ABSTRACT

The 2017 evacuation from Hurricane Irma has been referred to as the largest evacuation in the history of the United States. Approximately 6.5 million Floridians were placed under either mandatory or voluntary evacuation orders. Research on evacuation phenomena during Hurricane Irma was fueled by several factors that were unique to the storm:

1) Hurricane Irma had already devastated a number of Caribbean islands, including the U.S. Virgin Islands and Puerto Rico, resulting in several known deaths at the time [2].
2) At one point, Hurricane Irma was the fifth strongest hurricane ever recorded in the Atlantic basin.
3) The storm’s path and “cone-of-uncertainty” threatened nearly the entire state of Florida.
4) Fluctuations in the storm’s path indicated possible devastating storm surge to nearly all of Florida’s coastal areas, where the majority of residents live.

The National Hurricane Center’s (NHC) storm path prediction for Hurricane Irma 67 hours before landfall suggested a Saffir-Simpson scale Category 4 hurricane making landfall in southern Florida. However, 21 hours later the NHC’s revised storm path predicted a landfall on the Florida Keys and a northern approach along the western coast [3]. It is the storm’s unplanned evacuation routes from both the eastern and western portions of the state as well as coastal regions in the south from Key West, north to Jacksonville, FL.

Ultimately, Hurricane Irma made two landfalls within the state of Florida. The first was near Cudjoe Key in the lower Florida Keys, on September 10th 2017 at approximately 9:10 AM ET as a Category 4 hurricane with sustained winds of 130 mph (209 kph). The second landfall was at approximately 3:35 PM ET near Marco Island, just south of Naples, FL as a Category 3 hurricane with winds of 115 mph (161 kph) [4]. The storm left approximately 6.7 million homes (65 percent of the state’s population), without power [5]. Hurricane Irma was attributed to taking the lives of 75 Floridians and costing an estimated $49 billion [6]. The lower Florida Keys remained closed to non-residents for approximately three weeks following the storm [7].

The objectives are achieved through the simulation and modeling of roadway volumes collected from ground based sensors (predominately, magnetic-loop detectors) and hurricanes (Irma 2017) evacuation. This two events provide a unique opportunity to study the evacuation phenomenon because it is among the largest in the history of the United States; it affected nearly all of the major population centers of the state, and traffic volumes are recorded on a geographic scale at levels of fidelity rarely achieved in prior evacuation studies.

This research seeks to provide a system for state departments of transportation and emergency management to develop best practices for future ad-hoc based evacuations. The method also facilitates parametric comparisons between evacuation events, an area needed to continue to evolve and improve evacuation practices. Standardized measures for hurricane evacuations are needed to facilitate systematic evaluations of performance. Future researchers could build upon methods presented here to develop a knowledge base of evacuation planning and response. This approach is similar to the way the Highway Capacity Manual uses the standardized cost-benefit analysis for the various stages of highway planning. 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 using proposed methods demonstrated in this paper in a significant practical value for state transportation and/or emergency management agencies seeking to accurately assess evacuation traffic management plans. Finally, this research creates a set of aggregate evacuation parameters that can be used to validate and calibrate evacuation modeling and simulation models for future research studies.

DATA ANALYSIS

This model includes the main road that connects all of the Florida Keys, US-1. In addition, route 90A, which is also known as Card Sound Road, provides a second route back to the main peninsula. This model includes the main roads and every intersection off of these two roads. Vehicles can enter the network using these access points.

In addition to using PT VISSIM, this project utilized ArcGIS. ArcGIS offers unique capabilities and is flexible when applying location-based analytics to the project. It provides great insights using contextual tools to visualize and analyze the data using interactive maps.

ArcGIS was used to analyze population data that we then used for our simulation model in PT VISSIM to generate traffic to the main roads US-1 and 90A. The data was collected from the U.S. Census Bureau that provided population data from 2010. The maps generated in ArcGIS provide the model with the number of citizens evacuating from each road, response, recovery, and evacuation routes imported into ArcGIS to spatially represent the population was provided by the U.S. Census Bureau.

To determine the accuracy of the model, travel information and traffic data from a real evacuation is needed. Travel times for September and October of 2017 were provided by the DOT, District 6 Hurricane Irma data and the evacuation occurred on September 9th 2017 and the evacuation process ended on October 10th and the Hurricane Irma was declared as a hurricane. This data was used to compare the evacuation traffic data from the real evacuation and the process. The evacuation traffic data from the real evacuation was used to compare the evacuation traffic data from the real evacuation and the process.

Due to COVID-19, this project has not been fully completed because of the reliance on various programs. The Data Analysis section above explains the different data sources and the programs and processes used to generate the model and traffic simulation.