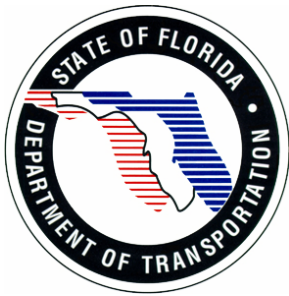


**White Paper**

# **Using Data from Intelligent Transportation Systems in Managing Evacuations**

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## **List of Acronyms**

CEMP.....	Comprehensive Emergency Management Plan
ELT .....	Evacuation Liaison Team
EOC.....	Emergency Operations Center
ETIS .....	Evacuation Transportation Information System
FDEM .....	Florida Division of Emergency Management
FDOH.....	Florida Department of Health
FDOT .....	Florida Department of Transportation
FEMA .....	Federal Emergency Management Agency
FHP .....	Florida Highway Patrol
FHWA.....	Federal Highway Administration
FPR .....	Florida Public Radio
GAR .....	Governor’s Authorized Representative
HAR .....	Highway Advisory Radio
HAZMAT .....	Hazardous Material
HEADS-UP.....	Hurricane Evacuation Analysis and Decision Support Utility Program
I-75 .....	Interstate 75
ITS.....	Intelligent Transportation System
NHC .....	National Hurricane Center
NWS.....	National Weather Service
PBS&J.....	Post, Buckley, Schuh & Jernigan
REVAC.....	Regional Evacuation Procedures
RPC .....	Regional Planning Council
SWFRPC.....	Southwest Florida Regional Planning Council
TMC.....	Transportation Management Center
TTMS .....	Telemetered Traffic Monitoring System
USACE® .....	United States Army Corps of Engineers®
VMS.....	Variable Message Sign

## **1. Background**

Clearly, the travel demand imposed on Florida's roadway infrastructure during hurricane evacuations has attained a critical mass. There are many scenarios in the State of Florida where the number of vehicles on the roadway during a hurricane evacuation will drastically exceed the capacity of all the roadways out of the risk area, therefore causing a massive gridlock. Unfortunately, many of those gridlock scenarios do not necessarily require category four or five hurricanes, and the resulting clearance times will be measured in days not hours. Consequently, the time needed to clear traffic along critical roadway segments for evacuations in many regions of Florida will require significantly more time than the most amount of credible warning time provided by the National Weather Service (NWS) and the National Hurricane Center (NHC).

An obvious solution to this hurricane problem is to increase capacity on most evacuation roadways, especially the ones most likely to become congested or overwhelmed during hurricane events. In that regard, the State is already embarking on the improvement of some of those critical roadway segments, and the benefits of the current construction efforts will result in significant improvements in clearance times for certain regions, at least temporarily. Despite these expected improvements to clearance times, in most cases, those highly vulnerable and populated regions will still require days to clear the roadway links and complete their evacuations.

Another problem with the construction solution to the evacuation problem is the time necessary to complete the work. The more ambitious the intended improvement project, the longer the time needed to complete the work and restore the road to normal operating conditions. Many of these projects will impose some degree of construction-related constraints to the improved roadways during one or more hurricane seasons. As a result of lessons learned during Hurricane Opal in 1995, the Florida Department of Transportation (FDOT) does include in their construction contracts a clause that requires that contractors undertake whatever measures are necessary to temporarily restore the original number of lanes present before construction during a hurricane event. Nonetheless, even if those measures are successful in restoring the original number of preconstruction lanes during an evacuation, in many cases, the equipment and other methods needed to accomplish that end will have a dampening effect on the amount of traffic that those roadway segments can convey.

A final drawback to the evacuation route construction and improvement strategy for reducing clearance times for the State is that evacuation demand will continue to rise, eventually outstripping the additional capacity created by the construction projects. During the decade from 1990 to 2000, the population of Florida increased by approximately 550 people a day based on United States (U.S.) Census figures. A majority of those new residents have moved to the barrier islands and the near-shore areas of the counties in south and southwest Florida, and in the Treasure Coast and Tampa Bay regions. Unfortunately, these are the very regions that will create most of the scenarios that will result in clearance times measured in days, even for a category two or three event.

