, travel time to evacuation shelter, and duration of flooding and rain after the actual storm passes. Schools, from colleges to local elementary schools, are shut down, grocery stores are closed, and residents are asked to stay home. Because of this, hurricanes and their associated evacuations can be drawn out processes.

Evacuations have been a part of life since the beginning of time. In the first century, the city of Pompeii was evacuated due to the eruption of Mount Vesuvius. From the beginning to the end of 1900s, people were fleeing from war zones. The twentieth century concluded with Hurricane Floyd and three million people moving away from the coast and path of the storm. In the 2000's, evacuation orders were issued for Hurricane Frances, Katrina, Rita, and Gustav. In September 2017, at least 700,000 people evacuated from Florida, Georgia, and South Carolina due to Hurricane Irma. Most recently, people have been evacuating from wildfires in the western United States and Canada. Although evacuations are nothing new, little progress has been made in improving their efficiency. When Hurricane Katrina hit the city of New Orleans, about 100,000 people were stuck inside the city after the storm due to the congestion that still existed on the highways exiting the cities (Sullivan, 2005). Hurricane Irma, the "most powerful Atlantic Ocean hurricane in recorded history" caused almost 7 million people in Florida, Georgia, and South Carolina to evacuate from their home (Florida Association of Counties, 2017). Obviously, this caused very large traffic jams on the main north-south highways in the southern part of the United States. Miami International Airport saw a 30% increase in the number of flights the Thursday before the storm hit (Florida Association of Counties, 2017). The evacuation process overloads the transportation system, leaving very little option other than sitting and waiting for the vehicles further north to move and letting the queue dissipate.



The Florida Keys is an archipelago consisting of many, small islands off the southeast coast of Florida. As of the 2010 Census, the population of this area is approximately 73,043. The evacuation process is critical in coastal, densely populated areas because every member of the community is required to evacuate and use the same transportation facilities. These facilities were not designed to handle the entire area's population. This problem is magnified even further in the Florida Keys because there is only one road that connects all the islands and provides access to the mainland, US-1. This creates a significant problem because all 73,043 of these people must use the same road and exit point. In addition to this, when US-1 returns to mainland Florida, the outlet is in Miami-Dade County, which is another densely populated area that has evacuation struggles of its own. Residents of the Florida Keys must be especially cautious when creating their evacuation timeline to make sure they are not still stuck in traffic when the hurricane hits.



Because of the unique geographical situation of the Florida Keys, additional research needs to be completed to provide recommendations to the local emergency response teams for improvement in the evacuation process. The overall goal is to better understand the evacuation process in the Florida Keys, FL to assist in the planning, mitigation, response, recovery, and adaptation of this area from disasters. This will be achieved by building a model of the Florida Keys and modeling various improvements. Analysis of average total travel time, total evacuation time, and vehicle emissions will be completed. This analysis will be used to determine feasible, effective recommendations for the local governments in the Florida Keys. This project will focus on researching improvements, providing analysis on their feasibility in the Florida Keys and ultimately deciding which improvements will be modeled for further analysis.

## METHODOLOGY

To provide a basis of measurement and comparison, this research seeks to develop a microscopic traffic simulation model of the Florida Keys to evaluate evacuation strategies such as contra-flow, hard-shoulder use, demand metering, and unconventional intersection control strategies. More importantly, the research seeks to illustrate methods to measure and quantify evacuations in an unbiased, practical, and repeatable fashion that is both intuitive and beneficial to state officials. Traffic volume counts collected during Hurricane Irma will serve as a validation parameter for model development.

Based on these ideas, the objectives of the research seek to better understand the evacuation process of vulnerable communities in the Florida Keys, FL to assist in the planning, mitigation, response, recovery, and adaptation of these areas from disasters. It is also expected that the findings from this research can be applied to evacuations of any hazard type or location.

