Structuring Modeling and Simulation Analyses for Evacuation Planning and Operations

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16. Abstract

This document is intended to provide guidance to decision-makers at agencies and jurisdictions considering the role of analytical tools in evacuation planning and operations.. It is often unclear what kind of analytical approach may be of most value, particularly in light of complex data requirements and staff training. The decision to create an analytical capability to support decision making can be a significant investment, and deserves careful consideration. In the end, evacuation planning and operations analysis should never be used to make key decisions but instead developed as a trusted resource for understanding the potential mobility impacts and using this information to inform key decisions.

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Executive Summary

The U.S. DOT seeks to assist agencies across the nation considering the development or enhancement of analytical capabilities to support evacuation planning and operations. This report, a guide for structuring analyses, is intended for the person or persons responsible for determining what role, if any, modeling and simulation should play in either evacuation-related planning or operational practices. This guide aims to provide decision makers with a general process to develop a successful evacuation modeling analysis. The process includes (a) identifying the decisions to be supported when conducting an evacuation modeling analysis, (b) addressing how these decisions are related or can be considered independently, and (c) developing a comprehensive transportation modeling approach that best addresses these decisions.

Jurisdictions and public agencies across the nation are increasingly engaged in evacuation planning. The nature of this planning has evolved in response to new potential threats. While changing threats may have expanded the context for potential evacuations, the transportation-related goal of evacuation planning and operations has remained essentially unchanged: namely, the safe and orderly movement of evacuees utilizing all available elements of the transportation system infrastructure efficiently. At the same time, a variety of commercial, academic, and governmental sources offer analytical tools with a capability to assess particular aspects of evacuation events. The availability of these tools and the advent of relatively low-cost, high-performance computing platforms have encouraged a broader range of public agencies to consider analytical methods to improve their evacuation planning or operational practices. Some agencies have established and deployed modeling capabilities specifically for evacuation planning, particularly in areas where evacuation events are more frequent (e.g., states and localities subject to recurrent threats from hurricanes).

Agencies considering the use of analytical tools may have little experience with modeling in general, or evacuation modeling in particular. A lack of modeling expertise may result in the commission of fundamentally flawed analyses related to a mis-match between the strengths of a particular tool and the goals of a planned analytical effort. Alternatively, agencies may be deterred from considering potentially valuable evacuation analyses because of uncertainties in cost, lack of staff expertise, or the suitability of data resources. Even agencies with extensive evacuation experience and existing analytical capabilities may not be aware of the capabilities of the broadening array of tools that can be deployed to support evacuation-related decision-making.

This guidance document is rooted in an overall philosophy that, with respect to evacuation modeling tools, “one size does NOT fit all” with respect to structuring the best transportation modeling approach. That is, no single transportation analysis tool or strategic methodology is the right answer for all types of evacuation planning analyses. The sophistication of the analysis should match the complexity and expected degree of impacts of the project. Evacuation planning and operations may involve a high-level, qualitative review for some projects, and a detailed, quantitative analysis using modeling and/or simulation tools for other projects.

This guide includes ten case studies that are used to highlight lessons learned from agencies that have developed evacuation-related analytical capabilities. Throughout this guide, these case studies are used to illustrate specific aspects of guidance regarding the application of modeling tools for evacuation-related decision-making. Where possible, the software and data sets for these case studies were obtained. In some instances both the developers and/or users of the information were contacted for lessons learned.

Overall, a key premise of this guidance document is that the development of an analytical approach is *decision-driven*, rather than tool-driven. This implies that tool selection is one of the last considerations made in the process leading up to the conduct of an evacuation-related analysis. Too often, however, tool selection is the first decision an agency makes. Then the pre-analysis period is spent trying to find decisions that are a good fit with the selected software, instead of the reverse. This document does not provide guidance on the relative merits of competing software packages.

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1.0 Introduction

Jurisdictions and public agencies across the nation are increasingly engaged in evacuation planning. The nature of this planning has evolved in response to new potential threats. While changing threats may have expanded the context for potential evacuations, the transportation-related goal of evacuation planning and operations has remained essentially unchanged: namely, the safe and orderly movement of evacuees utilizing all available elements of the transportation system infrastructure efficiently. Ensuring safe and efficient movement across the complete spectrum of possible evacuation situations is a difficult task. Response must be coordinated among multiple agencies and jurisdictions. Comprehensive plans must be developed and personnel must be trained to implement these plans. The public must be educated about their expected roles and responsibilities during evacuations. Further, mechanisms must be established to keep the public properly informed and directed throughout any evacuation event. However, planning for potential evacuations can be hindered by the fact that evacuation events themselves are relatively infrequent. It is neither feasible nor practical to conduct field exercises covering all potential contingencies for all possible evacuation events. However, a broad range of evacuation-related contingencies can be feasibly and systematically evaluated with modeling and simulation techniques. Modeling and simulation analyses can be used to predict the duration of congestion associated with an evacuation event, identify transportation system bottlenecks, and estimate traveler impacts under a broad range of potential evacuation conditions. Analytical techniques have been deployed to identify effective response strategies both in pre-event planning as well as in the tailoring of operational practices during an evacuation event.

A variety of commercial, academic, and governmental sources offer analytical tools with a capability to assess particular aspects of evacuation events. The availability of these tools and the advent of relatively low-cost, high-performance computing platforms have encouraged a broader range of public agencies to consider analytical methods to improve their evacuation planning or operational practices. Some agencies have established and deployed modeling capabilities specifically for evacuation planning, particularly in areas where evacuation events are more frequent (e.g., states and localities subject to recurrent threats from hurricanes). Other agencies considering the use of analytical tools may have little experience with modeling in general, or evacuation modeling in particular. A lack of modeling expertise may result in the commission of fundamentally flawed analyses related to a mis-match between the strengths of a particular tool and the goals of a planned analytical effort. Alternatively, agencies may be deterred from considering potentially valuable evacuation analyses because of uncertainties in cost, lack of staff expertise, or the suitability of data resources. Even agencies with extensive evacuation

experience and existing analytical capabilities may not be aware of the capabilities of the broadening array of tools that can be deployed to support evacuation-related decision-making.

The U.S. DOT seeks to assist agencies across the nation considering the development or enhancement of analytical capabilities to support evacuation planning and operations. This report, a guide for structuring analyses, is intended for the person or persons responsible for determining what role, if any, modeling and simulation should play in either evacuation-related planning or operational practices. For the purposes of this document, we identify an individual acting in this role as an evacuation analysis manager as shown in Figure 1 below. The analysis manager is responsible for explaining the results and implications of evacuation-related analyses to key decision-makers and transportation system managers, who may not be expert in modeling and simulation. Further, the evacuation analysis manager typically directs or coordinates a team of analysts, who are directly responsible for the application of an analytical tool. Finally, the evacuation analysis manager interacts with private sector vendors of analytical software, data vendors, and other technology companies. Although it may be rare to find someone formally identified as an "evacuation analysis manager", it is quite common for someone to be acting in this role, or asked to act in this role. The purpose of this document is to guide an evacuation analysis manager in structuring an evacuation-related analysis to both minimize technical risk and maximize the value of insights obtained from the analysis.

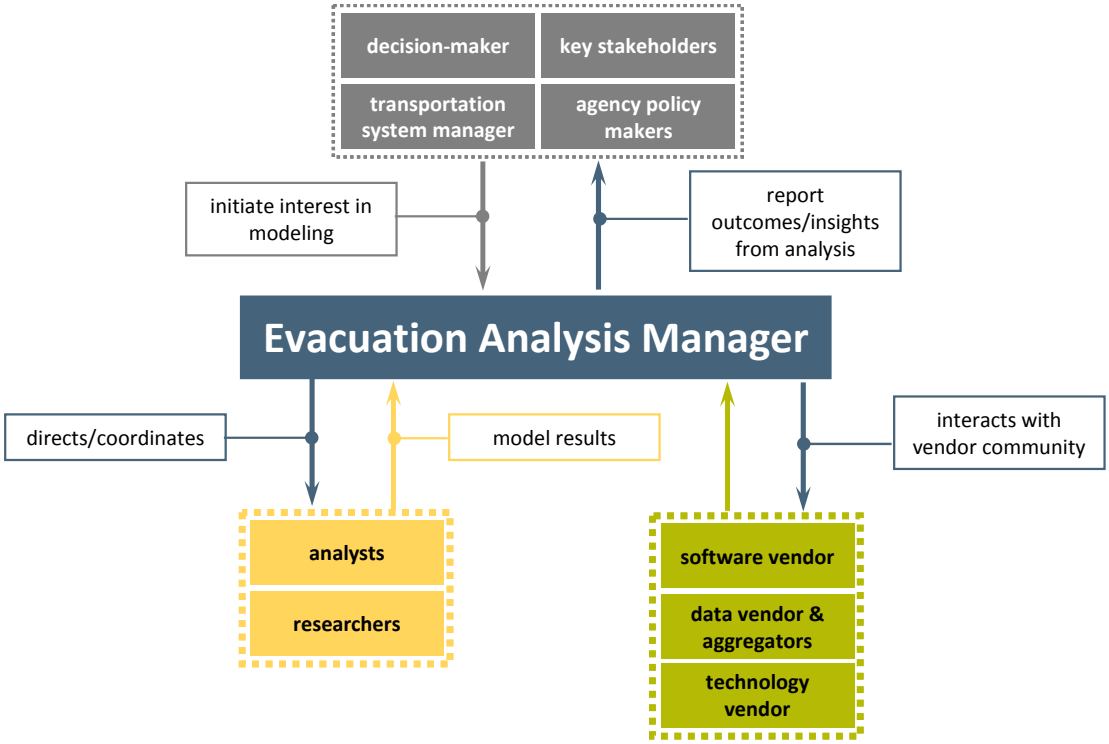

Figure 1 – Evacuation Analysis Manager Role

This guidance document is rooted in an overall philosophy that, with respect to evacuation modeling tools, "one size does NOT fit all" with respect to structuring the best transportation modeling approach. That is, no single transportation analysis tool or strategic methodology is the right answer for all types of evacuation planning analyses. The sophistication of the analysis should match the complexity and expected degree of impacts of the project. Evacuation planning and operations may involve a high-level, qualitative review for some projects, and a detailed, quantitative analysis using modeling and/or simulation tools for other projects.

Another key premise of this guidance document is that the development of an analytical approach is decision-driven, rather than tool-driven. This implies that tool selection is one of the last considerations made in the process leading up to the conduct of an evacuation-related analysis. Too often, however, tool selection is the first decision an agency makes. Then the pre-analysis period is spent trying to find decisions that are a good fit with the selected software, instead of the reverse.

Results obtained from analyses covering a broad range of evacuation contingencies can serve to improve decision-making. In addition, the analyses can also serve to improve overall understanding of transportation system dynamics, including where the transportation system is strong and resilient, and where the transportation system is weak. Analyses of potential evacuations do not *make* key decisions. However, if an analytical capability is developed into a trusted resource for understanding the likely impact of these decisions, analyses can play an important role in *informing* key decisions.

1.1 TRANSPORTATION MODELING INVENTORY

The *Evacuation Management Operations Transportation Modeling Inventory* documents 30 tools that have been used to conduct evacuation-related analyses[1]. These tools represent a range of analytical approaches, all of which have a number of strengths and weaknesses that must be examined when selecting a specific tool. Twenty-five (25) of the tools are currently supported in some manner (commercial, academic, or government), while five are considered legacy systems. Twenty-eight (28) of these tools have been used primarily for planning purposes, with only two being used for evacuation operations.

[1] U.S. Department of Transportation, Research and Innovative Technology Administration, ITS Joint Program Office, *Evacuation Management Operations Modeling Assessment: Transportation Modeling Inventory*. October 2007.

These tools have been used primarily for large-scale, relatively long lead-time evacuation events (hurricanes, special events) representing the easier types of event for which to plan. Recently, many of these modeling tools have been used to initiate a "scenario database" of possible evacuation events. Some localities have even begun to test operational scenarios in pseudo-evacuation events such as the clearing of the National Mall in Washington, DC after the Fourth of July celebration activities.

Prior to September 11, 2001, most of the modeling efforts and tool development were a reaction to specific events that occurred repeatedly (hurricanes and wildfires) or events whose locations were known and impacts were potentially devastating to people in the vicinity (nuclear power plant incidents). Following September 11, 2001, more emphasis was placed on possible terrorist events and the creation of event scenarios. Also during this time, hurricane-prone regions began to focus more on the efficient evacuation of residents through innovative transportation management approaches (e.g., contra-flow lanes) or real-time operations.

1.2 CLASSES OF ANALYTICAL TOOLS

An important consideration in developing a successful modeling approach is identifying the role that one or more analytical tools will play in the approach. The *Evacuation Management Operations Transportation Modeling Inventory* report discusses three primary approaches distinguished by their ability to model a geographic area (scale) and the precision of analysis (detail level)[2]. Choosing a certain class of analytical tools is a tradeoff between these two criteria. Figure 22 below illustrates the different scales at which the three class of analytical tools operate for the Seattle, WA region.

[2] ibid.

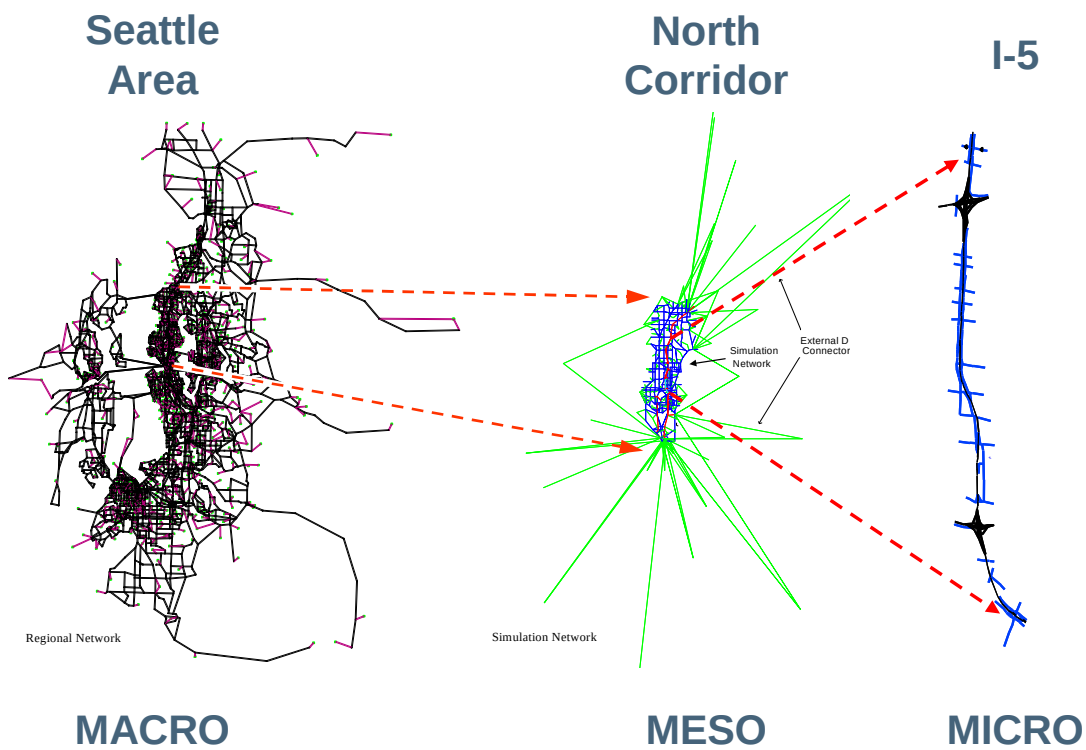

Figure 2 – Classes of Analytical Tools

A detailed discussion of the three classes of analytical tools is available in the *Evacuation Management Operations Transportation Modeling Inventory* report[3]. The Federal Highway Administration has published a comprehensive report that identifies a number of criteria in selecting a class of analytical tool. The *Traffic Analysis Toolbox (TAT) Volume I* includes information about a large number of tools ranging from sketch planning to microscopic simulation programs[4]. Provided below is a brief summary of the three classes of analytical tools:

- *Macro Model*—Represents a large geographic area, such as the Seattle metropolitan region. Macro models are capable of analyzing an entire metropolitan region, but cannot represent individual vehicles or people traveling in the network. Also, macro models lack time sensitivity.
- *Meso Model*— Allows for more precise results than macro models and represents larger geographic areas than micro models. In Figure 2 above, a section of the I-5 corridor north of downtown Seattle has been analyzed using a meso model. Meso models track individual vehicles as they traverse roadway links between specific origins and

[3] ibid.