For example, according to transportation models developed by PBS&J that were specifically designed to emulate hurricane evacuation conditions, a category five evacuation of the Southwest Florida and Tampa Bay regions will require 128 hours to clear all of the expected traffic from the interchange of Interstate 75 (I-75) and Florida's Turnpike. The Southwest Florida Regional Planning Council's (SWFRPC) *2000 Regional Hurricane Evacuation Study* determined that 80,000 new residents have moved to the category one evacuation zones alone in the region since 1995. Therefore, it is likely that evacuation traffic demand and clearance times will increase much faster than capacity can be added, even under the most ambitious of construction régimes.

Based on the above problems associated with a strategy that relies solely on improving the evacuation roadway network, it is obvious that alternate solutions must be instituted in order to enhance Florida's ability to evacuate its citizens from any hurricane threat. Among the other measures currently being employed to improve the State's evacuation throughput are reverse laning and the concept that all levels of government must learn to manage evacuation traffic flows and other associated activities much more effectively. In both of these alternate courses, the data from intelligent transportation systems (ITS) and transportation management centers (TMC) are critical to sustaining those operations.

## **2. Emergency Management, Emergency Operations Centers, and Disaster Events**

The *State Emergency Management Act*<sup>1</sup> is the primary legislation governing the programs and activities regarding Florida's response to hurricanes, as well as other natural and technological disasters. Probably the most important provision in that *Act* is that once a county's board of county commissioners signs an emergency declaration for their jurisdiction in response to any hazard, almost absolute authority over all local resources is transferred to a designated representative, usually in the emergency management office. At the state level, once the Governor declares a state of emergency for a specific event, the Governor's Authorized Representative (GAR), usually the Director of the Florida Division of Emergency Management (FDEM), assumes the Governor's authority to appropriate and manage all state agency resources to coordinate an integrated response to the threat. To some degree, even private resources can be commandeered in support of state disaster operations.

The significance of this *Act* and the authority it conveys to local and state emergency management offices during disasters is that, during evacuations, once an emergency declaration is signed by the Governor, all agencies and activities from that point on come under the control of the GAR and the local emergency management representatives. This same *Act* also requires the development of a comprehensive emergency management plan (CEMP). These plans, which are required for state government and for each county in the State, govern the general conduct and activities of disaster operations within their jurisdictions, and elaborate on the specific responsibilities of each participating agency. The structure of Florida's *CEMP* must be closely mimicked by the county plans to ensure consistency at all levels during a disaster.

Normally, coordination activities and response operations required by the CEMP during a disaster are carried out in the emergency operations centers (EOC), both at the state and local level. Within each EOC, all agencies with the resources and capabilities required to engender an appropriate response to a particular threat are represented and manage their operations in the field from there. Elected officials and other decision makers are also in the EOCs during a disaster, overseeing the conduct of response operations. In essence, during disasters, these normally hardened facilities become the de facto center of government from which most decisions emanate, and field operations are coordinated and managed.

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<sup>1</sup> *State Emergency Management Act, Section (§) 252, Florida Statutes (2003)*

Specifically, for any type of evacuation, the State and the local EOCs will house elected officials and primary decision makers from the following agencies to perform the duties outlined below:

- Representatives from the FDOT and local public works will coordinate and facilitate operations on evacuation roadways;
- Traffic management and security requirements will be coordinated through the Florida Highway Patrol (FHP) and other law enforcement officers;
- Public and private organizations will be responsible for opening shelters and other mass care activities;
- Medical staff and Florida Department of Health (FDOH) personnel will coordinate the evacuation of hospitals and assisted living facilities;
- Fire/Rescue personnel will notify and provide first response to any exigent circumstances; and
- Public information officers will communicate with the public and interact with the media.

The representatives from the emergency management offices normally manage the operations of the entire EOC and work to ensure an integrated and comprehensive response from all agencies during a hurricane evacuation. Normally, emergency management is also responsible for liaising with officials from adjoining jurisdictions and with all levels of government.

