Enhancements to Emergency Evacuation Procedures

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16. Abstract

The Alabama Gulf Coast region is periodically subjected to tropical storms and hurricanes. These events are traumatic and many people evacuate the coast. Normal traffic flows turn into congestion, frustration and gridlock. Drivers may become frenzied and take unusual risks. This reduces the number of vehicles that can leave the area if an evacuation order is issued. If a severe hurricane strikes the coast, stalled traffic flow can contribute in catastrophic loss of life and damage.

This study was conducted to review and evaluate existing emergency evacuation procedures for the Gulf Coast, and to make recommendations for the use of advance technologies to enhance evacuation procedures. An advisory committee of transportation and emergency management officials was involved throughout the project. The study included the examination of existing emergency evacuation plans, interviews with involved individuals and agencies, identification of technologies that can be adopted to improve planning and management of evacuations, simulation of evacuation traffic flows, and other technical steps. The study terminated with recommendations for enhanced procedures for conducting evacuations.

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Executive Summary

The Alabama Gulf Coast region is periodically subjected to tropical storms and hurricanes. These events are traumatic and many people evacuate the coast. Normal traffic flows turn into congestion, frustration and gridlock. Drivers may become frenzied and take unusual risks. This reduces the number of vehicles that can leave the area if an evacuation order is issued. If a severe hurricane strikes the coast, stalled traffic flow can contribute in catastrophic loss of life and damage.

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Section 1
Introduction

Problem Statement

The objective of this study was to review current emergency evacuation plans and procedures for the Alabama Gulf Coast, and to make recommendations for the use of advanced technologies where appropriate to improve evacuation during extreme events.

The study did not consider storm prediction and tracking which are essential parts of a hurricane emergency management system. This information allows officials determine which areas need to be evacuated and when the call for mandatory evacuation is needed. Accurate tracking of the storm reduces the chances of the decision-makers to make false alarms. Repeated false alarms will have a negative effect on the population as they start loosing faith in the decision-makers. Thus, false alarms should be avoided.

Research Approach

The work was broken into a series of sequential tasks. It started with the formation of an advisory committee and a review of procedures currently being utilized by the Alabama Emergency Management Agency (EMA), the Alabama Department of Transportation (ALDOT), and the Federal Emergency Management (FEMA). Discussions with representatives from these agencies disclosed strengths and weakness in prior efforts and identified several excellent planning documents and support documents.

The UTCA research staff evaluated tools like global positioning satellites (GPS), geographic informational systems (GIS), and Intelligent Transportation Systems (ITS) as ways to monitor and improve flow. Additionally traffic flows for major transportation arteries involved in emergency evacuations were simulated. Consequently, recommendations were developed for improved technologies and procedures, and for technology transfer efforts to improved knowledge and job skills to enhance future emergency evacuations during extreme events.

Advisory Committee:

The project was initiated by formation of and advisory committee, composed of representatives from EMA, ALDOT, and the University Transportation Center for Alabama (UTCA) at the University of Alabama. The Advisory Committee helped identify and obtain existing documents, identified and contacted resource people, reviewed and evaluated previous efforts, and otherwise guided the research project. The UTCA researchers are indebted to them for their assistance and advice.

Section 2
Initial activities

Involved State Agencies

The initial project work steps involved bringing members of the advisory board to a common state of knowledge about available information, agency plans, previous activities, legislation, other guidelines, and other factors that would affect the project. This included learning the roles of individual agencies.

EMA is responsible for coordinating emergency management at the state and local levels, and developing plans for response to disasters and other traumatic events. It plays a lead role in building emergency management capacity and ensuring that other agencies, organization, and individuals are prepared to help with its four main functions of mitigations, preparedness, response and recovery.

ALDOT works closely with EMA during declared emergencies. ALDOT coordinates support agencies and directs utilization of transportation resources in prioritizing transportation service needs and planning and deploying transportation resources.

Transportation Related Self-Emergency Preparedness Plans

A key transportation element of emergency preparedness is reverse-laning of Interstate highways for hurricane evacuations. ALDOT had developed a plan for reverse-laning I-65, had published the report, coordinated it with other agencies, and had conducted limited field trials to ensure that it would function appropriately.