[4] U.S. Department of Transportation, Federal Highway Administration, *Traffic Analysis Toolbox Volume 1: Traffic Analysis Tools Primer*. June 2004. Publication No. FHWA-HRT-04-038

destinations. However, precise vehicle location within the system (e.g., specific lane position) is generally not directly modeled.

- *Micro Model*—Represents the movement of individual vehicles in the system, tracked precisely by location and lane position at 0.1 second intervals. Micro models are rarely used to represent large geographic areas, such as an entire metropolitan region, since the micro models themselves require extensive input data and computational power to operate at this scale. Calibration of any class of model at the regional level requires significant effort by expert staff, but calibration of a micro model requires the highest relative level of effort among the three classes of tools. However, micro models are proven tools for modeling detailed congestion formation and dissipation in smaller networks representing a key facility, geographic bottleneck, or complex interchange.

1.3 EVACUATION MODELING CASE STUDIES

Ten case studies are included in this document to highlight lessons learned from agencies that have developed evacuation-related analytical capabilities. Throughout this guide, these case studies are used to illustrate specific aspects of guidance regarding the application of modeling tools for evacuation-related decision-making. Where possible, the software and data sets for these case studies were obtained. In some instances both the developers and/or users of the information were contacted for lessons learned. Case studies are separated into three event categories: no-notice, hurricane evacuation planning, and planned special events. As seen in Figure 33 below, the case studies are distributed across the nation and include at least one example of each event category. A detailed summary of each case study is provided in the Case Studies section of this report.

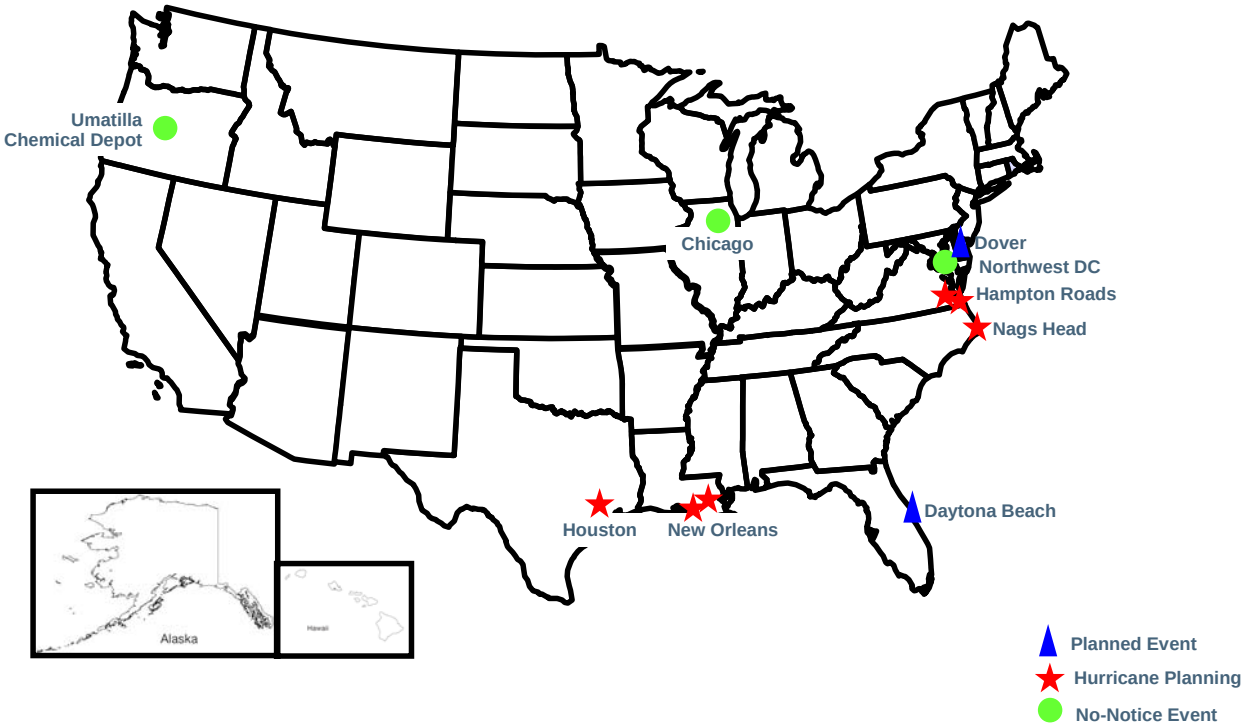

Figure 3 – Case Study Sites

The 10 case studies are summarized in Table 1.

Table 1 – Case Study Summary

Location	Event Type	Tool Used
Washington, DC	No Notice	CORSIM
Houston-Galveston, TX	No Notice	DYNASMART-P
Umatilla & Morrow Co., OR	No Notice	OREMS
Houston-Galveston, TX	Hurricane Evacuation	CUBE Avenue
Hampton Roads, VA	Hurricane Evacuation	VISSIM
Nags Head, NC	Hurricane Evacuation	TRANSModeler
New Orleans, LA	Hurricane Evacuation	CORSIM
New Orleans/Baton Rouge, LA	Hurricane Evacuation	TRANSIMS
Daytona Beach, FL	Planned	DYNASMART-P
Dover, DE	Planned	ARC GIS

1.4 DOCUMENT ORGANIZATION

This guide aims to provide decision makers with a general process to develop a successful evacuation modeling analysis. The process includes (a) identifying the decisions to be supported when conducting an evacuation modeling analysis, (b) addressing how these decisions are

related or can be considered independently, and (c) developing a comprehensive transportation modeling approach that best addresses these decisions.

The organization of the document reflects these three key steps in the process:

- **Section 2.0 Analysis Factors**—Provides a detailed discussion of factors that should be considered when deciding to conduct an evacuation modeling analysis. This includes a consideration of key evacuation-related decisions potentially supported by analysis.
- **Section 3.0 Strategic Methodologies**—Provides guidance on establishing a sound strategic methodology for evacuation analysis that considers interactions between evacuation-related decisions.
- **Section 4.0 Identifying a Transportation Modeling Approach**—Provides guidance on the strengths and weaknesses of the various classes of tools considered in evacuation-related analyses. These strengths and weaknesses are then matched against the analytical factors surrounding the decisions to be supported by the analysis to create a comprehensive analytical approach.
- **Section 5.0 Conclusions**—Summarizes the key themes in the document, provides observations on the current capabilities of modeling and simulation with respect to evacuation analysis, and identifies a set of relevant trends influencing evacuation-related analyses.

2.0 Analysis Factors

The ultimate reason for developing and implementing a transportation modeling approach is to help make informed decisions regarding the evacuation of a certain geographic area. The need to make decisions regarding planning and conducting an evacuation can include a long timeframe (as part of long term planning for scenario building) or a short timeframe (as part of an imminent natural threat such as a hurricane). Also, these decisions do not stop once a commitment is made to evacuate but continue through the actual real-time operations. During all of these decision-making timeframes, transportation modeling tools can be used to support decision-making. To complicate matters, there is a broad array of transportation modeling approaches and analytical tools available to practitioners as shown in Figure 44. In this figure, the modeling approaches and specific tools are placed on a continuum representing the geographic scale of the analysis—from an entire region to a specific corridor. The three classes of analytical tools (macro, meso and micro models) indicate where the specific tool fits best in terms of capability. The figure also provides a snapshot of specific tools available to practitioners.

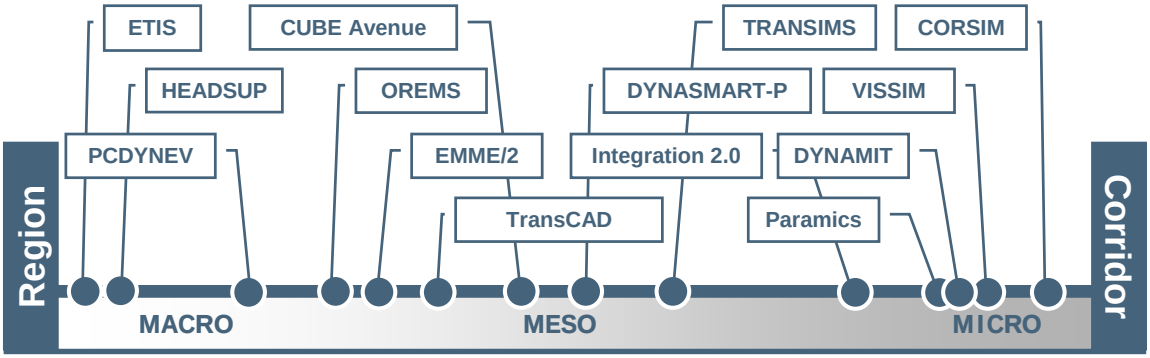

Figure 4 – Evacuation Modeling Spectrum

While Figure 44 is only a representative sample of the tools available to practitioners, it does demonstrate that (a) a large number of tools are available, (b) there are various modeling class of analytical tools, and (c) a number of tradeoffs have to be made when identifying a transportation modeling approach and ultimately selecting a specific tool. In the end, an evacuation analysis manager is faced with a tradeoff among five factors, including:

- **Modeling Context**—Evacuation strategies to be investigated (e.g., contra-flow lanes), timeframe, and event notification.
- **Geographic Scale**—The spatial extent of the analysis.
- **Data**—Availability of data types as well as sources and quality of the data.

- **Agency Resources—**Institutional arrangements as well as the technical capability of the agency including modeling experience, model availability, and funding.
- **Development and Analysis Time**—The amount of time available to develop and analyze an evacuation model.

The following subsections discuss these five factors in more detail with a definition of the various terms and concepts and case study examples of how others have successfully addressed these factors in evacuation modeling analyses.

2.1 MODELING CONTEXT

Evacuations can be associated with a broad range of evacuation events. The basic nature of these events, their predictability, frequency, geographic scope, intensity, and other factors define the decisions that must be made by public agencies both in pre-event planning and operational response. Modeling analyses in support of these decisions are also clearly influenced by the nature of the evacuation events themselves. In this section, three modeling context factors are discussed that provide guidance on the nature of the event (Event Notification), the amount of time available for decision-making (Timeframe), and the types of strategies that need to be investigated (Evacuation Strategies).

2.1.1 Event Notification

The breakdown of specific decisions within the event type helps a decision maker understand the chain of related decisions and their timing. This is critical for understanding where models and data can be deployed to support these decisions in an effective and timely way. Initially, various evacuation events can be placed on a continuum between a *planned event* and a *no-notice event* as shown in Figure 55 with six common event types labeled. On the left side are planned events where there is ample advanced notice to make a decision on evacuating a geographic area. On the right side are no-notice events that occur without warning, are generally unpredictable, and provide little time to make a decision about evacuating a geographic region. Generally speaking, it is easier to make fully-informed decisions about evacuations for planned events compared to no-notice events since there is a longer lead time to better understand the impact of the event (long-term planning), select an appropriate response (operational planning), and then implement the evacuation plan (real-time operations).

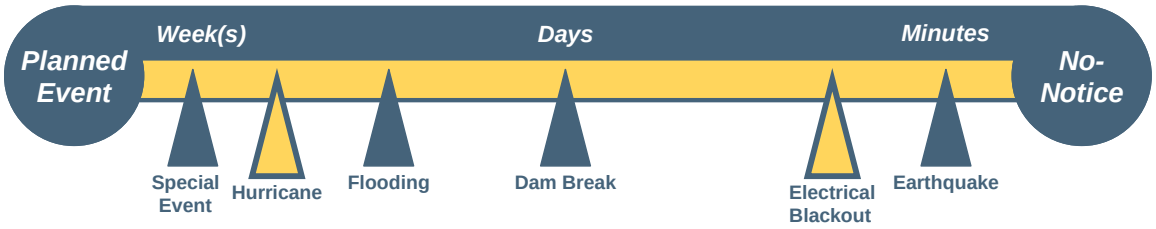

Figure 5 – Event Notification Continuum

2.1.2 Timeframe

As part of the *Evacuation Management Operations Transportation Modeling Inventory* report, a framework was developed to better understand the context for using a specific analytical tool in terms of three decision-making categories:

- **Long Term Planning**—Long-term planning in advance of a specific threat or event. During planning, strategic resources (including manpower and equipment) would be identified as well as the design and construction and of necessary infrastructure. For example, an analysis of hurricane contra-flow operations may demonstrate the need for additional manpower to direct traffic or infrastructure improvements such as median cross-overs.
- **Operational Planning**—Planning in response to a specific imminent threat. During operational planning, decision makers are concerned with monitoring conditions, mobilizing resources, and determining whether or not an evacuation threshold is met to make a go/no-go decision.
- **Real-time Operations**—Adapting a previously developed operational plan during the course of an evacuation. During real-time operations, resources are actively deployed and the overall evacuation operations are managed based upon real-time conditions and events.

These three decision-making categories are shown in the Decision Making Timeframe Framework (Figure 6). The categories are placed on the horizontal axis with a time scale ranging from years (long-term planning) to seconds (real-time operations). The categories are also represented by the blue, grey, and yellow boxes respectively. The width of these boxes roughly indicates which decisions need to be made for each category. For example, long-term planning generally includes regional studies and, time permitting, some aspect of assessment of the impact of the possible evacuation events (hurricanes, flooding, earthquakes, etc.). Operational planning

includes event impact assessment as well as the decision to implement an evacuation, implementing the evacuation plan, and some aspect of system monitoring. Real-time operations include system monitoring and system modification. The height of the boxes indicates at what geographic scale the evacuation decision categories operate. The scale ranges from a single intersection to a geographical region.

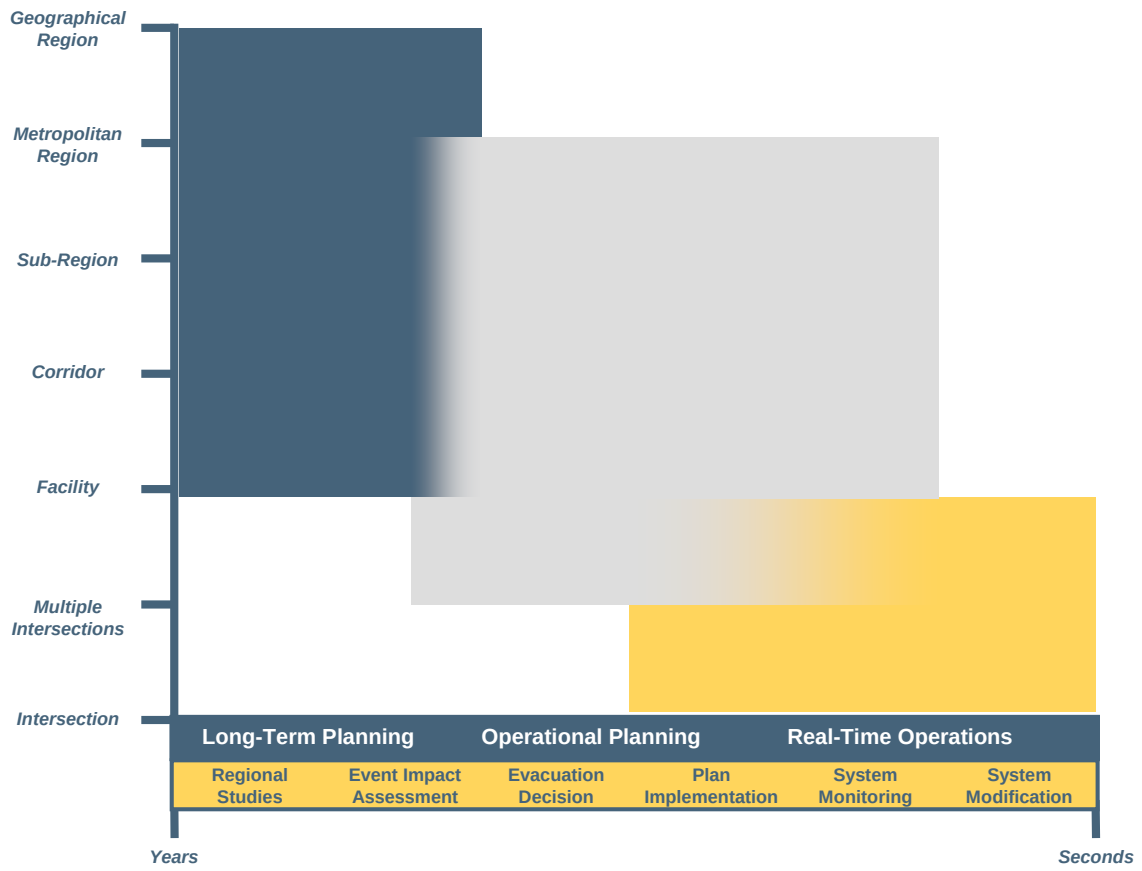

Figure 6 – Decision Making Timeframe Framework

This framework can be used to better understand the role of transportation modeling with respect to the evacuation event notification time. All events requiring evacuation will include the same categories (long-term planning, operational planning, and real-time operations) as well as the decisions that need to be made (regional studies, event impact assessment, evacuation decision, plan implementation, system monitoring, and system modification). Also, there is likely a number of years available for planning for an evacuation event in order to conduct regional studies and analyses (referred to as scenario building) but only minutes and seconds to monitor system operations (traffic signal timing, real-time traffic information, etc.). What will vary for each event will be the available time to make the evacuation decision (Event Notification

discussed previously) and the geographic scale at which the decision has to be made (discussed in 2.1.3).