### **3. Using ITS and TMC Data in Managing Evacuations – Decision Making**

Hurricane evacuation clearance times are used by emergency management officials and other decision makers to determine the amount of lead time needed to begin an evacuation before the forecasted arrival of tropical storm winds. The clearance time is one of the most critical pieces of information used to establish what time an evacuation order must be issued. Throughout the State, transportation modeling performed by PBS&J under the auspices of regional hurricane evacuation studies commissioned by the FDEM, the Federal Emergency Management Agency (FEMA); the U.S. Army Corps of Engineers® (USACE®) and the regional planning councils (RPC), have established clearance times for every county, as well as for entire regions or multiple regions. Despite the proven accuracy of these clearance times, they are reasonably static figures that cannot factor in every possible evacuation decision scenario, only the most likely ones. Various combinations of evacuating counties or regions, delays in timing, and other variables may have dramatic effects on the clearance times that should be used by State and local decision makers when coordinating evacuation orders.

With the advent of the telemetered traffic monitoring systems (TTMS), or real-time traffic counters, specifically located on key evacuation roadway segments, emergency management officials and other decision makers finally have the capability to modify their clearance times to account for observed or actual conditions on the evacuation roadway network. Additionally, any remote sensing capability of evacuation roads at the local or statewide level, from real-time traffic counters to the wide array of surveillance equipment, will dramatically improve evacuation decision making. By directly observing in real-time the prevalent traffic flow and other conditions on the evacuation roadway network, emergency management and other decision makers can tailor the amount of lead time needed to account for those circumstances and thereby allow sufficient time for all evacuees to clear the congested roadway segments during an evacuation. This real-time, observed data will provide decision makers with concrete evidence that additional time may be required, over and above the normal clearance time, to take into account road conditions. Access to real-time traffic counter data, and images from remote roadway surveillance systems in the State and local EOCs will provide that capability, an advantage heretofore not enjoyed by evacuation decision makers.

Another important tool for use by decision makers in EOCs throughout Florida for evacuation purposes is the Hurricane Evacuation Analysis and Decision Support Utility Program (HEADS UP). The FDEM, the FDOT, and other state agencies have collaborated with PBS&J to develop a real-time hurricane evacuation analysis tool. HEADS UP is a Florida-specific, follow up version of the Evacuation Transportation Information System, or ETIS, which is used by the Federal Highway Administration (FHWA) and FEMA's Evacuation Liaison Team (ELT) to coordinate evacuations for all states in the southeastern United States. The HEADS UP tool will allow the agencies in the State EOC to better analyze existing roadway conditions as compared to predicted evacuation travel demand, and communicate those results with local EOCs throughout Florida. This analysis tool will provide better information to improve decision making at the State and local levels and to allow a much more proactive response to potential problem areas during an evacuation event.

The program will weigh the travel demand caused by cumulative evacuation decisions and determine a realistic clearance time for that scenario; predict probable congestion problems by roadway segment, hour, and duration; and perform rerouting analysis for accidents and other exigent circumstances. The HEADS UP analyzation tool will generally give all EOCs a much more accurate prediction of how the statewide evacuation roadway network will function during an evacuation event, factoring in real-time data on the actual performance of critical roadway segments. The data from the TTMS and remote traffic surveillance cameras will provide the needed information for HEADS UP to perform its various analysis functions. Without the critical real-time observed data, the capabilities of HEADS UP to assist EOCs in managing evacuations will not be available.

#### **4. Using ITS and TMC Data in Managing Evacuations – Traffic Management**

The clearance times used for evacuation decision making, although proven to be very accurate in post-storm analyses for major hurricane evacuation events, are mostly applicable in optimal circumstances. Any exigent occurrences or other unforeseen factors that restrict traffic flow cannot, and therefore, have not been considered when calculating county or regional clearance times. An accident, severe weather event, or other temporary event that has an adverse effect on traffic flow before or after an evacuation order can render these clearance times unsuitable for use in decision making. Any incidents along evacuation corridors, especially at critical and congested segments, will result in dramatically higher clearance times, far greater than the dire figures provided earlier in this document.

The real-time roadway data provided to officials in the EOCs through ITS measures such as TTMS and TMCs will definitely yield many benefits to responders and residents of Florida during hurricanes, and dramatically improve public safety during disasters. The susceptibility of evacuations to the adverse impacts of accidents and other traffic incidents requires that the appropriate agencies in the State and local EOCs be prepared to resolve those problems as quickly as possible using whatever resources are available at the time. Law enforcement and incident management teams, such as the FDOT's Road Rangers Service Patrols, must be ready to deploy quickly in order to resolve problems and assist in restoring traffic flow in a timely manner. The transmission of real-time monitoring data provided by TTMS and surveillance cameras directly into the EOCs ensures that the appropriate State and local agencies can respond much more quickly and decisively to any incidents that may occur during an evacuation event. Furthermore, travel demand predictions provided by ETIS and HEADS UP in conjunction with real-time roadway monitoring capabilities will provide officials in EOCs with the ability to predeploy incident management and traffic control resources much more effectively and reduce their response times in resolving traffic problems.