In the Gulf Coast region, reverse-laning is converting the southbound lanes of I-65 to carry northbound traffic. It must be done carefully so that people fleeing the coast are not accidentally diverted into oncoming traffic on an Interstate highway. In simple terms, each entrance ramp for southbound traffic must be block by uniformed officers. Each southbound exit ramp must be temporary converted to an entrance ramp. Traffic normally flowing south on I-65 must be redirected to other southbound routes with detour signs. After southbound traffic has been halted and all changes have been made to the ramps, pilot vehicles must drive each section of the route to make sure that no southbound vehicles were inadvertently trapped in a section. If this is not done, vehicles could be met by oncoming evacuation traffic. This entire process is difficult and time consuming.

Reverse-laning can also be used for U.S. 331, U.S.231 and U.S.431. However, this is much more difficult because all intersections have to be blocked for the entire route, and there may not be alternative means for drivers to cross the reverse lane road when evacuation is at high flow.

There are twenty interchanges on I-65 within the reverse-laning area. At each interchange four ALDOT employees and two Department of Public Safety (DPS) officers must be stationed. Other ALDOT and DPS employees must be placed at the north and south termination points of the four laning, and at the four intermediate cross-over points where traffic moves from the northbound lane into the southbound lane. Additional employees must work in the ALDOT and DPS district division offices for communications and other purposes. Overall, more than 150 people must be at work while the reverse-laning is in operation. This obviously requires planning, coordination and practice.

Section 3
FEMA Coordination

FEMA Coordination between States

Coordination between FEMA and multiple agencies in multiple states is, to say the least, a major challenge. Post disaster research has substantiated the problems that have occurred between FEMA and the states during emergency evacuations, and has indicated that there is room for improvement in coordination. This statement is not meant to belittle the previous coordination efforts, instead it points out that more agencies are now involved and that complexity and resource demands are growing. There are many more people living along the Gulf Coast than previously, and there are many more local governments, first responders, private contractors, and humanitarian efforts involved in disaster response and recovery.

Example Coordination

Hurricane Floyd occurred in September, 1998. It illustrates the coordination procedures in place at that time. The Gulf Coast states had preplanned evacuation using the available study products based upon average or estimated evacuation times and typical evacuation procedures. A simulation program called HurrEvac had been used to predict evacuation results. The simulation results were used by the involved departments of transportation to prepare for such events. For example, evacuation information was displayed at rest areas to assist evacuees.

During the evacuation there were extensive inland traffic delays along Interstate highways. The prevailing thought was that this was due to a shortage of personnel to safely and efficiently control traffic at median crossovers, entrances and exits. In addition, it was thought that the absence of emergency message signs and remote message signs contributed to the problem. Post event studies showed that emergency management agencies had trouble in obtaining good data on how the evacuation was preceding, which made managing the evacuation very difficult.

FEMA conducted regional meetings between the states to identify areas for improvement, to identify required research, and to establish initial plans for improvements. As a result, funding was provided for improved modeling, training, supplies and equipment, and practice drills for evacuations.

Section 4
Potential Technology Applications

A major component of this project was to identify new technologies which might assist in planning for, responding to, and recovering from catastrophic events along the Gulf Coast. The research team examined several of these, including ITS, GIS and GPS, for possible applications. Several pieces of software were identified. One of these was the internet-based Evacuation Traffic Information System, which was reviewed by the research team. Potential applications in Alabama were identified and documented for agency decision makers. In some cases specific recommendations were made to agencies.

Intelligent Transportation Systems

For ITS, approximately ten million dollars of Federal funds were traced to specific projects already conducted in the Gulf Coast region. These were discussed with advisory committee members, and used to illustrate improved traffic management capabilities. For example, traffic management centers and traffic operations centers have been funded in several cities. Traffic monitoring cameras, highway advisory radio and variable message signs have been funded through this program and appear to be applicable to evacuation of the Gulf Coast.

Incident management received particular attention during the study. This provides an organized system for quickly identifying and responding to vehicle accidents, break downs of traffic flow, and other non-recurring incidents. This improves the arrival time of emergency medical services on site, quantifies the degree of damage or traffic interruption, and assists in restoring service in a minimal amount of time. This function would be particularly useful during mass evacuations.

Another ITS component that appears to be useful is advanced traveler information systems. If widely employed across the Gulf Coast this system could provide up-to-the-minute information about the location and magnitude of the storm, the status of evacuation orders, and traffic volumes in various points with in the highway system. This would be ideal for motorists planning the best evacuation route.