2.1.3 Evacuation Strategies

Evacuation strategies are implemented in order to safely and efficiently evacuate a specific population from a geographic area. These strategies include physical infrastructure projects (such as constructing cross-overs to facilitate reversible lanes) as well as policy variables (such as how to stagger an evacuation to mange overall demand). An evacuation modeling tool is used to better understand the effects of these different strategies in terms of managing overall demand and the implementation of specific vehicle and people control strategies. Thus, there are two types of major evacuation strategies that should be considered when choosing a class of analytical tools: travel demand management strategies and control strategies.

- **Travel Demand Management**—This evacuation strategy aims to manage the overall demand placed upon the transportation network in the event of an evacuation. Often, these types of strategies are policy-oriented, meaning they do not include the installation or construction of physical infrastructure. For example, an emergency management agency may want to better understand the effect of staggered evacuation times on network performance. Or, a transportation agency may want to better evaluate the role of traveler information in affecting overall travel during an evacuation.
- **Control Strategies**—This evacuation strategy aims to control the movement of vehicles and people once an evacuation order has been given by directing people to certain locations, temporarily increasing roadway capacity, or controlling facility access to maintain a certain level of network performance. Specific control strategies that could be assessed for evacuation modeling purposes include (but are not limited to) contra-flow lanes, reversible lanes, signal re-timing, and signal coordination.

NEW ORLEANS, LA
The State of Louisiana and the City of New Orleans have conducted four studies into the application of contra-flow lanes as part of hurricane evacuation operations. In addition, the region is examining travel demand management and transit strategies. Read more in the New Orleans, LA case study on page 57.

2.2 GEOGRAPHIC SCALE

An important evacuation modeling consideration is the geographic scale at which the analysis will occur. The geographic scale, as presented in Figure 66, defines seven different scales

ranging from an individual intersection to an entire geographic region. The smallest scale is an individual intersection which may include a detailed assessment of pedestrian movements, vehicle movements, signal timing, and roadway characteristics. The largest scale is a geographic region which may include multiple states (such as the Northeastern United States) and only include limited data on current traffic flows. The following provides definitions of the different geographic scales.

- **Geographic Region**—Multiple states and, more than likely, multiple metropolitan regions. Geographic regions require the close coordination of different government agencies. A geographic region is likely larger in physical size than a metropolitan region. For example, the mid-Atlantic is a geographic region made up of multiple metropolitan regions.
- **Metropolitan Region**—Multiple local areas (counties and cities) that may or may not cross state boundaries. Metropolitan regions are not as large as a geographic region in terms of required institutional coordination among multiple state and local agencies. For example, the metropolitan Washington, DC region includes two states, the District of Columbia, as well as multiple counties and cities.
- **Sub-Region**—An area that is smaller than a metropolitan region. For example, Northern Virginia is a sub-region of the metropolitan Washington, DC region.
- **Corridor**—A unit of a sub-region consisting of multiple roads or facilities. For example, the I-95 corridor in Northern Virginia consisting of I-95, US Route 1, and the rail/transit lines located within the corridor (Virginia Railway Express, AMTRAK, and Metro).
- **Facility**—An individual transportation infrastructure component within a corridor. For example, US Route 1 between Fort Belvoir, Virginia and Alexandria, Virginia.
- **Multiple Intersections**—More than one intersection on a facility. For example, the intersections of US Route 1 with King Street and Prince Street in Alexandria, Virginia.
- **Intersection**—An individual intersection on a facility. For example, the intersection of US Route 1 and the Capital Beltway in Alexandria, Virginia.

Often, the type of tool that can be used will be dictated by the geographic scale of the evacuation modeling analysis. Less detail will be associated with models at larger geographic scales. More detail will be associated with models at smaller geographic scales. For example, a microscopic simulation model is readily able to model a corridor with multiple signalized intersections. However, a microscopic simulation model cannot model an entire metropolitan region. Macroscopic models, on the other hand, can easily model a metropolitan region but cannot provide detailed results regarding changes to an individual facility or intersection.

Washington, DC
In the Washington, DC region, the DC Department of Transportation wanted to study how well evacuations occurred on signalized arterial in the city. The analysis required examining 124 intersections and 89 traffic signals. Because of the geographic scope (multiple intersections) and the control strategy (coordinated signal timing) the team used a microscopic simulation tool. Read more in the Washington, DC case study on page 37.

2.3 DATA

One of the most important factors when deciding to use an analytical tool to conduct an evacuation analysis is the availability and quality of data regarding the transportation network to be analyzed. All models rely on good data and it can be difficult to construct a realistic evacuation model representing demand and capacities during times of uncertainty (such as an evacuation) without having good historical data from which to draw. Since evacuation events are not necessarily common, an important consideration becomes whether or not there is sufficient data which can be used to calibrate and validate evacuation models. Thus, any evacuation modeling analysis will be a balance between the type of data that are needed, where the data come from, and the quality of the data.

2.3.1 Type

Important elements to evacuation modeling analysis are data describing the transportation network, the demand placed upon the transportation network, and real-world data with which to validate the evacuation model. The extent to which these data are needed depends primarily upon the analytical tool being used as well as the questions being asked. Travel demand characteristics and validation data may be difficult to obtain, especially for evacuation modeling, since these events are rare (compared to more general day-to-day travel) and there are no hard and fast rules regarding the use of these data in an analytical tool except that, in general, the more accurate the data the more accurate the results.

- ***Transportation Supply Characteristics***—These data can be thought of as describing the transportation network infrastructure such as physical attributes (lane configuration, intersection location, traffic signal location, alternate routes, etc.), policy attributes (estimated roadway capacity, signal timing plans, etc.), and service attributes (transit schedules). Together, these attributes are required to create the necessary network that the model will use to generate results. Most models and analysis tools will require some form of transportation supply characteristic data. The type and amount of data will vary by tool. Physical attributes can usually be collected from field surveys, aerial photographs, or geographic information system (GIS) files. Policy attributes are often available in

various guidebooks or reports. Service attributes are readily available from the agency providing the service.

- ***Travel Demand Characteristics***—These data describe how the transportation network infrastructure is utilized by the user. This would include traffic counts, vehicle demand data, and transit data if applicable. Traffic counts, vehicle mix, delay data, transit data, and origin-destination data are examples of the types of travel demand data that will be required to prepare an assessment model of the evacuation analysis. Like transportation supply characteristic data, all the models and analysis tools discussed in this report will need some form of travel demand characteristic data. The tools chosen will determine to what extent data are needed. Real-time decision support tools require fewer data requirements, whereas macroscopic, mesoscopic, and microscopic simulation models may require more data. As stated previously, the more site-specific data that are provided, and the more accurate the data, the better the results of the model. If site-specific data are unavailable and the resources to collect travel demand data are insufficient, there are sources that can provide default values for some of these parameters. Many of the models and tools themselves will include default variables to be used in situations where data are not available. Default data should be used cautiously, as the default values may not reasonably approximate the site-specific conditions.

2.3.2 Source

There are many sources of data related to an evacuation modeling analysis. In general, these data sources are separated into two categories: primary and archived.

- ***Primary***—Primary sources of data include any number of data collection techniques whereby traffic data counts are collected in the field using automated sensors such as video cameras, electronic toll collection transponders, loop detectors, or station counters. Mesoscopic and microscopic simulation models are data intensive and require field traffic counts for model development and calibration as well as analysis. Data that are collected more recently are likely to produce more accurate the modeling results will be. Primary sources of data also include any number of analytical models available to an analyst from previous studies or other agencies such as a regional planning organization. In addition, many state DOTs collect transportation statistics as part of the highway performance monitoring system which could be used as primary sources of data.
- ***Archived***—Depending on the analysis tool chosen and the required accuracy of the results, it can also be used to some degree by travel demand models; traffic signal optimization models; and macroscopic, mesoscopic, and microscopic simulation models. There are many sources of archived data including public entities such as a regional planning organization or departments in a transportation agency, as well as commercial

vendors. Using archived data can be a cost-effective solution to conducting an evacuation modeling analysis if resources are limited or a decision needs to be made quickly. However, it is important to emphasize that archived data may be outdated or inaccurate compared to current conditions.

2.3.3 Quality

An important component in using data for evacuation modeling is the quality of the data. The purpose of using quality data (be it primary or archived) is to prepare models that best represent actual field conditions thereby producing the most accurate analyses possible. Primary data can often be the most valuable for modeling; however, collecting these data is resource-intensive and costly. Many analyses for evacuation planning purposes are conducted without primary data collection. When possible, analysts can benefit from visual observation because they can identify behavior in the field that is not as obvious with other data collection methods. This allows analysts to adjust models to better reflect existing conditions and improve the results. In general, analysts are concerned with the following four characteristics regarding data quality: collection frequency, geographic coverage, archive length, and accuracy.

- ***Collection Frequency***—Collection frequency describes how often data are collected and is important based upon the type of evacuation event being analyzed. Planned events can be more easily modeled since there is available time to collect more accurate data. No-notice events do not necessarily provide enough time for data collection and may require the use of historical data. In this case, it may necessary to set up a data collection process to have the data available.
- ***Geographic Coverage***—An important consideration of data quality is the extent to which data are available for a specific location or region. Depending upon the location of the evacuation event, traffic data may not be available for a certain location (e.g., rural interchange or intersection). In these situations, representative data may be used from other sources. Also, larger, no-notice evacuations that are region-wide events may require data that encompass an entire region rather than for smaller-scale, planned evacuation events such as routine special events.
- ***Archive Length***—Archive length is the extent to which historical/archived data are available to an analyst. The length of the archive is important when temporal variations need to be considered as part of the evacuation analysis. For example, an evacuation modeling analysis concerned with coastal communities will need to account for seasonal fluctuations in traffic demand.
- ***Accuracy***—Accuracy is concerned with two aspects of the model. First, it compares outputs (results) of the model with real-world conditions such that the model can be validated. In this case, the accuracy of the model will depend in large part on whether

there are historical data with which to compare model outputs. Second, it takes into account the requirements of the analyst and whether or not the model can yield useful results. In other words, what are the tolerances of the model? In some cases, such as a high-level regional analysis as part of long-term planning, a rough order of magnitude or directionality is sufficient. However, an evacuation modeling analysis concerned with a recurring special event (perhaps similar to a work zone analysis) may require higher accuracies such that the analyst can estimate queue formation every 15 minutes.

2.4 AGENCY RESOURCES

Developing a transportation modeling approach for evacuation management and operations will depend strongly upon available resources. These include the institutional arrangements within the organization that enable or hinder the flow of information, technical staff that are able to conduct the required analysis and/or data collection, funding to acquire the technical expertise or models, and scheduling requirements. All four of these agency resource categories play an important role when determining whether to deploy a transportation modeling approach.

2.4.1 Institutional Arrangements

Evacuation management and operations require the coordination of a diverse set of agencies including transportation, health and human services, emergency management, and security. Each agency involved needs to recognize that the traveling public is not concerned about lines on a map, but about receiving good information to move quickly, safely, and efficiently through the network in the even of an emergency evacuation. Therefore, transportation officials need to focus on this system-level result. For example, operational personnel at successful traffic management centers have found innovative ways to overcome institutional and technical limitations when coordinating traffic incident management. By developing small personal groups, some regions establish a trust that permeates throughout the corresponding organizations. The co-location of agencies within an emergency operations center helps to strengthen the interagency relationships.

The lack of an integrated or strategic methodology for evacuation management and operations analysis can be characterized by four key institutional barriers:

- **Culture**—There exists within many agencies a culture of compartmentalization whereby one agency is not necessarily concerned with the requirements of another agency (transportation versus emergency management). To achieve a continuous flow of information and data for evacuation management and operations, these barriers need to be overcome. It is important that all players and stakeholders are brought together on a

regular basis in order to develop relationships such that when an evacuation event does occur, everyone is focused on the issue at hand rather than getting to know each other.

- **Leadership**—Leadership is important to ensure the successful deployment and use of transportation analysis tools for evacuation management and operations. Often, key leaders will set an overall vision and strategy requiring the use of modeling tools to support the decision-making process.
- **Data Management**—Because of the compartmentalization of many agencies involved in the evacuation management and operations process, it is sometimes difficult to acquire the necessary data. Often, an analyst will have to go to multiple departments or organizations to get the data (e.g., operations, planning, transit).
- **Contracting**—As discussed below, acquiring the technical expertise to conduct an evacuation management and operations analysis may require the use of contractors with specialized knowledge and tools. Agencies will need to have flexible contracting arrangements whereby services can be obtained quickly and easily.

Agencies need to work together to overcome the institutional challenges in order to provide significant benefits for all agencies involved. The benefits of establishing a strategic methodology for evacuation modeling analysis are much greater than what could be achieved through the deployment of components operating in isolation by individual agencies.

HOUSTON-GALVESTON, TX
As a result of Hurricane Rita in 2005, the Houston-Galveston Region decided to try to better manage traffic conditions in the event of hurricane evacuations. The agency desired a modeling tool that could test operational policy scenarios prior to an evacuation event as well as provide support during an evacuation event. In the end, a number of institutional arrangements were overcome with the Houston-Galveston Area Council, Texas Transportation Institute, and Citilabs working together. Read more in the Houston-Galveston, TX case study on page 47.

2.4.2 Technical Staff

A critical component to the successful use and deployment of evacuation modeling tools is the technical expertise to use them. Often, a transportation agency will have either in-house expertise on the use of a specific model or access to a consultant with the expertise through a contractual arrangement. In these situations, an agency may be limited to a specific model based upon the technical capability at hand. For example, many transportation agencies make a decision to use modeling products from a specific vendor. In this case, if an agency/analyst wanted to use a different modeling tool that is not available from the vendor, additional time and resources

would need to be made available to acquire and run the model. Even if an outside contractor is used to conduct the analysis, the transportation agency will still need to have enough expertise on-hand to oversee and validate the evacuation modeling analysis findings.

Another aspect which may be relevant to the evacuation analysis manager is to leverage resources outside of one transportation agency. Many localities have a federally mandated regional planning organization (commonly referred to as a metropolitan planning organization or council of governments) chartered to conduct long-term planning analysis. The planning organization can sometimes provide a base transportation network that could be used by the transportation agency in an evacuation analysis.

NEW ORLEANS/BATON ROUGE, LA
The city of New Orleans is working with Louisiana State University (LSU) and the Federal Highway Administration to develop a TRANSIMS model capable of evaluating evacuation policy scenarios for the city. By partnering the LSU, the city is leveraging the technical expertise available at the university. Read more in the New Orleans/Baton Rouge LA case study on page 60.

