ASSESSING IMPACTS OF HURRICANE EVACUATION STRATEGIES ON TRANSPORTATION NETWORK: A CASE STUDY OF HOUSTON-GALVESTON REGION

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ABSTRACT

The deadliest natural disaster in US history was the Galveston Hurricane of 1900, which claimed over 8,000 lives as the storm inundated the entire island. Recent developments in warnings and evacuations have significantly reduced the number of US fatalities due to storm surge (*1*, *2*). Unfortunately, as illustrated during the 2005 hurricane season and the evacuations surrounding Hurricanes Katrina and Rita in particular, many improvements can still be made in these regards. While many improvements have been made in the technical tools developed to aid decision-makers, the events of 2005 served to highlight the important role of cooperation between jurisdictions, timely relevant information, and consistent communications with the public (*3*). With populations in hurricane-prone regions projected to continue increasing, and the elderly – a significant portion of the "special needs" population – expected to triple by the Year 2050, the challenge of mass evacuations of Texas coastal regions will only increase in complexity and magnitude as we move forward (*3*, *4*).

Since the 1970s, evacuation modeling techniques have improved significantly. It is interesting to note that many of the early models were initially developed to plan for other civil defense emergencies, such as nuclear missile attacks and nuclear power plant accidents. Among these programs are NETVAC, TEDSS and DYNEV. When applied for hurricane evacuation purposes, the data that feed many of these programs have come from the inventory of Hurricane Evacuation Studies (HES), which were initiated in the late 1980s by FEMA to integrate key aspects of hurricane evacuation planning and to assist in disaster preparedness (*2*). Several models have been developed for and/or including hurricane evacuation traffic flow analysis. Such tools include Evacuation Traffic Information System (ETIS) and the Evacuation Travel Demand Forecasting System. Today, simulation programs are used to model weather, flooding, traffic flow and evacuation travel behavior, among others. An effort is also underway to develop a computer-based incident management decision aid system (IMDAS).

More recent research describes a simple, rapid method for calculating evacuation time estimates (ETEs) that is compatible with research findings about evacuees' behavior from approaching hurricanes. The revised version of an earlier version of the empirically-based large scale evacuation time estimate method (EMBLEM) uses empirical data derived from behavioral surveys and allows local mangers to calculate ETEs by specifying route system, behavioral, and evacuation scope/timing parameters (*5*). Data used to estimate and test the models of evacuation travel demand were from a household survey conducted in southwest Louisiana, with information related to Hurricane Andrew (in 1992).

This presentation will describe the quantitative assessment of the performance of alternative evacuation strategies using dynamic traffic assignment model DynusT. Two major evacuation strategies being considered in this talk are "evaculane" and "contraflow."

TxDOT developed a special pavement marking symbol to designate shoulders for use as an additional travel lane during evacuation. These lanes are referred to as "*evaculanes*." Recent study by TTI developed guidelines for various hurricane evacuation signs and markings, including route signs, contraflow signs, emergency shoulder lane signs, and pavement markings (*6*).

Contraflow is a form of reversible traffic operation in which one or more travel lanes of a divided highway are used for the movement of traffic in the opposing direction. Contraflow is one of the hurricane evacuation tools that will be extensively modeled and evaluated in the current research effort.

Contraflow is more practical on freeway facilities because they do not have at-grade intersections, which can interrupt flow or permit unrestricted access into the reversed segment. Several recent studies have examined the characteristics of contraflow operations. The highest flow rates measured by the South Carolina Department of Transportation (SCDOT) during the Hurricane Floyd evacuation were between 1,500 and 1,600 vphpl (*7*). Traffic flows measured during the evacuations for Hurricane Ivan and Katrina on I-55 in Louisiana were somewhat lower at 1,230 vphpl and 820 vphpl on normal and contraflow lanes, respectively, on average over the peak 10 hours of the evacuation (*8*).

Preparation of contraflow can take at least six hours in addition to the time to plan and acquire equipment for traffic control. Inadequate designs at the upstream and downstream ends can further limit the effectiveness of the contraflow operation. In addition, traffic incidents and work zones on evacuation routes can affect pre-planned operations. Therefore, these characteristics must be appropriately captured in the modeling process in order to realistically simulate and analyze evacuation strategies.

Since the Hurricane Rita in 2005 and Hurricane Ike in 2008, segments of I-10 and US-290 have been widened and shoulders have been paved and signed for the evaculane operation. In addition, a partial contraflow plan was developed on I-45 where the operation would begin south of Loop 336-South in Conroe and would terminate near the Walker/Madison county line using FM 2889 and Spur 67. With these developments, TxDOT has sponsored a study to develop a decision support tool to help determine if these strategies would adequately handle the hurricane evacuation demand. The simulation scenarios were designed to cover a range of possible evacuation demand and potential evacuation strategies with the primary focus on providing realistic impacts of evacuation demand on the transportation network. The simulation model was used to evaluate the network performance for the proposed evacuation scenarios. The results from the models capture the quantitative aspects of the decision support tool being developed to aid decision makers in selecting appropriate hurricane evacuation strategies.

The simulation results indicated that the average network-wide evacuation travel time using existing infrastructure (expanded I-10 and US 290) will be approximately 30% lower than those experienced during the Hurricane Rita's evacuation. The results also indicated that the evaculane strategy on I-10 and US-290 can save up to 2%-5% in the average evacuation travel time in the high and very high demand scenarios. In addition, when the evaculane strategy is deployed in conjunction with the partial contraflow on I-45, this combination can reduce the average network-wide evacuation travel time up to 5%-7% without the need to implement the full-scale contraflow operation.

References

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