Global Information Systems

GIS systems are very useful in planning for and responding to catastrophic events. They allow categorical storage of large volumes of data and quickly display selected portions of that data on a map of the affected area. In other words, the old axiom is true, “One picture is worth a thousand words” when dealing with emergency situations. The simplicity with which information can be captured and displayed, even complex data, is ideal for discussion making. Furthermore, the data imbedded in a GIS system can be used as input for emergency evacuation modeling, and this feature was demonstrated during the research project.

The GIS system can be organized to serve virtually any emergency evacuation situation. For example, embedded functions can be designed (and labeled) for disaster forecasts, vulnerability analysis, resource inventories, existing infrastructure inventory, shelter identification and status, and many other useful functions. The ability to customize the embedded functions and label them for users means that the user does not have to understand GIS. Even novices can use the system and this information can quickly be displayed on a screen during a catastrophic event to provide decision makers at any level with data. It is possible import existing data bases into a GIS system to compile attribute tables however this may require editing of the data using automated or manual procedures. This can be done during the planning process, long before an extreme event, and used in real-time during the event.

Section 5
Simulation and Optimization of Traffic Flow

The objective of this portion of the project was to use simulation to study traffic flow during an extreme event. The data was taken from a GIS database of the Alabama Gulf Coast. The Oakridge Evacuation Modeling System (OREMS) was used to perform the simulation. This software estimates evacuation time and develops evacuation plans for different events for user defined spatial boundaries (Tufecki, 1995). Simulation models were developed for Baldwin and Mobile counties Alabama. The output of the OREMS model included graphic files (animation) tabular reports and raw data.

OREMS was selected after considering several other software packages. This included CORSIM produced by the Federal Highway Administration, DYNEV produced by KLD Associates, and WITNESS produced by the Lanner Group.

During evacuation exercises, time is the crucial element. Initiating the evacuation and managing it must be initially based upon accumulated meteorological data and known capacities of local roadways. Once that decision has been made it is crucial to move traffic toward the appropriate roadway within the network to minimize congestion and save time. This was an important reason that OREMS was selected. It consists of three major components: (1) an input data manager, (2) an ESIM (evacuation simulation) graphic model and (3) an output display manager. ESIM is the key element. It is a Fortran-based program that simulates network conditions as the evacuation proceeds.

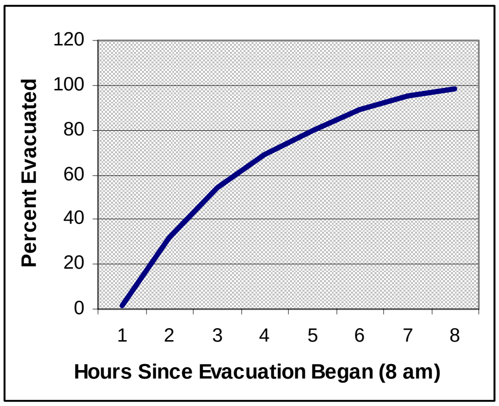
The simulation models developed during this study were limited to Baldwin and Mobile Counties. They included I-65 (with reverse-laning) and I-10 (with no reverse-laning) because these are the two major routes for moving traffic in large volumes. US routes 331, 221, and 431 were the other major north /south routes.

This simulation model required that the user enter the highway network as a series of links and nodes. Additional inputs were required for traffic control devices, speed limits, traffic volumes, turning movements, and local population. In each case a systematic procedure based upon screen prompts and data collection was used. Once the researchers had created the models for this study, they were calibrated. Each section of the model was reviewed for accuracy and reasonableness by observing the animation and the model output. During calibration, minor changes were made to network geometry and traffic control.

After calibration, the model was run for several scenarios and the results were captured for analysis. The model outputs were presented in a seminar for representatives of the EMA, ALDOT, US Army Corp of Engineers, Department of Defense, and consulting firms. Several minor changes were made as a result of suggestions received at this presentation.

Section 6
Results of Simulation

This simulation model presented several measures of effectiveness so that users could evaluate the effects of a particular simulation scenario. In addition, the results could be displayed for a particular point in time or as a trend over time. A good example of this is shown as Figure 6-1, which displays the evacuation of Mobile County. For this scenario, the initial evacuation announcement was made at 8:00 am and it took more than seven hours to evacuate the affected area. The computer output indicated that 50 percent of the vehicles were evacuated in less than two hours, with the rate of evacuation slowing gradually over time.



Evacuation Started	8:00 am
50% Evacuated	9:55 am
75% Evacuated	11:25 am
95% Evacuated	1:55 pm
Evacuation Ended	3:13 pm
Evacuation Time, hrs	7:13
Average Speed, mph	27.9

Figure 6-1 Example simulation summary for Mobile County

Twelve simulations were performed for Mobile and Baldwin Counties with slight changes to geometry, variation in maximum speed and similar changes to other parameters. An example of the output from these simulations is shown in Table 6-1. These results were stored within the OREMS data base for later analysis.