2.4.3 Funding

Funding availability to conduct an evacuation modeling analysis is another critical issue. While there are many progressive agencies trying to plan for an evacuation and develop evacuation plans, justification may still be needed to allocate specific project funding to conduct a comprehensive evacuation modeling analysis as part of a larger evacuation program. Funding availability may limit the extent to which an evacuation modeling analysis can be conducted or a contract issued for analysis by a consultant. Regardless, any type of evacuation modeling analysis will require some resources and the accuracy and results of the analysis will depend to a certain degree on the amount of money available.

2.5 DEVELOPMENT AND ANALYSIS TIME

A critical consideration in deciding to conduct an evacuation modeling analysis is the overall project schedule and how much time is available for development of the model and analysis of the results. While it is possible to plan for many different types of evacuation events (planned to no-notice), agencies will have time constraints. Thus, any agency must budget enough time to develop and apply an evacuation modeling tool as either part of long-term planning, operational planning, or real-time operations.

It is also important that an evacuation analysis manager recognize the limitations of available resources as well as work within the existing data and analysis capabilities. Establishing independent networks and analysis processes outside of ongoing planning and operations activities reduces the probability of continued usefulness of establishing a modeling capability. Thus, an evacuation analysis manager should try to leverage to the fullest extent possible the work that others have done so as not to "reinvent the wheel." Agencies that have taken a strategic approach to developing a transportation modeling approach as part of the overall evacuation decision-making framework have an advantage in addressing schedule constraints. Agencies that have invested in developing modeling resources from the beginning (via contractors or in-house technical expertise) with a deployed capability in "stand-by" mode are better able to address unanticipated questions when they arise and make decisions quickly. Agencies that have invested in standing analytical capabilities will be more nimble in responding to these situations than those that start from scratch for each analysis. Thus, these agencies limit the impact that a schedule constraint has on generating useful results from the models as part of the decision-making process.

3.0 Strategic Methodologies

Careful consideration of all the modeling analysis factors outlined in the Section 2.0 guides an evacuation analysis manager in tailoring a modeling approach to support a specific decision. A tailored modeling approach will include the identification of one or more analytical tools. In some cases the application of a single tool may be an appropriate way of focusing resources and addressing key issues. For example, the Virginia Department of Transportation used a single tool (VISSIM) to analyze the effect of evacuation policies in the Hampton Roads, VA area (see the Hampton Roads, VA case study on page 51). In other cases, an array of connected tools can be deployed to support aspects of a decision that differ in geographic scope or the detail of the proposed control to the system. For example, the Houston-Galveston Area Council is developing a multi-scale tool that can support decision-making for both long-term planning and operational aspects of an evacuation (see the Houston-Galveston, TX case study on page 47).

Before developing a tailored capability supporting a specific decision, however, the analyst should also recognize that officials rarely make individual, independent decisions when managing evacuation planning and operations. A broader strategic approach for analysis should also be considered that includes a range of evacuation-related decisions. In some cases, a combined modeling approach covering several or all of these related decisions can be both technically sound as well as cost-effective. Wisely managing this tradeoff between investing in a tailored analysis for a specific decision versus a broader approach supporting a number of decisions is one of the most critical decisions an organization must make when considering incorporating analysis into evacuation planning and operations. However, because of resource constraints, lack of inter-agency cooperation, and lack of technical expertise, few evacuation-related analyses begin with a thoughtful consideration of this strategic tradeoff.

This section focuses on establishing a sound strategic methodology for evacuation analysis. When an evacuation analysis manager focuses on a single decision in developing an analytical approach, they can expect a close match between decision support and analytical capability. However, the approach may, by default, treat that specific decision in isolation from other key decisions. In some cases, the input to the analysis may assume that other key decisions will already have been made. For example, an analyst may have to assume that an order to evacuate has already been issued at a specific time when performing an analysis of detailed plans to implement a particular lane-control strategy on inbound freeway segments. Using a strategic methodology that incorporates interaction among major decisions (such as travel demand management strategies and control strategies) provides this linkage. However, the resulting analysis is typically more complex and the treatment of details specific to individual decisions

may have to be sacrificed to make the analysis tractable and understandable. In the case of the analyst developing detailed lane-control plans, a more complex analysis would be to jointly consider two related decisions (evacuation timing and lane-control plan). This analysis may require resources beyond what has been budgeted for the lane-control plan development. The two decisions, although related, may be the responsibility of two different agencies. Institutional, technical, and resource constraints may preclude certain joint analyses. Whatever strategic approach is chosen, the evacuation analysis manager must justify that selection as the best use of resources to capture the key dynamics of the transportation system informing one or more specific key decisions.

In this section, strategic methodologies for evacuation analysis are organized into three general categories:

- **Mono-Scale**—The *mono-scale* strategic methodology features a *single transportation analysis tool* applied consistently to support one or more evacuation-related decisions.
- **Multi-Scale**—The *multi-scale* methodology involves the deployment of *multiple transportation modeling approaches* in an integrated and strategic way to support one or more evacuation-related decisions.
- **Integrated Data Platform**—The *integrated data platform* methodology integrates the data used to drive one or more analytical tools, usually in a geographic information system.

A decision between a mono-scale or multi-scale methodology is mutually exclusive. Depending on the nature of the integrated data platform approach, analyses supported by this platform may take on attributes of either a mono-scale or multi-scale approach.

Just as no single transportation analysis tool is right for all evacuation-related analyses, no single strategic methodology represents the single best analytical approach in all situations. Sections 3.1 through 3.3 provide a more detailed discussion about the strengths and weaknesses of these three strategic methodologies.

3.1 MONO-SCALE METHODOLOGY

The *mono-scale* strategic methodology features a single transportation analysis tool applied consistently to support one or more evacuation-related decisions. The advantage of this methodology is that model consistency is essentially guaranteed when one is considering specific aspects of a single decision (use of contra-flow lanes) or multiple decisions (use of contra-flow lanes and a phased evacuation). Resources invested in developing the tool and its supporting

data are focused on a single tool, which can be cost-effective. Further, a focus on a specific tool will often result in a deeper level of understanding of how well the tool represents (or fails to represent) the evacuation-related traffic phenomenon under study.

The disadvantage of a mono-scale approach is that a single tool may be well-suited to support some types of decisions but not well-suited to others. For example, a mono-scale methodology using microscopic simulation of a key evacuation route bottleneck may capture detailed elements of traffic control (junction geometry and traffic signal operations) but have only limited capability to predict impacts from diversion on parallel routes. A mono-scale methodology may be an attractive option if a calibrated and a well-maintained model of the desired analysis area is already in hand. Mono-scale analyses are the most typical type of evacuation-related analyses and usually address a single key decision.

Hampton Roads, VA
The Virginia Department of Transportation used a mono-scale approach to analyze the effects of evacuation policies in the Hampton Roads, VA area. Read more in the Hampton Roads, VA case study on page 51.

3.2 MULTI-SCALE METHODOLOGY

The *multi-scale* methodology deploys several tools in combination to support evacuation-related analyses. Interactions and inconsistencies between models must be identified and resolved as a part of the methodological development. This type of methodology is effective for looking at a range of issues using the most appropriate tool with the added value of cross-validation among tools and data types.

The disadvantage of this methodology is that the agency resources (the technical staff, funding, and scheduling) can be significant as well as the required data describing the transportation system (specifically its quality and availability). The complexity of integrating and resolving potentially conflicting results from multiple models can be resource intensive and require significant lead time to sequentially resolve technical issues as they arise.

Some transportation software vendors offer *unified suites* of tools that share common databases and facilitate an off-line exchange of inputs and outputs among tools. *Hybrid* analytical software allows two related tools to interact at run-time with inputs and outputs passing between the tools at defined time intervals. Unified tool suites and hybrid software packages both have attributes that can help mitigate the technical risks involved in multi-scale approaches. These approaches

are relatively new for evacuation-related analyses, however. Projects pursuing hybrid approaches in particular can be characterized as modeling-related research projects and cannot yet be considered state-of-the-practice applications. In general, the development and use of a multi-scale approach for evacuation-related analyses is not common compared to a mono-scale approach due to complexity and resource requirements.

Houston-Galveston, TX
The Houston-Galveston Area Council is developing a multi-scale methodology to assist in testing evacuation policy scenarios and to provide support during and after an evacuation. Read more in the Houston-Galveston, TX case study on page 47.

3.3 INTEGRATED DATA PLATFORM METHODOLOGY

The consolidation of evacuation-related data into a centralized platform in support of a range of applications can be an attractive proposition for an agency. The support of modeling and analysis is just one of many applications that may be considered in this mix. For example, many agencies integrate traffic data and infrastructure-related data into a GIS system. These GIS can support a broad range of operational, planning, and asset management functions for agencies in addition to the support of evacuation-related analyses. The role of GIS software in support of evacuation-related analyses is a logical consideration for agencies with institutional familiarity with and investment in GIS tools. GIS software may already be used to collect and visualize field data (e.g., speed and volume data), providing agency decision-makers better situational awareness about the location and intensity of congestion in emergency and non-emergency situations. Evacuation-related operational decisions may already be supported by these displays of current conditions. Extrapolating current conditions and predicting future conditions is often sought as an enhancement to situational awareness, and a GIS-based integrated platform is a logical platform for displaying these predictions in the same format the end-user visualizes the current state of the system. While GIS software is often thought of as primarily a visualization tool, the GIS platform itself is becoming increasingly capable of supporting internally-generated predictions about future conditions – a capability that has generally been the domain of stand-alone transportation-specific modeling software.

The rationale behind including a GIS-based approach as a strategic methodology in this section hinges on the specific roles identified for GIS software in support of an evacuation-related transportation analysis. In some cases, the GIS software is used to organize and produce input files for other tools (e.g., transportation network structure, travel demand patterns). In these cases, the GIS software is also typically used to display and visualize model outputs (e.g., bottleneck locations, travel speeds) from other analytical tools. In this case, the GIS software is

not central to the analysis but supports an analysis in another tool. Key decisions about the analytical approach are made with respect to how that analysis (outside of the GIS) will be structured and conducted. This is the traditional role that GIS software has taken (if any) in evacuation-related analyses.

However, as noted above, GIS software is increasingly capable of performing predictive analysis. In this case, data from the GIS is not simply output to an external tool. Instead, analytical routines are called within the GIS software itself to perform the prediction. This obviates the need for an external analytical tool and the called routines within the GIS become the key focus for how the evacuation-related analysis will be structured and conducted. Currently, these analytical capabilities are much less complex or comprehensive than the capabilities offered by stand-alone transportation analysis tools. In many cases, extensive customization will be required to support evacuation-related analyses. The advantage of a GIS-centric integrated data platform approach is that the analysis resides within the domain of a well-known GIS software system. The disadvantage is that intrinsic GIS software analytical capabilities are much less capable than stand-alone tools specifically built to perform transportation analyses.

An analyst who gives thoughtful consideration to developing a strategic methodology prior to a commitment to a specific analysis will have a significantly strengthened justification for any proposed analytical project. Understanding the nature of the decisions to be supported is a critical consideration. In some cases, multiple decisions are best considered jointly. If the decisions are very different in scale or level of detail, a joint analysis involving more than one tool may be appropriate. Further, clearly identifying the role of GIS software is a key step, either as a data preparation and visualization tool or to house the analytical platform itself.

Dover, DE
The City of Dover has developed an integrated GIS tool to provide decision-makers with necessary information on traffic conditions for key special events. The tool was specifically developed for the NASCAR events held every June and September but is being expanded. Read more in the Dover, DE case study on page 67.

4.0 Identifying a Transportation Modeling Approach

The two preceding sections provided a detailed overview of the factors that influence the development of an evacuation-related analytical approach and three strategic methodologies when considering supporting decisions jointly or in isolation. However, to develop a complete modeling approach, the next step is to consider two critical questions:

1) *What are the strengths and weaknesses of the types of tools typically considered for evacuation-related analyses?*
2) *What collection of analytical tools best supports the set of identified evacuation-related decisions?*

The following two sub-sections discuss each of these questions in more detail. Section 4.1 provides a discussion of the broad classes of analysis tools (macro model, meso model and micro model) that are typically considered for transportation analyses. The section includes a checklist of key analysis factors that can used when considering the application of one of these classes of tools. Section 4.2 discusses the criteria and components in the development of a modeling approach. Section 4.3 covers the consideration of technical risk when deciding to initiate an evacuation-related modeling analysis.

4.1 SELECTING AN ANALYTICAL METHODOLOGY

A key premise of this guidance document is that the development of an analytical approach is *decision-driven*, rather than tool-driven. This implies that tool selection is one of the last considerations made in the process leading up to the conduct of an evacuation-related analysis. Too often, however, tool selection is the first decision an agency makes. Then the pre-analysis period is spent trying to find decisions that are a good fit with the selected software, instead of the reverse. This document does not provide guidance on the relative merits of competing software packages. Rather, the emphasis is on the strengths and weaknesses of broad classes of tools (macro, meso and micro models). Choosing the right type of tool is the first step in the process; selecting the specific software from that class of tools is the second.

4.2 DEVELOPING A TRANSPORTATION MODELING APPROACH

This subsection provides a short description of the general strengths and weaknesses for each class of tool as well as a high-level checklist that can be used as a rough guide in the development of a more detailed analytical approach.

4.2.1 Macro Models

These tools can represent large geographic regions, such as a metropolitan region or in some cases, statewide networks. A range of modes of travel can be represented and modeled concurrently, including rail and bus networks. While macro/travel demand models have a broad scope of analysis, these models cannot represent individual vehicles or people on the network. Further, macro models lack time sensitivity; that is, travel demand cannot vary from one time period to another. Finally, macro models do not model the build-up and dissipation of congestion at bottlenecks.

In what context is a *Travel Demand/Macro Model* likely to be most useful?

- A calibrated, well-maintained travel demand or macro model is available encompassing the area where evacuation-related traffic impacts are expected.
- The time periods represented in the calibrated travel demand model coincide with those that are important for the evacuation-related analysis.
- Evacuation-related mobility impacts are expected over a large geographic area, particularly impacts on parallel and adjacent facilities, including transit networks.
- Accurate estimates of congestion timing, extent, and intensity are less critical than a need to identify the likelihood that congestion will form.

4.2.2 Meso Models

These tools allow for more precise results than macro models and represent larger geographic areas than micro models. Meso models generally represent individual roadway links and vehicles on a network, but not individual lanes on each roadway segment. Some models in this class use simple rules to assign vehicles to individual lanes but do not track precise vehicle location. Meso models most often employ a combination of time-dependent, flow-speed relationships (also called impedance functions) and simple first-in-first-out queuing restraints as a basic approach. This allows the models to capture the dynamic build-up and dissipation of congestion with a lower computational burden than micro simulation tools. In addition, some meso models represent individual travelers who can dynamically alter the time of trip start, mode choice, and route selection. These tools have been used in analyses of large urban corridors where it is critical to assess dynamically changing bottleneck locations and diversion-related strategies associated with travelers moving to alternative routes or modes (transit).

In what context is a *Meso Model* likely to be most useful?

- A calibrated, well-maintained corridor model at the meso-scale is available encompassing the area where evacuation-related traffic impacts are expected.
- Evacuation-related congestion impacts are expected on an array of parallel facilities, including diversion-related congestion; key facilities generally feature uninterrupted flow (few signals or stop signs).
- Coordination and control of vehicle flow on parallel routes involve traffic management strategies that dynamically adjust to realized congestion levels.
- Travel demand management and/or traveler information strategies are critical elements of the transportation management plan.
- Significant staff and data resources are available for model development and validation, including time-dependent vehicle counts at key bottlenecks in the network and dynamic end-to-end travel time estimates for the mainline and alternative routes at 15-minute intervals for recurring congestion.

4.2.3 Micro Models

The class of micro models includes traditional traffic simulation software used for operational analyses. Micro models are rarely used to represent large geographic areas, such as an entire metropolitan region, primarily because of the difficulty in assembling the large amount of detailed input data required. In addition, micro models are costly to set up and run and they are often difficult to calibrate over a broad geographic area. However, micro models are useful in modeling smaller aspects of a network such as a specific corridor or interchange. Micro models also provide very precise results since individual vehicles are tracked on the network for a small time segment (normally 0.1 second).

In what context is a *Micro Model* likely to be most useful?