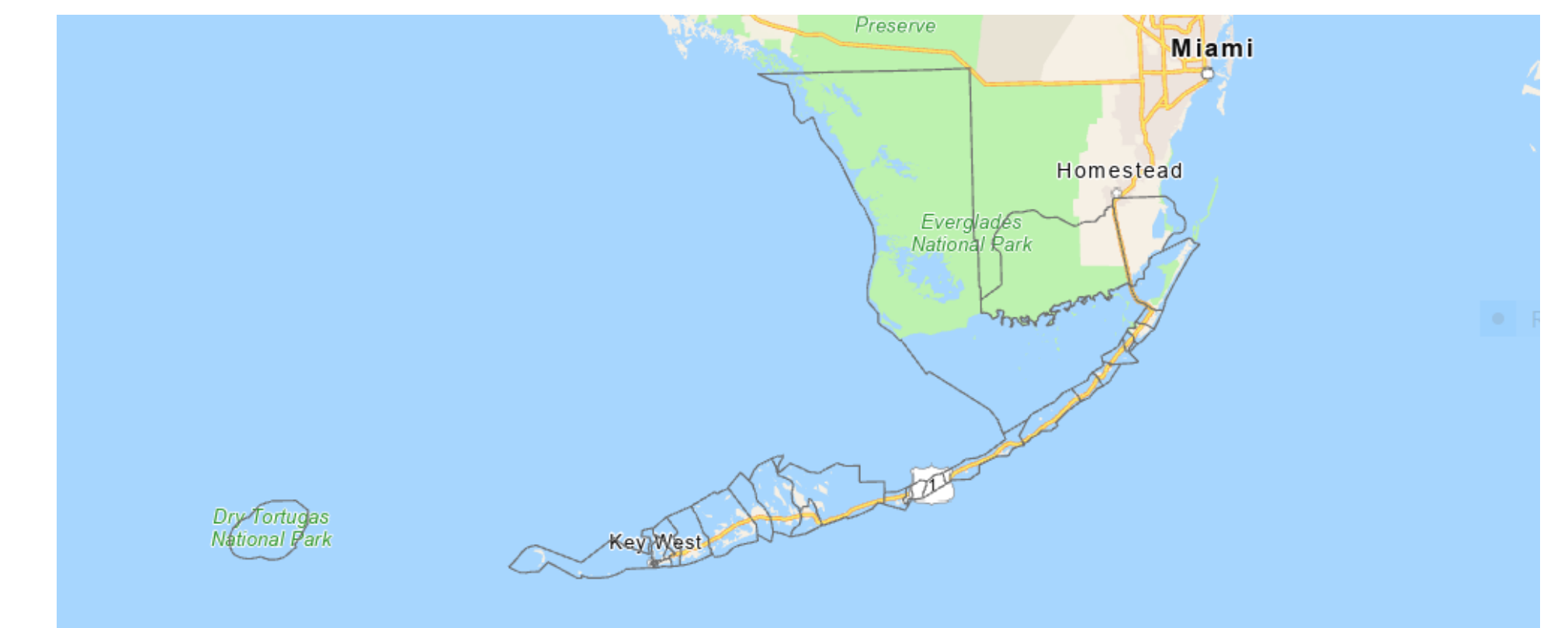
The following process will be followed to produce recommendations that will help local agencies produce a more safe and efficient evacuation.

- 1) Collect Data on the Florida Keys and Understand Project Study Area – Data was collected on the population of Census Tracts, Signal Timings, and other Operations Data. In addition, data was provided by the Florida Department of Transportation that provided travel times for part of this segment during the Hurricane Irma Evacuation in 2017.
- 2) Generate Base Model of the Florida Keys Using VISSIM – This includes building the roadway network, addressing conflict areas, and providing input number of vehicles in the form of an Origin-Destination Matrix.
- 3) Validate Travel Times – Using the data provided by FDOT, and running the model with base conditions, the provided travel times of the route are calibrated. This will verify that the same number of vehicles are modeled as using the roadway as they do in a real evacuation.
- 4) Research Improvements – There are many different philosophies on improving traffic congestion during a hurricane evacuation. These often rely on various physical features of the existing roadways and traffic tendencies. This step will include research, review of the existing evacuation plan in the Florida Keys, analyzing the feasibility of different improvements in the Florida Keys, and determining the recommendations that will be modeled in VISSIM to improve the evacuation process.
- 5) The improvements that were selected will then be modeled in VISSIM by modifying the existing condition model.
- 6) Each simulation of the improved evacuation of the Florida Keys will then be analyzed in comparison to the existing conditions and other improvements. The total time of the evacuation, the average travel time for a vehicle evacuating, and the environmental impact of each improvement will be considered. From this analysis, the best improvement will become the recommended evacuation technique for the Florida Keys.