## **5. Using ITS and TMC Data in Managing Evacuations – Shelter Management**

Since a large segment of the population indicates in behavioral surveys that they intend to seek public shelters as their refuges from hurricanes, sheltering activities must occur concurrently with evacuation operations. The capabilities provided by ITS to agencies within the State and local EOCs will have a significant impact on improving sheltering operations. Every county in Florida is required to have specific host sheltering procedures in their CEMP. The intent of these procedures is to allow each county sufficient time to marshal the resources needed to accept evacuees from the risk counties and convey them quickly to safe shelter locations in their jurisdictions. In order to fulfill this requirement, the EOCs in the host counties must have better information regarding the magnitude and timing of the onslaught of vehicles and people.

The real-time roadway monitoring data from TMCs and ITS will provide the State EOC with a more accurate picture of the overall need for shelter facilities. As required by Florida's *Regional Evacuation Procedures (REVAC)*, the agencies in the State EOC must designate which counties are to assume a host sheltering role during an evacuation, therefore any volumetric data regarding the movement of evacuating vehicles will result in more effective strategies to cope with the expected shelter demand. The ITS-related data in conjunction with the transportation modeling capabilities provided by HEADS UP will enhance the State EOC's ability to determine where evacuees are going; develop better estimates of how many shelter spaces are needed in each area; and increase the amount of time that host areas will have to implement their shelter operations.

From the local emergency management perspective, images from strategically placed cameras and real-time traffic counters on local roadways and the statewide evacuation roadway network will provide local response staff with a better indication of how the influx of evacuating vehicles will proceed into their jurisdictions. With this visual and digital volume data, county EOCs will be able to better anticipate the resources needed to expeditiously convey evacuees from congested roadways to public shelters. The same hourly-observed volume data as recorded by the strategically placed TTMS sensors will provide local response agencies with concrete data regarding the eventual demand for shelter space and how those facilities should be distributed in relation to incoming traffic. Finally, hourly average speed data from the telemetered traffic counters when related to the distance from the host county will provide a better indication of how much time is available to prepare their shelter facilities for accepting evacuees.

## **6. Using ITS and TMC Data in Managing Evacuations – Public Information and Communications**

During hurricane evacuations, ITS may yield the most benefits for State and local emergency management operations in the realm of public information and emergency communications. Public information relates to notifying residents and visitors in risk and host areas of the imminent threat, and advising them of appropriate protective actions. Public information also informs residents and visitors about what to expect and what to do during an evacuation before they begin their journey. Emergency communications pertains to providing information and instruction to evacuees already in their vehicles and on the roadways.

During the massive evacuations caused by Hurricane Floyd in 1999, many evacuees were very displeased about the lack of information regarding congestion on the roadway. Evacuees were not dissatisfied with the long delays or waiting in their vehicles, instead they complained that no information was provided to them about the condition of the roadways, expected delays, or alternative courses of action to counter the long lines and traffic congestion. From the lessons learned for that particular evacuation event, State and local officials began emphasizing the concept of improving emergency communications. In that respect, Florida has entered into a cooperative agreement with the Florida Public Radio (FPR) network to broadcast emergency information during hurricane evacuations, and the FDOT has posted the FPR frequencies on evacuation route indicator signs throughout the State.

With State and local EOC access to TMC and TTMS data, Florida can drastically improve its ability to communicate with the public about what it can expect and what it should do during a hurricane evacuation. Traffic volume data on a local and statewide basis can be used to inform the public in risk counties of traffic conditions and other exigent circumstances on the entire evacuation roadway network. With a better handle on what the actual conditions are on evacuation roadways, evacuees can be motivated to begin their evacuation trips earlier to avoid long household commute times and directed to avoid certain roadways due to potential, or actual, evacuation congestion. As real-time traffic demand and roadway condition data from the ITS is funneled into State and local EOCs, that information can be used to develop a public information strategy that will advise the public in risk counties of evacuation conditions before they leave their homes. State and local EOCs can also use the data from real-time roadway sensors to develop 511 and “know before you go” type information for dissemination by telephone, the Internet, or other communications method.