- A calibrated, well-maintained network for a traffic microscopic simulation is available encompassing the area affected by the planned work zone activity.
- Critical performance measures are required at the lane level, or require the detailed assessment of alternative traffic control configurations (including signals) in interchanges, intersections, or lane shifts in the evacuation-related activities.
- Diversion impacts are less critical than the detailed assessment of mainline traffic control.
- Significant staff and data resources are available for model development and validation, including network level descriptions of lane widths, turning movement bay lengths, traffic signal timing plans and validation data including time-variant turning movement counts, vehicle counts by lane at critical bottlenecks, and end-to-end travel time estimates for the mainline at 15-minute intervals for recurring congestion.

4.3 DECIDING TO MODEL OR NOT TO MODEL

Effectively managing the tradeoff between analytical opportunity and technical risk is one of the most important responsibilities of the analyst developing an analytical approach. Failure to realistically account for technical risk is the most frequent underlying issue when analytical efforts fail to meet the expectations of both analysts and decision-makers. This failure can manifest itself in missed deadlines, budget overrun, or abandonment of the technical approach even after the expenditure of significant agency resources.

When significant data and staff resources are available, there are many more options for matching a transportation modeling approach with the decisions to be supported. When resources are limited, however, the analyst must consider whether a less detailed analysis using a simpler tool is adequate to the requirements of the analysis. If the mismatch between the necessary level of detail and resource availability is high enough, the corresponding technical risk may be so high that a drastic re-consideration of modeling approach may be appropriate.

In some cases, the technical risk of attempting to conduct an evacuation-related analysis with little reliable data or too few resources may outweigh the benefits of conducting it. In these cases, there is a risk that rushed or poorly-informed evacuation analysis will provide highly inaccurate or misleading assessments of mobility impacts. Such analyses are to be avoided, since they not only represent a waste of project resources, but also because they may entrench institutional mistrust of transportation analysis tools and analytical results, even in cases where well-calibrated models do provide meaningful results.

5.0 Conclusions

This section presents a set of key overarching considerations for evacuation-related analyses in three subsections. First, a summary of key themes central to this guidance document are highlighted. Second, some observations are provided regarding the types of evacuation analyses either underway or undertaken in the past. The document concludes with a brief summary of emerging trends that are influencing the nature of evacuation-related modeling and simulation.

5.1 SUMMARY OF KEY POINTS

This sub-section summarizes key themes for the development of an evacuation-related modeling capability. A critical initial step is the identification of an individual to act in the role of the evacuation analysis manager tasked to develop an analytical approach rather than to simply apply a tool. It is clear that following the process presented in this document may run counter to prevailing institutional momentum to simply select software and "get started." However, such a rushed approach is rife with technical risk. Further, even if the analysis can be successfully completed, the modeling results and capability may not sufficiently address the highest priority evacuation issues facing decision-makers and other key stakeholders.

Evacuation analysis managers who develop a complete plan after broadly considering the context for modeling will not only mitigate technical risk, but will also be able to clearly identify the role of modeling with respect to specific key evacuation decisions. Further, evacuation analysis managers who develop a sound overall analysis plan will be able to set reasonable expectations with decision-makers on likely outcomes of the analysis and technical risk. It is the contention of the authors that the resources expended prior to analysis in appropriately structuring and focusing the analytical effort will easily be recovered in terms of reduced analytical costs, schedule adherence, and end-state modeling capability.

The key steps an evacuation analysis manager should take in the development of an evacuation-related modeling capability are:

- *Begin with a consideration of decisions, not tools*. Spend time and resources to clearly identify the specific evacuation-related decision the analysis will support prior to the consideration of any particular tool or class of tool. (Section 2.1, Modeling Context).
- *Identify the most appropriate geographic scope of analysis* required to address these decisions. (Section 2.2, Geographic Scope).
- *Inventory agency resources and expectations* (data, staff, funding, and schedule). Note that the consideration of these resources should include both analytical capability

development and the incorporation of the analysis into routine planning or operational practice. (Sections 2.3, Data; 2.4, Agency Resources; and 2.5 Development and Analysis Time).

- *Strategically integrate or isolate evacuation-related decisions* to focus analytical resources. (Section 3.0, Strategic Analytical Methodologies).
- *Craft a defensible analytical approach that includes tools representing a best-fit with both evacuation decision support and agency resources*. Begin by considering the strengths and weaknesses of classes of tools prior to identifying any particular tool. Further, this process should include the specific consideration of an option not to model in cases with significant technical risk. (Section 4.0, Approach Development).
- *Document the analytical approach development process.* This document will serve to articulate the goals and motivation for analysis as well as focus analytical effort.

5.2 CASE STUDY OBSERVATIONS

The case studies included in the appendix of this guide provide a snapshot of current and ongoing modeling efforts related to evacuation modeling. The case studies were identified as part of the *Emergency Management Operations Transportation Modeling Inventory* report with detailed interviews and follow-up discussion with the subject analysts and stakeholders (*1*). The following observations are made from two different perspectives.

First, from a decision-making perspective, what the case studies reveal is that evacuation modeling to date has focused primarily on long term planning and operational planning. Typically, the use of evacuation models for operational responses is limited. This is interesting in that while the ability to model different operational conditions and control strategies is improving, analysts are just beginning to understand how behavior changes during an evacuation event and what differences in conditions (e.g., facility closures, staggered evacuation times) lead to different behaviors.

Second, from an evacuation analysis management perspective, the case studies show that significant effort is required to develop, calibrate, validate, and maintain detailed evacuation models. In many cases, where evacuation events are extremely rare, planned special events (e.g., departures from a sports venue) can be used as surrogates for model calibration and validation. The importance of taking the time to validate any evacuation model once it is developed cannot be over emphasized. This is especially true for models that feature dynamic traffic assignment and traffic simulations that are very sensitive to network coding errors. On the other hand, sketch-based web tools also require maintenance and may not have the detail or ability to respond to the questions of concern. Finally, in order to be maintained and usable when needed,

evacuation models need to be closely coordinated with the regional travel forecasting models and other ongoing analysis efforts of regions. One-study-only tools or tools deployed in isolation from mainline analytical capabilities cannot benefit from the continuous model improvement process associated with consistent application over time.

5.3 TRENDS IN EVACUATION MODELING

The capability and application of transportation modeling tools for evacuation planning continues to evolve in response to a variety of factors. The planning context for potential evacuations evolves in response to changes in the types or likelihood of threats that may result in an evacuation. Key evacuation decisions may also change in response to the deployment of new control technologies or system surveillance and detection technologies. The capability of analytical tools and computing platforms will continue to expand possibilities for ever-larger or more detailed analyses. The following are four trends identified in the compilation and development of this guidance document:

- **Increasingly Complex Human Behavior Modeling**—Researchers continue to examine and characterize human behavior under a broad range of evacuation conditions. This research examines both strategic aspects of human behavior (e.g., propensity to engage in evacuation preparation, the choice to evacuate, and route choice) as well as more tactical behavior (e.g., more aggressive or cooperative behaviors with other individuals, changes in behavior in response to information). More precise or accurate knowledge of these behaviors will improve evacuation modeling tools, potentially expanding the type of analyses that can be reliably performed.
- **Convergence of GIS and Transportation Analysis Tools**—GIS is fast becoming a mainline evacuation planning and operations tool. Many evacuation planners are moving towards increasingly capable GIS platforms for a range of evacuation planning and real time operational analyses. It is likely that there will be an increasing convergence of stand-alone traffic and transportation analysis capabilities within GIS tools. Likewise, stand-alone transportation analysis tools will continue a current trend to incorporate capabilities associated with GIS platforms.
- **Faster Computers + Bigger Networks = Better Analysis?**—Transportation analysis software packages are increasingly capable of taking on more detail even as the scale of application grows from facility to corridor to regional analyses. The capability of analysts to control and understand these increasingly complex modeling capabilities does not appear to be expanding at the same rate. Although there are some efforts underway to automate some calibration and validation activities, the problem of how to validate

large networks with limited resources and untrained staff remains a barrier to widespread evacuation modeling.

- **Evacuation-Specific Modeling Suites**—Analyses using a collection of tools with different features, focus, and capabilities may be appropriate to address common issues in evacuation planning and operations. One example is the need to better account for transit and emergency response vehicle operations during evacuation conditions. Software vendors will likely see these needs as opportunities to tailor tools to specific situations in order to increase sales growth for their tools. A logical conclusion to draw from this market opportunity is the emergence of competing analytical solutions tailored for evacuations based on current analytical capabilities.

Case Studies

Case Study 1:	**Washington, DC**	**Page 37**
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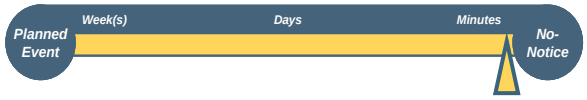
Case Study 1: Washington, DC

Location
Washington, DC

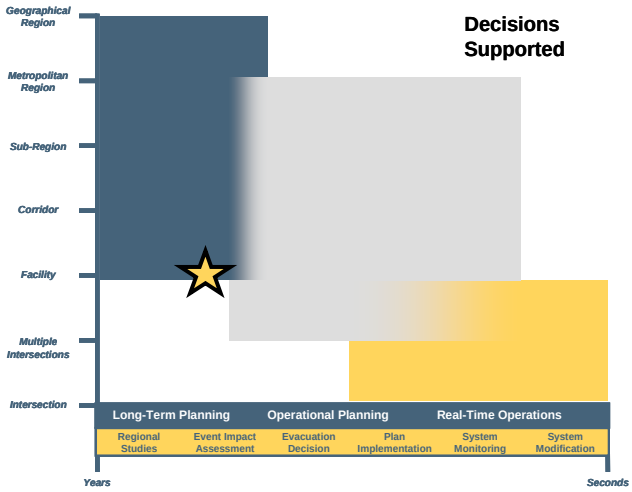
Event Type
No-Notice Event
Arterial Signal Timing

Event Planning Horizon



Researcher Affiliation
Elise Miller-Hooks & Philip Tarnoff (UMD)

Model
Micro Simulation CORSIM

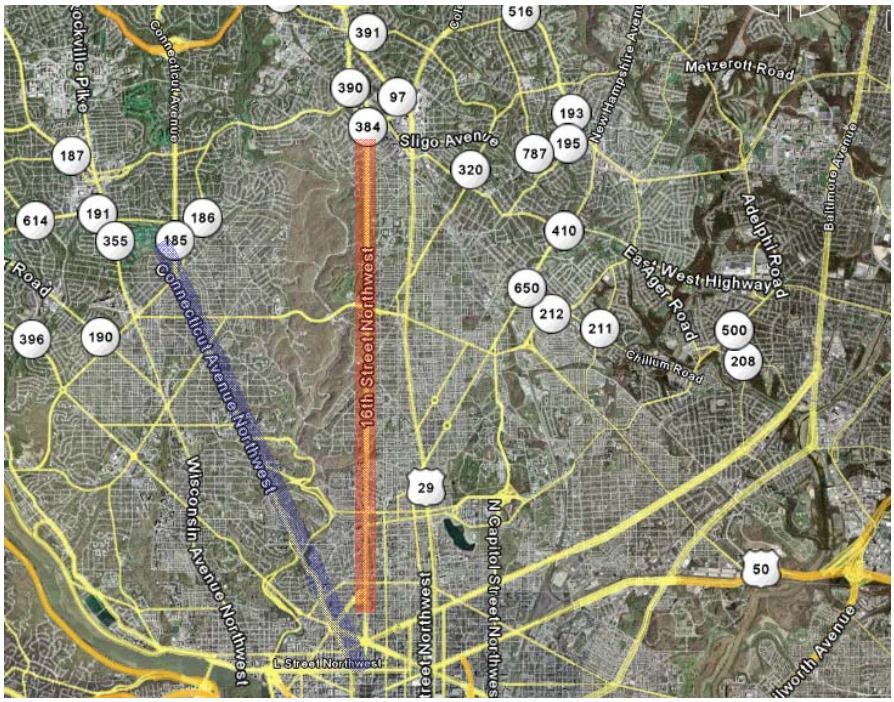


STUDY SUMMARY

Status: **COMPLETE**
Title: "Traffic Signal Timing for Urban Evacuation"
Who: Elise Miller-Hooks, Philip Tarnoff
Contact: Elise Miller-Hooks, University of Maryland, elisemh@umd.edu
Sponsor: DC Department of Transportation, Federal Highway Administration
Timeline: 9 months (2004 through 2005)
Resources: Person Year
Status: Completed

STUDY ABSTRACT

This study assessed approaches for signal timing to facilitate evacuation and response in the event of a no-notice disaster requiring evacuation in an urban area. A simulation model using CORSIM was constructed with data for a corridor in Washington, D.C. involving 124 intersections, 89 of which are signalized. A number of signal timing plans were tested in the simulation model including setting the signals on flash; setting the signals on the PM-peak (outbound) setting; and setting plans to the maximum cycle length on the evacuation routes as governed by the controllers, giving a very small duration of green time to the minor roadways. To examine the effects of setting different cycle lengths in an evacuation, four alternative signal timing plans were developed and tested. Finally, plans generated by Synchro, a software product developed for creating signal timing plans, were assessed



Study Area: Northwest DC Analysis Corridors
Source: Google Earth

MODELING APPROACH

After September 11, 2001, the District Department of Transportation (DDOT) adopted an evacuation plan intended to facilitate outbound traffic flow during an evacuation which includes 25 primary evacuation routes. The signal timing plans for an emergency evacuation for the approximately 400 signalized intersections require they be set to the maximum value of the controllers (roughly 240 seconds) to provide outbound traffic with the maximum amount of green time. In developing this plan, DDOT did not conduct any type of analysis to see the impact of this policy decision would actually have on traffic operations. In order to better understand this impact, a modeling approach was developed that uses the microscopic simulation program CORSIM to model the movement of individual vehicles along two typical evacuation routes: Connecticut Avenue and 16th Street. In addition to developing the model, four operating scenarios were developed based upon the DDOT policy and interviews with experts from across the country knowledgeable about state-of-the-practice traffic signal timing for evacuation.

DATA SOURCES

DDOT provided signal timing plans by time of day for ordinary operations and for evacuation which are built and stored in Synchro. The Synchro files also contain all desirable network data, including characteristics of each roadway section (length, number of travel lanes, lane width, grades, free flow speed, etc.) and each intersection (number of lanes for each approach, lane

channelization, lane alignment, etc.). These data were imported into CORSIM with some small and necessary modifications.

FINDINGS/LESSONS LEARNED

The results of the analysis demonstrate there are significant trade-offs between efficiency (i.e. network clearance time) and fairness (i.e. delays incurred) in choosing an appropriate signal timing plan for evacuation. Among the signal timing plans tested, there is no single plan that dominates all others in terms of the total number of vehicles evacuated in a given time period and average delays incurred by vehicles on both evacuation routes and minor roadways.

Which plan is "best" depends on the severity of the emergency event and the magnitude of the delays on the minor roadways that decision-makers are willing to accept. If the only objective is to maximize throughput, the ideal solution is to provide infinite green time to the evacuation routes until these routes are cleared, leaving the vehicles on the minor roadways waiting until the evacuation routes are cleared. However, this is probably not politically acceptable nor able to be enforced to any degree. On the other hand, if the only objective is to maintain fairness in average delay for vehicles along both major and minor roadways, the ideal solution is the flash mode or peak hour plans. When trade-offs between both objectives are considered, which plan is best depends on the level of preference for one objective over the other. Perhaps the best compromise plan is the evacuation plan proposed by DDOT or one that is similar, but with longer or shorter cycle length depending on the level of demand requiring evacuation.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

- Hooks, Elise-Miller, and Tarnoff, Phil. "Traffic Signal Timing for Urban Evacuation: Draft Final Report", Maryland Center for Advanced Transportation Technology, University of Maryland for the Federal Highway Administration. 18 August 2005
- Chen, M., L. Chen and E. Miller-Hooks (2007). "Traffic Signal Timing for Urban Evacuation, "Special Emergency Transportation Issue of the *ASCE Journal of Urban Planning and Development*, 133(1), 30-42.