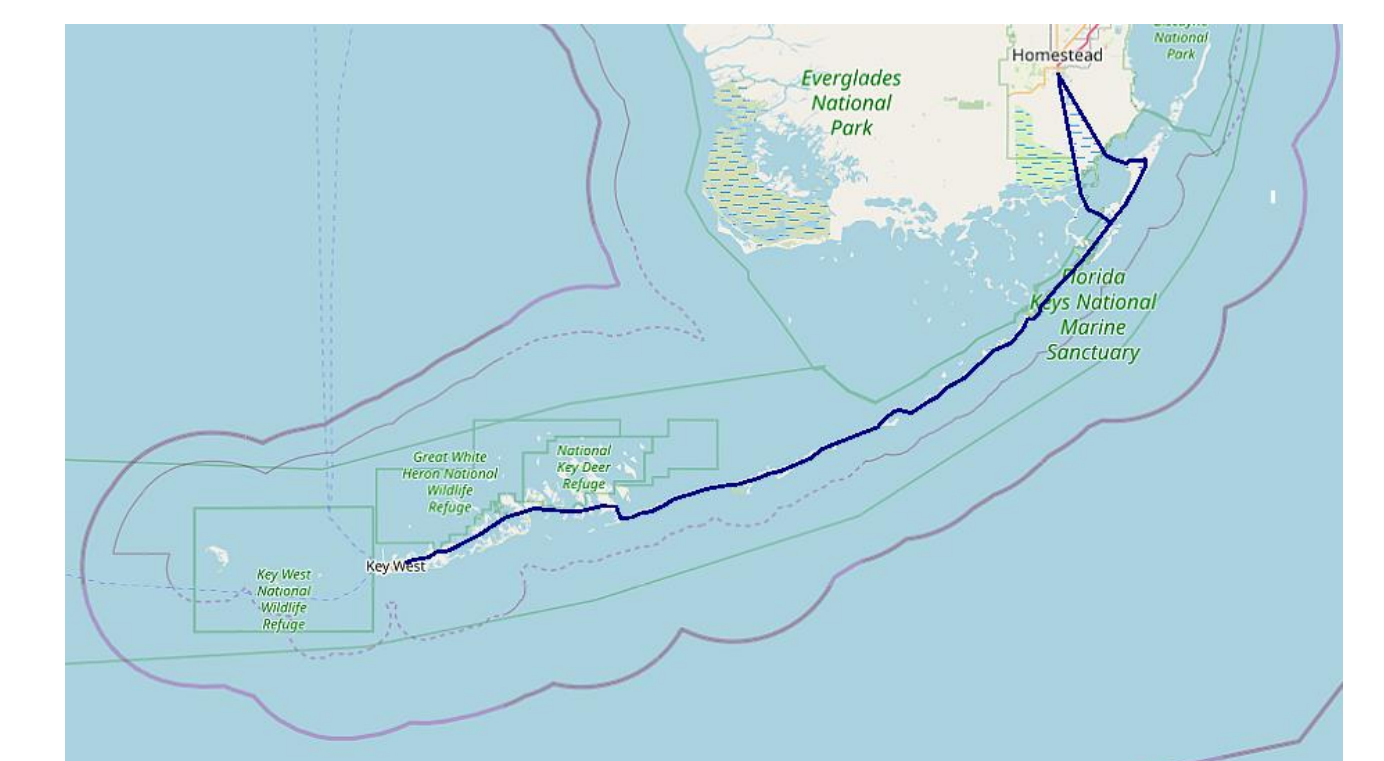
This research seeks to provide a system for state departments of transportation and emergency management officials to analyze future auto-based evacuations. The method also facilitates parametric comparisons between evacuation events, an area needed to continue to evolve and improve evacuation practice. With additional research, the methods laid out in this paper could also lead to a more comprehensive understanding of evacuation traffic processes and behavioral responses to improve their planning and management. The scientific contribution of this work is that it demonstrates a straightforward and reproducible methodology to evaluate the auto-based evacuation response for an impacted area. The proposed methods demonstrated in this paper have a significant practical value for state transportation and/or emergency management agencies seeking to accurately assess evacuation traffic management plans.

## DATA ANALYSIS

The research completed provided important information about the Florida Keys to be able to create the model. Below, a picture of the ArcGIS Map that provided the population of each census tract in the project study area is provided. This information provides the base level for number of vehicles on the roadway and the number of Origin-Destination pairs during a hurricane evacuation. The total population of the project study area is 73,043.



The traffic simulation model for this project was created in PT VISSIM. This program is the world's standard for traffic and transportation planning because it provides a realistic and detailed overview of the traffic flow and the impacts this would have on the community. In addition, what-if scenarios can provide a reliable predictive simulation that accounts for driver behavior and decision making in a transportation network. The traffic model that was created can be seen below. It required providing signal timings, creating the roadway network, providing priority for every conflict zone and creating the other traffic control devices like stop signs. There are thousands of intersections on this route.



Verifying this model is the end goal for the Fall 2020 Semester. Because of this, it has not been completed yet.

Research and analysis of possible improvements has occurred. The following improvements will be modeled: contraflow, emergency shoulder use, flashing yellow signals, conflict elimination, and evacuation by zone. The improvements are safe and could be implemented relatively easily in the Florida Keys. The physical demands of each method are met by US-1 in the Florida Keys and should improve the capacity in a safe and efficient manner. Each method has a negative, but that is expected because evacuating from a hurricane is an emergency traffic pattern, and vehicles just need to move toward the mainland as quick as possible. Because of this, these five methods will be modeled in VISSIM and the outputs of the model will be analyzed to determine the best recommendations.