With respect to emergency communications, ITS data will be instrumental in the development of advisories for evacuees already in their cars and on the roadway. With hourly traffic volume and average speed data from the TTMS sensors, and imagery from traffic surveillance cameras, the State EOC can prepare advisories for direct broadcast over all FPR stations regarding actual or expected roadway conditions; accidents and other incidents to avoid; alternative routes; and sheltering options. The real-time roadway data provided by TMCs and ITS sensors can also be converted into traveler advisory statements that are disseminated using highway advisory radios (HAR) and strategically located programmable message signs. The same traveler advisory capabilities are available to county EOCs through the use of locally owned or leased portable AM radio transmitters and variable message signs (VMS).

## **7. Using ITS and TMC Data in Managing Evacuations – Terminating Evacuation Operations**

Given the already serious clearance times throughout Florida, it is likely that State and local emergency management officials will have to terminate an evacuation before it is complete. In terminating an evacuation, the potential consequences are that evacuees will be stranded on the roadway as tropical storm force winds escalate into hurricane strength winds or greater. The difficult part of this particular operation is to clear the evacuation roadway network of all vehicles before those potentially dangerous winds arrive. In terminating an evacuation that is underway, State and local EOCs must determine when to start discouraging new evacuees from entering already congested roadways, and also diverting those vehicles already in traffic queues to nearby shelters or refuges.

In order to be successful in terminating an evacuation, real-time information about traffic conditions is of paramount importance. The ITS and TMC data regarding traffic volumes will provide the State and local EOCs with indications of how long traffic queues may be at certain evacuation bottlenecks. In turn, this queue length data can be used by emergency management officials in determining where to open shelters and refuges of last resort. Additionally, PBS&J has developed an evacuation termination threshold for redirecting new traffic away from congested roadways and traffic queues based on the hourly average speed observed at strategic TTMS sensors. This threshold for terminating evacuations determines how many hours before the arrival of tropical storm force winds must State and local officials start traffic diversion and clearing operations in order to ensure that no vehicles are stranded on evacuation routes when those winds arrive. Without the real-time data from the real-time traffic sensors, the EOC will not have the data needed to establish those decision time frames. The lack of this data in the EOC could have potentially fatal consequences in the future.

## **8. Using ITS and TMC Data in Managing Evacuations – Special Traffic Operations**

Another outcome of the lessons learned from Hurricane Floyd in 1999 is the development of reverse-lane and shoulder-use plans for select evacuation routes throughout the State. These traffic management strategies are effective in increasing the numbers of evacuating vehicles that can leave a risk county or region, but they require reliable, real-time data regarding the status of vehicular movement on both the normal and reverse lanes. For the six reverse-lane and one shoulder-use plans, the selection of TTMS counters was predicated on location with respect to those operations. Traffic surveillance cameras on those reverse-lane and shoulder-use road segments are also a priority, and should also be transmitted directly to the State and county EOCs. The data provided by these ITS measures is instrumental in the management of these operations from a traffic management, sheltering, and emergency communications standpoint.

## **9. In Summary**

The provision of ITS and TMC data directly into State and local EOCs is probably the only viable, short-term method for improving Florida's ability to effectively deal with an ever-growing evacuation travel demand. If provided to all of the agencies represented in the EOC at all levels, this data will spell the difference between starting an evacuation and hoping for the best, and actually managing one and increasing the likelihood of a favorable outcome. As argued above, direct EOC access to ITS data in all its forms will have major impacts on all activities related to evacuations including:

- Decision making;
- Traffic management;
- Special traffic operations;
- Sheltering;
- Public information; and
- Emergency communications.

The ITS data is also the linchpin in terminating evacuation operations. Real-time roadway data, when coupled with the other capabilities associated with the ITS infrastructure, such as VMS and HAR, will yield many benefits in addressing the overwhelming evacuation issues in Florida. In a final note, ITS will provide many significant benefits to emergency response agencies in the management of any event that may require evacuations as a protective action. Direct EOC access to ITS data will also provide the same substantial benefits for managing the evacuations caused by hazardous material (HAZMAT) incidents, terrorist actions, and nuclear power plant emergencies.