Case Study 2: Houston – Galveston, Texas

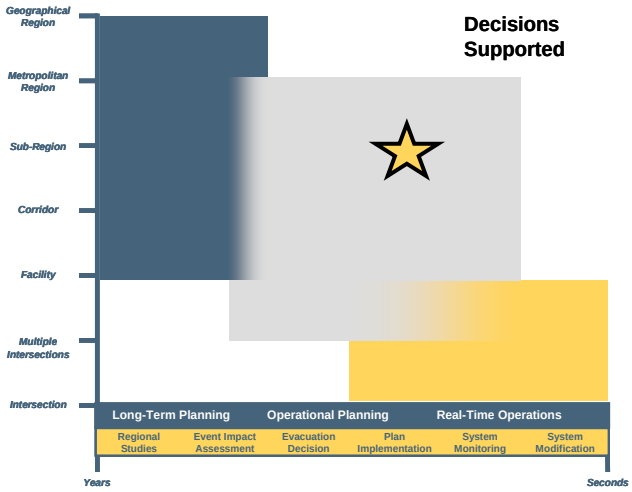
Location
Houston – Galveston, TX

Event Type
No-Notice Event
Contraflow Lanes

Event Planning Horizon

Researcher Affiliation
Yi-Chang Chiu, University of Arizona

Model
Meso Simulation DYNASMART-P

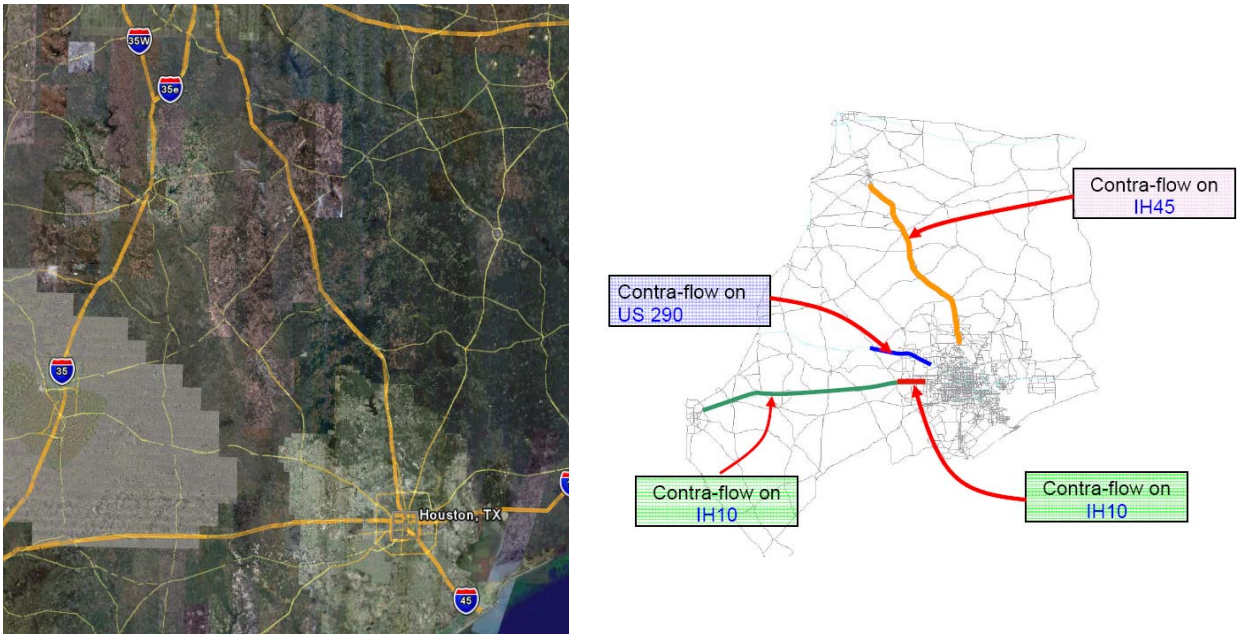


STUDY SUMMARY

Status: **COMPLETE**
Title: "Evaluating Regional Contraflow and Phased Evacuation Strategies for the Central Texas Area"
Who: Yi-Chang Chiu, Hong Zheng, et. al.
Contact: Yi-Chang Chiu, University of Arizona, chiu@email.arizona.edu
Sponsor: Texas Department of Transportation
Timeline: 2005 through 2008
Resources: Multi-faceted and Multi-year research effort
Status: Completed

STUDY ABSTRACT

The purpose of this study was to develop a large-scale vehicular traffic simulation model to evaluate both the contraflow and phased evacuation strategies at a regional level of analysis in lieu of a small and isolated corridor-based viewpoint for the Houston-Galveston area. The analysis was conducted using a large-scale regional traffic simulation modeling approach which incorporated the DYNASMART-P meso-scopic simulation software tool. The analysis provided detailed measures of benefit and impact from contraflow and phased evacuation from the perspective of various performance measures such as travel time, cumulative safe arrival and space-time speed profile. The result shows that a contraflow strategy would yield considerable improvement in all transportation corridors in spite of several hot spots requiring mitigation. Phased evacuation, in conjunction with contraflow techniques, yields further incremental improvement particularly for the coastal high risk zones.



Study Area: Houston-Galveston Regional Analysis Area (left), Dynasmart-P Network (right)
Source: Google Earth (left image)

MODELING APPROACH

Due to the questions being asked and study are size, the analysts determined that a microscopic simulation model would not be capable of running and that a regional travel demand model would not provide enough detailed data. Thus, the analysts decided to apply the DYNASMART-P meso-scopic simulation model which required a number of enhancements to meet the computational and modeling requirements set forth by the study sponsor.

DATA SOURCES

- **Network**—The core network was based upon the 2005 travel demand model provided by the Houston-Galveston Area Council. Additional geo-coded GIS data were obtained and merged into the regional network. Roads included interstate, primary and secondary state as well as more than 2000 signals.
- **Origin-Destination Data**—Following the evacuation of Hurricane Rita, detailed household survey data were collected of evacuees in order to obtain behavioral data. This data set was used to estimate O-D patterns.
- **Background Traffic**—The behavioral activity data did not represent background traffic pattern, an important consideration for evacuation events. Background traffic was estimated based on the travel demand model provided by the Houston-Galveston MPO. In the end, a total of 3.08 millions of vehicles were estimated for a 24-hour period, including 398,000 evacuation trips.

FINDINGS/LESSONS LEARNED

This research was undertaken to assess the impact of contraflow lanes in concert with phased evacuations on operational conditions for the Houston-Galveston area. Previous research has demonstrated the benefit of contraflow lanes which local decision-makers in the Houston area instituted as policy measure to improve evacuation times. However, based upon experience with Hurricane Rita, local leaders have now considered implementing a phased evacuation plan. The results of this research suggest that contraflow operation is a promising strategy for Houston-Galveston evacuation and that contraflow lanes were capable of alleviating traffic congestion along major evacuation corridors. However, a few areas could not handle the surge of traffic volumes even with the increased capacity provided by the contraflow lanes. The phased evacuation policy component, considered as a supplement to contraflow operation, did help alleviate hot-spots beyond the contraflow operation's capability. In the end, the phased evacuation strategy in conjunction with the contra-flow operation significantly benefitted evacuees from coastal zones, at the cost of slightly increasing travel time for evacuees from other flood zones.

Of significant importance regarding the development of the overall Houston-Galveston network model is its potential use for other network and policy assessments. The developed model and results can be further utilized for the study of other related issues such as logistic planning of emergency response resources, location of refueling stations or triages, and routing of emergency or transit vehicle fleets for low-mobility communities. However, the model does require 20 hours to complete the meso-simulation of an evacuation period of 24 hours.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

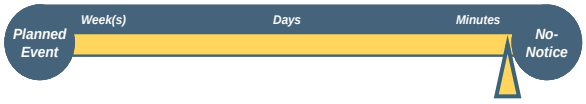
- Chiu, Y.-C., Zheng, H., Villalobos, J.A., Peacock, W., and Russell Henk. Evaluating Regional Contra-Flow and Phased Evacuation Strategies for Texas Using a Large-Scale Dynamic Traffic Simulation and Assignment Approach. Journal of Homeland Security and Emergency Management, Vol. 5, Issue 1, 2008, pp. 1-27

Case Study 3: Umatilla & Morrow Co., Oregon

Location
Umatilla & Morrow Co., OR.

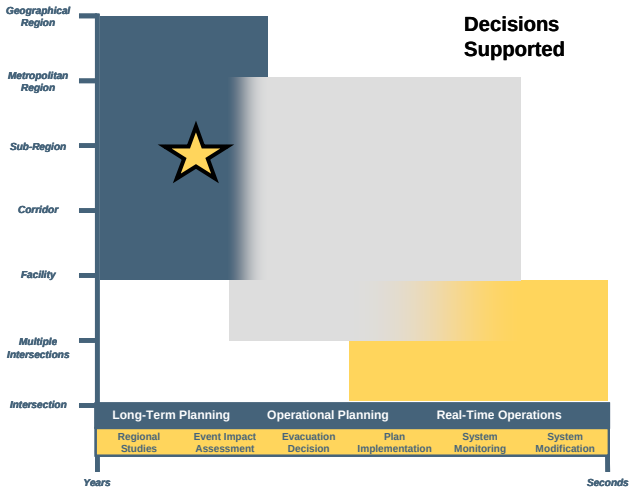
Event Type
No Notice Event
Chemical Depot Evacuation Plan

Event Planning Horizon



Researcher Affiliation
Oscar Franzese, Oak Ridge National Lab
Richard Arnold, Oregon DOT

Model
Meso Simulation OREMS



STUDY SUMMARY

Status: **Complete**

Title: Morrow & Umatilla Co. Transportation Evacuation Plan: Phase I. Overall Assessment of Proposed Alternatives

Who: Oak Ridge National Laboratory (Oscar Franzese)
Oregon DOT (Richard Arnold)

Contact: Richard Arnold, Richard.Arnold@odot.state.or.us

Sponsor: Army Chemical Stockpile Emergency Preparedness Program, Oregon DOT

Timeline: Original model developed in 1998, Updated in 2002 - 2003

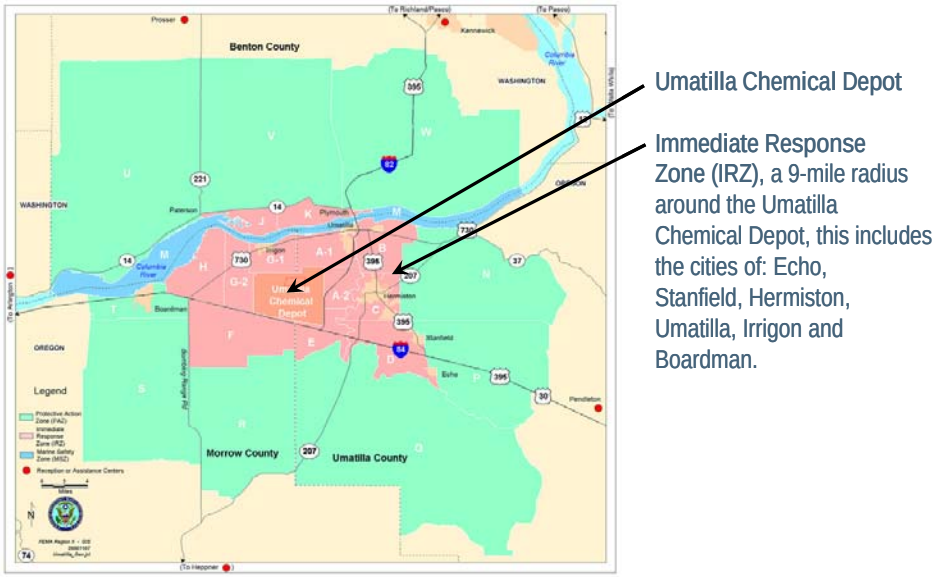
Resources: Approximately one-year initial model development: ~ ¼ year for model update and alternatives analyses

Status: Complete (2003)

STUDY ABSTRACT

The Department of the Army has stored chemical warfare agents at eight locations around the country and currently maintain emergency transportation evacuation plans covering the region surrounding each facility. The Umatilla Chemical Depot is one such facility. In the 1980's, Oak Ridge National Laboratories (ORNL) developed evacuation models utilizing the Federal Emergency Management Information System (FEMIS) and analyzed evacuation time estimates (ETEs) under each different scenarios for of the facilities. Shortly afterwards, ORNL created OREMS based upon their previous work as a microcomputer based tool for evacuation modeling with a user-friendly interface for data input and enhanced map displays of results.

In 2002 -2003 a study was undertaken to update the Umtilla Emergency Evacuation Plan for Morrow and Umtilla counties, by exploring infrastructure and operational enhancements to reduce potential ETEs across different scenarios (am, pm, severe weather, etc.). As part of the study the FEMIS model developed in 1998 was tranfered to OREMS and enhanced and validated. The study resulted in recommendations for improvements on various facilities including various combinations of physical improvements, contraflow, reverse lanes, and double lane on ramps. Upgrades to the traffic signal hardware and traffic operations were also recommended. The study also recommended additional OREMS model enhancements, training and increased public information. The model was used to estimate changes in the ETEs.



Study Area: Umatilla and Morrow Counties, Oregon
Source: Oak Ridge National Labs (see Reference)

MODELING APPROACH

As stated, the ODOT staff used OREMS to analyze different physical and operational improvements across different scenarios (plume location, wind direction, and good and bad weather, etc.). The update was conducted in three phases. Phase I of the work was to replicate the 1998 (FEMIS) results within the OREMS PC environment. The ODOT Team was able to replicate the original work, but as part of this phase found a number of issues that caused recommendations for additional modeling. One issue was the exceptional evacuation times shown for the City of Hermiston.

Consequently, Phase II consisted of a significant validation and re-analysis of potential improvements found in Phase I. An additional Phase III was also carried out to analyze day time

Phase II of the modeling effort was an extensive model validation effort for the No-build alternative using 1990 and 2000 demographic data. This included the development of 60 different cluster zone combinations to account for plume location and spread and four separate weather evacuation scenarios: good with evacuation, good without evacuation, bad with evacuation and bad without evacuation. This resulted in 240 evacuation scenarios to model for each operational alternative. The study found that in general ETEs for different clusters varied between 1.5 to 2.5 hours with the exception of the City of Hermiston which took between 6.5 to 8.5 hours.

As part of the validation, ODOT found several network conversion issues which were corrected. The original analysis used census data of where people lived and therefore simulated PM evacuations. In Phase III, employment data was obtained for each traffic analysis zone and daytime evacuation demand scenarios were analyzed and incorporated into the results

DATA SOURCES

- **Network**—The initial 1998 FEMIS/OREMS model network and inputs were obtained from ORNL. These were enhanced based upon new information on network characteristics and traffic operations provided by each county.
- **Demographic Data**—Population and Household data per traffic analysis zone from the 1990 and 2000 census was used to develop nighttime evacuation origin and destination flows. Additional employment data from each county was used in Phase III to examine daytime evacuations
- **Operational Characteristics**—Field survey data collected by ODOT staff.

FINDINGS/LESSONS LEARNED

1. Once setup and validated, the model proved to be a useful tool in quickly analyzing a number of different operational scenarios. This easy scenario analysis was stated to be a key a driving factor in using the tool. However, the data input, error checking and validation along with the creation of the many environmental scenarios prooved to be daunting.
2. ODOT also found hat a known “bug” associated with a closure scenario was losing very long trips in the system in the original FEMIS system caused over estimates of some ETEs in their analysis. This has been corrected in the current version of OREMS.