In interpreting the output it is important to remember that simulation does not give exact answers, but by changing parameters such as the highway network maximum speed, it does give very realistic analyses of the effects of different traffic management strategies. Thus provides good data to managers.

Table 6-1 Summary of simulation results for Baldwin County – model run 1

Input	Flow Speed		Interstate: 50 mph, Urban roads: 30 mph
Output	Evacuation Time		21 hours, 8 minutes
	Average Speed		23.6 mph
	Intersections with traffic congestion, indicated via dynamic display	Speed < 10 mph	I-10/Co 27; I-10/AL59; I-65/AL287
		10 < Speed < 20	I-65/Co27; Co27/Co64; AL59/Co64; US31/Co138; US31/AL59

The results of the twelve simulation runs indicated that it takes approximately twenty-one hours to evacuate Baldwin County and approximately eight hours to evacuate Mobile County. These results were obtained with speed limits of approximately 60 mph on Interstate highways and 40 mph on urban streets. The research showed that small variations in speed limits had almost no effect on the model because traffic would eventually reach a speed well below the speed limit. The worst case was reached when traffic speed fell to less than 10 mph during the evacuation.

One useful piece of information that emerged from the simulation was that the highest degree of congestion occurred in Baldwin County at several key intersections/interchanges: I-10 and county highway 27, I-65 and state highway 287, I-10 and state highway 59, and I-65 and state highway 225. The worse locations for Mobile County were the intersections/interchanges at: I-10 and state highway 163, I-65 and county highway 56, I-65 and US highway 90, county highway 59 and US highway 90, state highway 188 and Pinecrest Road, and US highway 45 and county highway 96. Knowledge of these congestion bottle necks, and the relative amount of speed reduction associated with the various lanes configurations provided good clues as to where traffic management activities must be carefully planned during evacuation.

The simulation exercise demonstrated that the OREMS software could be coded and calibrated to simulate the Gulf Coast during an extreme evacuation. The software estimated time frames associated with evacuation, percent evacuation completed any designated time and other key measures of effectiveness. This data, plus other model output, allows evaluations and additional scenarios to be conducted to maximize decision data for managers.

Section 7
Recommendations

This project analyzed extreme event traffic flow in the Gulf Panhandle. It identified and demonstrated software capable of modeling such flows. Furthermore, it investigated the roles of technology (ITS, GPS, GIS) in enhancing evacuations.

This study noted the good previous cooperation and coordination between EMA, ALDOT and FEMA. But the study also encouraged that coordination be increased through joint exercises, joint development of plans and joint practice training sessions. Specific recommendations included placing additional officers at the key intersections identified in this study, and if possible to position tow trucks and other emergency services at these locations as well as other possible traffic bottlenecks.

The researchers made specific recommendations for incorporating technology to members of the advisory committee. This included the use of GPS and GIS for receiving, storing, and using data during the planning and response phases of emergency evacuation. This is particularly useful to decision makers.

Technology systems like variable message signs and highway advisory radio can be adopted in greater numbers throughout the region to facilitate the distribution of information to evacuees, whose stress level can be reduced if they have real time information about the threat and their best course of action. Likewise regional traveler information signs increase highway assistance to motorists, and in-vehicle systems can offer significant communication advances in the future. The use of portable variable message signs at key locations along evacuation routes was recommended, provided that they could be moved or secured prior to the arrival of the storm. Also the placement of additional motorist call boxes along evacuation routes would be helpful to motorists needing to report break-downs or otherwise request assistance.

The simulation exercises conducted during this project demonstrated that evaluation flows can be successfully conducted, and that decision data can be obtained. The research team recommends that such modeling be continued, and that it be used for planning for extreme events, and managing those events when they do occur. Specifically, simulation of different levels of evacuation should be performed, including situations where storm intensity indicates that only partial county evacuation is required.

Other modeling could include simulating traffic flows as residents return home after the storm has passed. With better storm prediction and tracking, evacuees may receive notice to evacuate days before the storm arrives. However, when the “all clear” is given and residents are able to travel home, everyone may try to return on the same day which can cause additional traffic problems and gridlock.

In closing the authors express there appreciation to members of the advisory committee, the project team and others who provided data, assistance and advice.

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