3. At the end of Phase I of the study, a recommendation was made to carry out additional runs TO validate the model, to reflect designated evacuation routes, and to test additional recommended improvements.
4. The ODOT staff also emphasized the importance of careful network checking and detailed validation as part of any future studies. They pointed out that one or two problem intersections incorrectly represented can significantly bias the results.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

- Evacuation Time Estimated for Umatilla Depot Activity and Vicinity (ORNL, 1991) OREMS studies for each chemical depot maintained by CSEPP (Kentucky Blue Grass Army Depot and others)

Case Study 4: Houston-Galveston, Texas

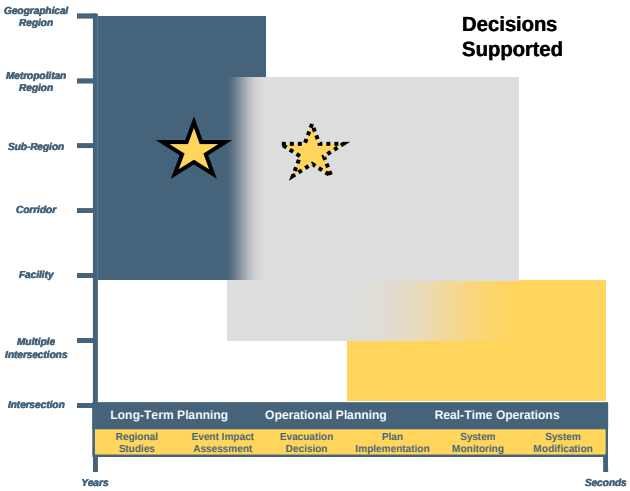
Location
Houston Galveston Region, Texas

Event Type
Hurricane Planning
Hurricane Evacuation

Event Planning Horizon

Researcher Affiliation
Colby Brown, Citilabs
Chris Van Slyke, HGAC

Model
Meso Simulation (DTA) Cube Avenue



STUDY SUMMARY

Status: **Ongoing**
Title: Houston Galveston Hurricane Evacuation Dynamic Traffic Assignment Model
Who: Citilabs and Texas Transportation Institute for HGAC
Contact: Chris Van Slyke chris.vanslyke@h-gac.com
Sponsor: Houston Galveston Area Council
Timeline: 2006 - 2008
Resources: $200k - $250k (initially ~ $100k consultant + ~ $60k staff)
Status: Ongoing

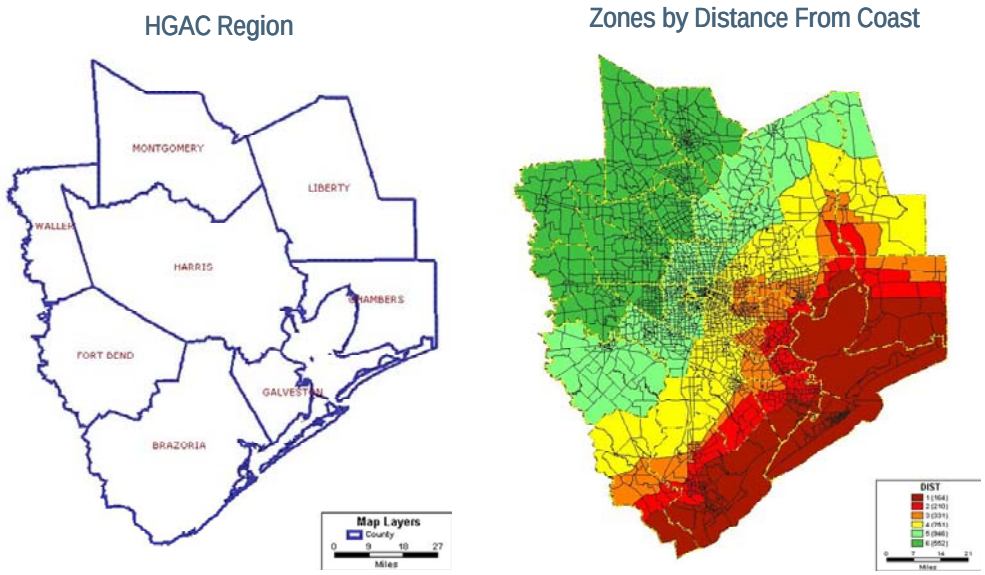
STUDY ABSTRACT

In response to the severe traffic congestion and gridlock that occurred during Hurricane Rita (2005), HGAC was asked to develop a tool for evacuation planning to identify bottlenecks in the transport system and policies that could more effectively move evacuees during the next natural disaster. The goal of the effort was to improve the understanding of evacuation transport system operations and impacts on travelers. This was important so that potential policies and operational decisions could be tested resulting in safe, secure and efficient evacuations when the time came.

The project, a result of the combined efforts of the Houston-Galveston Area Council, the Texas Transportation Institute and Citilabs, incorporated the development of a dynamic traffic assignment module for evaluating the performance of major evacuation routes within the H-GAC

region. To minimize model run time while maximizing policy analysis capabilities, a two-tier approach was selected wherein a “strategic” model using super-zones was developed in addition to a “detailed” model using the full H-GAC regional model network and zone system.

Policy analysis tools provided with the model include supply-side controls such as contra-flow lane reversal timing, facility closures, incident response, as well as demand-side controls such as evacuation trip departure scheduling. The model can be applied to compare the relative system and evacuation corridor performance of alternative policy scenarios.



Study Area: 8 County Houston Galveston Region, TX.
Source: Colby Brown, et. al. (see Reference)

MODELING APPROACH

Travel demand associated with evacuation conditions are extremely concentrated temporally while at the same time the transportation network is highly unstable with disorderly link flows and oversaturated queues. These conditions combined with the unique nature of evacuation travel make it difficult for traditional static equilibrium based transportation models to adequately represent evacuations. Consequently, dynamic traffic assignment simulations are the logical type of tool needed to properly model these conditions. Cube Avenue was chosen for the DTA evacuation modeling as part of the larger effort to convert the HGAC regional forecasting tool to the overall Citilabs Cube Platform.

To minimize model run time while maximizing policy analysis capabilities, a two-tier approach was selected. A “strategic” model using super-zones was developed in addition to a “detailed” model using the full HGAC regional model network and zone system. Both use the same region,

initial traffic analysis zone structure, and network as the HGAC regional travel forecasting model and process. Initially, an attempt was made to base the evacuation model upon HGAC's calibrated 3000 zone weekday travel model. However, it was soon found that evacuation travel demands and flows have different characteristics that are better represented using a strategic representation of super zones focused on evacuation routes. Therefore, while the regional model road network was used, a strategic super-zone aggregation was implemented to better represent evacuation conditions and evacuation routes. This has the advantage of reducing excessive network loading away from the evacuation routes, and improving run times. The focus of the tool is to answer what if questions. Since, common networks and inputs are used, scenarios and evacuation plans can be screened using the strategic model and refined later with more detailed tools.

In the network assignment model, background and evacuation trips are incrementally loaded using a dynamic generalized-cost framework that accounts for route preference, traveler information, transportation supply dynamics and congestion feedback over a 72-hour model period. Different dynamic traffic assignment methods and packet sizes were explored during the model development including all or nothing, Stochastic (Burell) assignment and incremental by-time and traditional assignment. Traditional incremental assignment was chosen to best balance theory and application.

Supply and demand policy analysis options were added to the model processes. Supply side options include:

- Modification of location and timing of reversible contra-flow lane operations;
- Modification of timing and location of shoulder utilization; and
- Ability to close entire parts of the network at specific hours of the day for both natural conditions (flooding) as well as policy reasons (mandatory facility closings).

Demand side options include:

- Ability to change the diurnal distribution traffic for the "normal day;"
- Ability to change the diurnal distribution for traffic during the/an "event;" and
- Ability to change the total number of evacuees by evacuation district (and by hour).

DATA SOURCES

- **Network**—Houston Galveston Area Council CUBE Voyager 3000 zone weekday travel forecasting model network.
- **Background demand**—HGAC Cube avenue weekday trip tables in production and attraction format by trip purpose and mode converted to hourly trip tables and adjusted

using bucket rounding techniques to maintain trip totals and avoid excessive assignment packets in DTA. These are then aggregated to the super-zone system and reduced to produce background demand over the 72 hour evacuation model period, and trip lengths adjusted to account for shorter back ground trips during evacuation.

- **Evacuation demand**—Evacuation demand also estimated for four vehicle types by TTI using surveys and traffic counts collected during the Rita evacuation.

FINDINGS/LESSONS LEARNED

Some initial findings are:

- Initially, a hybrid model process with aggregate zones and network was explored for the evacuation model. This proved to add complexity and was difficult to validate. Consequently, only a strategic-zone simplification was used in the final model approach.
- Network coding and the correct representation of operations features (signals) is extremely important in DTA assignments. Problems may be caused by poor centroid connectors, incorrect turn prohibitions, lanes, distance, or aggregations (lazy coding).
- Validation of assignments and packet sizes is extremely important in order to properly represent operations and avoid false bottlenecks in the assignment.
- Using a two tiered model approach with both strategic and detailed model levels is desirable. The strategic level model is capable of completing 72-hour simulations within less than 8 hours of run time. As such, it may be suitable for quick-response planning and scenario analysis in the short-term window prior to or even during a future evacuation event. This will be extremely helpful in adjusting pre-landfall scenarios and responding to changing flooding and other conditions as land fall approaches.
- Differences between Hurricanes Rita and Ike highlight that while modeling capabilities for DTA are now becoming a reality, there is still additional research that needs to be done concerning how people behave during an approaching hurricane. Uncertainties include impacts on time of departure, destination, auto occupancy, and route choice.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

- Brown, Colby et. al. “Development of a Strategic Hurricane Evacuation Dynamic Traffic Assignment Model For the Houston Region,” Paper presented at the TRB 2009 Annual Meeting, Washington DC, January 2009
- Lam, Chi Ping, et. al. “Applying Meso-scopic Simulation to Evacuation Planning for the Houston Region.” Paper presented at the 12th National Transportation Planning Applications Conference, Houston Texas, May 2009

Case Study 5: Hampton Roads, Virginia

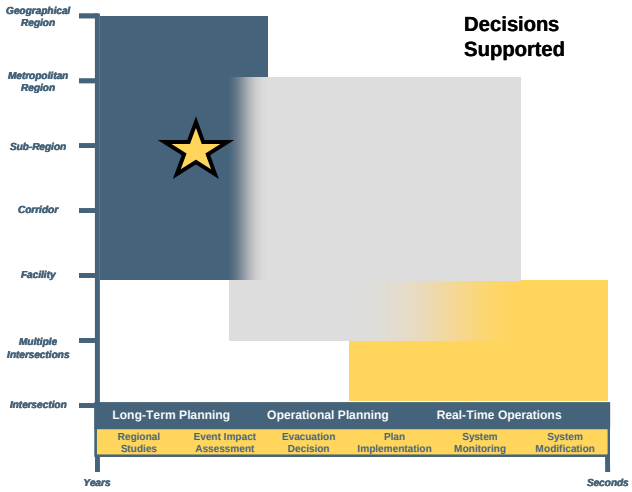
Location
Hampton Roads, Virginia

Event Type
Hurricane Planning
Hurricane traffic operations

Event Planning Horizon

Researcher Affiliation
Catherine C. McGhee, Virginia Transportation Research Council

Model
micro Simulation VISSIM



STUDY SUMMARY

Status:	**Complete**
Title:	Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan
Who:	Virginia Transportation Research Council and HRPDC
Contact:	Catherine C. McGhee Cathy.Mcghee@vdot.virginia.gov
Sponsor:	VDOT and Hampton Roads Planning District Commission
Timeline:	2004-2006, with update in 2007-2008
Status:	Complete

STUDY ABSTRACT

The modeling effort to analyze the operational characteristics of the evacuation routes of the Hampton Roads Region of Virginia was first carried out in 2006. It focused on the operational performance of the interstate evacuation routes (I-64, I-264, and I-664). An additional update was carried out in 2007-2008 to include the arterial routes (Rt. 58, Rt. 460, Rt. 60, Rt. 17, and Rt. 10) that carry much of the traffic during an evacuation.

The analysis was conducted using the VISSIM micro traffic simulation package to capture the detailed operations of the transportation system and analyze queues and bottleneck development. The road network and its traffic operations components (signals, variable message signs, etc.) were coded into VISSIM. The model was then calibrated and validated and used to help develop the Traffic Control Plan for the region under different hurricane category and landfall scenarios.

Study Area: Updated Hampton Roads Vissim Simulation Evacuation Roads and Routes
Source: Catherine McGhee (see Reference)

MODELING APPROACH

The modeling analysis included developing the model, identifying and developing scenarios, executing the model and analyzing the results. Steps for the model development included converting the network from the regional GIS, and entering it into VISSIM. Coding signals and ramp meters, developing the demand volumes, coding the scenarios and the reversal scenarios, and placing "virtual count stations" on the network for obtaining the simulation results.

To obtain the evacuation demand volumes, Virginia's evacuation process uses a spreadsheet based abbreviated transportation model (ATM). The ATM converts population, employment, and hotel occupancy data for each zone in order to estimate who will shelter in place, evacuate within the region, or evacuate to outside the region based on different threat levels and storm category. Evacuees are assigned to different routes based upon their origin zone. In the update, some manual assignments were made. The time distributions lie between the COE response curves for slow and medium response from the public to the evacuation order.

Since there was little data to use for validation of different storm categories in the region the initial model runs were checked for reasonableness and unjustified bottleneck development.

DATA SOURCES

- **Network Data**—Regional GIS network information coded in conjunction with VISUM, the regional network sibling of VISSIM. This network was then exported to VISSIM
- **Operations Data**—Traffic signal data for all the cities in the Hampton roads region and from Virginia DOT for state maintained signals. Ramp meters were coded based upon information from the TCP.
- **Evacuation Travel Demand**—Population, employment, and hotel occupancy converted to origin destinations using the ATM (see above)
- **Evacuation Temporal Distribution**—The original 2006 study was used.

FINDINGS/LESSONS LEARNED

The simulation analysis results proved useful in developing the Traffic Control Plan for the region and show the importance of carrying out operational analysis using micro-simulation tools. Extending or updating an existing tool for an area is much less time consuming than the initial development.

Conclusions made from the simulation are:

- To achieve the best traffic performance, lane reversal should be implemented for all category 4 or higher storms.
- For a category 4 storm with high hotel occupancy, 99% of the vehicles were able to evacuate by the end of 27 hours. It might be reasonable to add this 3 hour cushion to the typical 24 hour lead time given under evacuation situations.
- Traffic demand on certain sections of I-64 is much more than capacity. The simulation showed that the reversed lanes are being underutilized. Consequently, it was recommended to explore options (e.g., multiple entry/exit points to the reversed lanes) that will increase the utilization of reversed lanes.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

- McGhee, C.C., Grimes, M.C. An Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan. VTRC 06-R15. Virginia Transportation Research Council, Charlottesville, 2006.
- Edara, Praveen; Sharma, Siddharth; McGhee, Catherine; “Simulation Analysis Of The Hampton Roads Hurricane Evacuation Traffic Control Plan,” Paper Presented at the 2009 Transportation Research Board Annual Meeting, Washington DC, January 2009.

Case Study 6: Nags Head, North Carolina

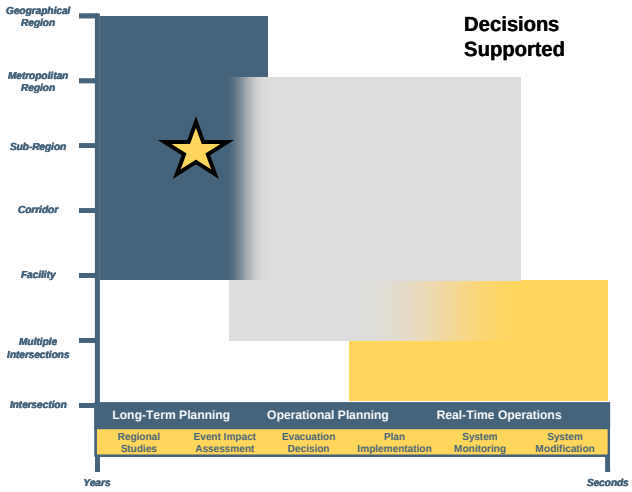
Location
Nags Head, North Carolina

Event Type
Hurricane Planning
Hurricane Evacuation

Event Planning Horizon

Researcher Affiliation
Daniel Morgan, Caliper Corporation.

Model



Multi-Scale Simulation TransModeler

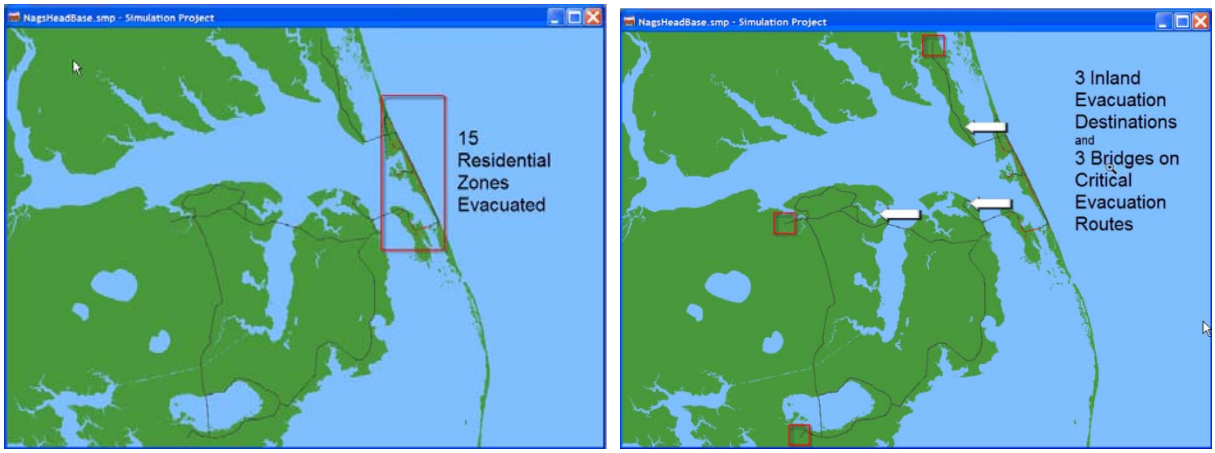
STUDY SUMMARY

Status: **Complete**
Title: Nags Head Evacuation Model TransModeler Demonstration
Who: Caliper Corporation
Sponsor: Caliper Corporation
Timeline: 2006
Resources: Internal 1 to 2 man months
Status: Complete

STUDY ABSTRACT

This case study is based upon a demonstration project which showed the usefulness of the TransModeler simulation tool in analyzing traffic operations during a forced evacuation from Nags Head. There are three bridges along critical evacuation routes; alternate routes are therefore limited. Severe congestion occurs at traffic signals when evacuation proceeds under normal operations. Demonstration showed the benefits of reverse lanes, using the shoulders and modified traffic signals (yellow in the evacuation direction). The demonstration also showed the usefulness of integrated visualization of the simulation results.

STUDY AREA



Study Area: Evacuation of Nags Head NC (15 Residential Zones) to inland destinations.
Source: Daniel Morgan

MODELING APPROACH

Represented the Nags Head resort area by 15 residential zones with 3 inland evacuation destinations and 3 critical bridges along the evacuation routes.

Under normal signal timings, bottlenecks developed at signals along the approaches to the bridges. These caused extensive queues to develop. Also, only two lanes provided outbound flow off the island under normal configuration.

Under the evacuation plan:

- Traffic was permitted in reverse direction on one way streets;
- All four lanes on bridges were used in outbound evacuation;
- Signals were set to yellow in the direction of the evacuation; and
- Shoulders on the bridges were also used.

The changes resulted in significant reduction and elimination of queues and delay for the evacuation.

DATA SOURCES

- **Network**—GIS for region and observed signal timing plans
- **Evacuation Demand**—Hypothetical population by Traffic analysis zone.

FINDINGS/LESSONS LEARNED

While this was not a complete study, some observations from the demonstration were made:

- Integrated transportation analysis packages such as Calipers' Transcad and TransModeler programs or Cube's Voyager and Avenue programs provide useful simulation capabilities for evacuation operations planning.
- The before-and-after visualization and animation of traffic from a simulation is a powerful way to convey the impact of different operations solutions for improving traffic flow during an evacuation.

Case Study 7: New Orleans, Louisiana

Location
New Orleans, LA

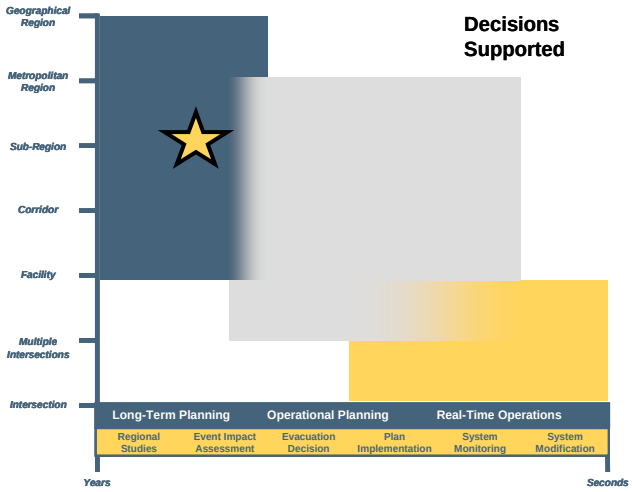
Event Type
Hurricane
Contraflow Lanes

Planning

Event Planning Horizon

Researcher Affiliation
Brian Wolshon (LSU)

Model
Micro Simulation CORSIM

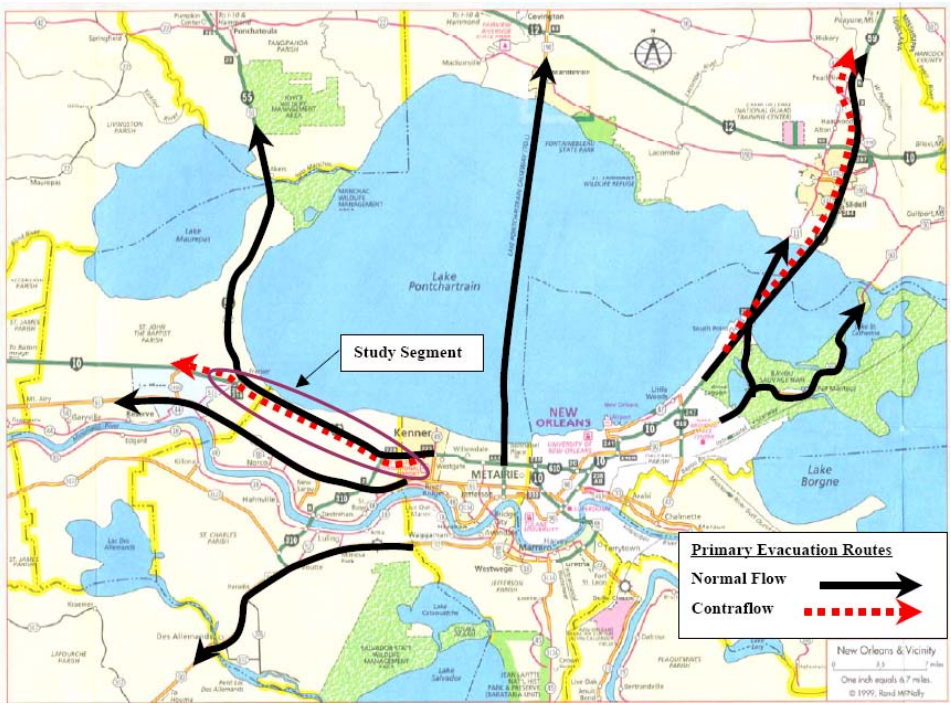


STUDY SUMMARY

Status: **COMPLETED**
Title: "Modeling and Analyses of Freeway Contraflow to Improve Future Evacuations"
Who: Gregoris Theodoulou, Brian Wolshon
Contact: Brian Wolshon, Louisiana State University, brian@rsip.lsu.edu
Sponsor: Louisiana Department of Transportation and LSU
Timeline: 2000 through 2001
Status: Completed

STUDY ABSTRACT

This research was undertaken to improve the understanding of traffic conditions on contraflow freeway segments during an evacuation. The paper describes a project in which the CORSIM microscopic traffic simulation program was used to model the freeway configuration used to evacuate New Orleans, as well as two alternative scenarios for this same segment. The results showed that the currently proposed configuration is likely to result in an underutilization of the contraflow segment, thus significantly limiting the number of evacuees that can get out of the city. The study also shows how the effectiveness of the New Orleans contraflow segment could be significantly improved with some simple and inexpensive modifications to the existing plan. Most importantly, however, the results of this research underscore the critical nature of proper planning and design of contraflow entry points and how it is often overlooked for both emergency and non-emergency conditions.



Study Area: New Orleans Metropolitan Area
Source: Brian Wolshon

MODELING APPROACH

Prior to this study, contraflow evacuation had not been used in New Orleans; thus, no field data under such conditions existed. In order to study the effect of contraflow lanes, traffic simulation was used to depict freeway contraflow evacuation conditions using a conventional simulation program then use it to evaluate it effectiveness. The CORridor SIMulation (CORSIM) model was selected for this purpose. To limit the scope of the project to a manageable size, the assessment focused specifically on the planned westbound Interstate 10 (I-10) contraflow evacuation segment out of New Orleans with the simple objectives of assessing its operational characteristics (i.e., queuing, delay, travel speed, travel time, and total number vehicles exiting the segment).

DATA SOURCES

Three key data elements were collected as part of this project:

- **Evacuation Travel Demand**—Travel volumes on key evacuation routes were collected from previous hurricane evacuation studies conducted as part of a larger hurricane preparedness effort.

- **Behavioral Response Curves**—Temporal characteristics were developed based upon behavioral response curves. For this study, curves developed as part of an Alabama hurricane evacuation study were used.
- **Operating Scenarios**—Various scenarios for implementing contraflow lanes were taken from plans developed by the Louisiana State Police, Department of Transportation and Office of Emergency Planning in the wake of Hurricane Georges.

FINDINGS/LESSONS LEARNED

This research was undertaken to increase the level of understanding of traffic operations on a planned contraflow segment that will be used for the evacuation New Orleans. New Orleans is among the most vulnerable cities in the world to the threat of hurricanes. This research makes three primary contributions.

1) Demonstrated how a conventional micro-scale traffic simulation can be adapted and applied for the modeling of evacuation contraflow.
2) Quantified the significant benefit of contraflow operation over conventional non-contraflow evacuation. Initial estimates suggested contraflow would increase roadway capacity by 70 percent, while this study showed a 53 percent increase.
3) The critical role played by the entry point and the plan to load vehicles into the contraflow lanes. Emphasis had been placed on the location and control of the segments because it was assumed that segment length and termination design would dictate the effectiveness of the operations. These results further suggest that the contraflow segment planned for westbound I-10 out of New Orleans will create a bottleneck.

Case Study 8: New Orleans/Baton Rouge, Louisiana

Location
New Orleans / Baton Rouge

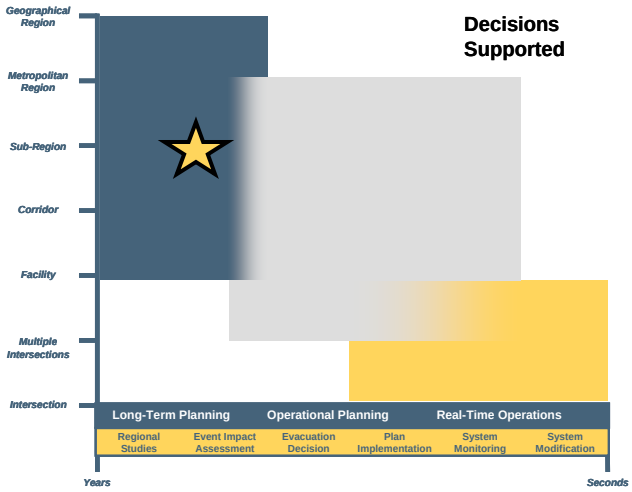
Event Type
Un-planned Event (with Notice)
Hurricane Evacuation

Event Planning Horizon

Researcher Affiliation
Brian Wolshon: Louisiana State Univ.

Model

Meso (Activity Based) Simulation TRANSIMS



STUDY SUMMARY

Status:	**ONGOING**
Title:	"Using TRANSIMS for Multi-Modal Evacuation Planning in the City of New Orleans"
Who:	Brian Wolshon, Louisiana State University
Contact:	Brian Wolshon (LSU) brian@rsip.lsu.edu
Sponsor:	FHWA Office of Planning (TRANSIMS BAA)
Timeline:	Award in October 2006, Spring 2007 through Spring 2009
Resources:	Multi-year research effort (~ $300k)
Status:	Ongoing

STUDY ABSTRACT

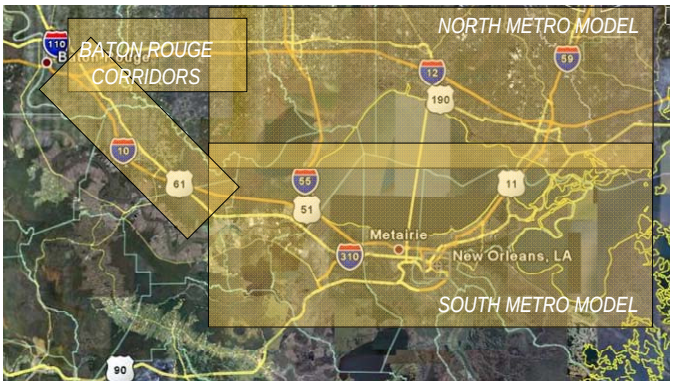
Traditional models and simulation tools are pushed to their computational limits when used for analyzing evacuations in terms of scale (number of vehicles) and scope (duration). They also do not permit the modeling and simulation of multiple modes of transportation simultaneously. TRANSIMS has the potential to overcome these limitations.

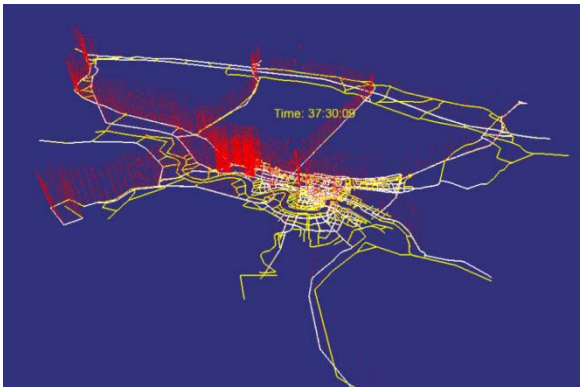
Recently, the United States Department of Transportation sponsored a research and development project to adapt and apply the TRANSIMS traffic simulation system for the purpose of modeling evacuation traffic conditions. This is a significant departure from prior applications of TRANSIMS which have been focused on routine, rather than emergency, travel patterns. The application of the TRANSIMS system also marks an advance in the modeling of evacuation

traffic because it permits simulation and tracking of various operational modes over geographic and temporal scales that were unattainable only a few years ago.

A TRANSIMS model has been developed for the New Orleans metropolitan region that includes the assisted evacuation process for mobility-limited individuals. The model was combined with a high level graphic visualizer developed by Balfour technologies. Steps in the model development included:

- Validate and calibrate a base model using regional traffic patterns recorded during the 2005 Katrina evacuation;
- Code a New Orleans multimodal evacuation plan;
- Code and test alternative plans and ideas.





Study Area: New Orleans, North Metro, South Metro, and Baton Rouge Models
Source: Brian Wolshon (see Reference)

MODELING APPROACH

Develop a regional model for New Orleans using a combination of 4 corridors based upon the TRANSIMS structure:

- **Network Input**—Structure and characteristics of the transportation network (control, capacity, etc.) and activity locations

- **Population Synthesizer**—Creates a disaggregate synthetic population based on aggregate census zonal information
- **Activity Generator**—Travel surveys or observation of past evacuations
- **Route Planner**—Used to develop spatial and temporal travel behavior and route assignments
- **Microsimulator**—Tracks and compiles movements and statistics of every individual agent (vehicles & pededestrians)
- **Visualizer**—3rd party developer Balfour Technologies Inc.

Validate using corridor and screen-line flows by time compared against records from Katrina. Presentation of results using the Balfour graphics visualizer

DATA SOURCES

- **Base Networks and Demographic Data**—New Orleans regional networks and forecasting process.
- **Travel Demand and Validation Data**—Regional traffic patterns recorded during Katrina evacuation.

FINDINGS/LESSONS LEARNED

The study showed that TRANSIMS is dynamic, models behavior of individuals, and has the ability to:

1) Simulate networks over geographic areas that may encompass thousands of square miles;
2) Model intermodal evacuations that include pedestrian, passenger vehicle, and transit modes;
3) Track and collect detailed statistics on millions of separate vehicles over several days; and
4) Produce output that can be displayed over high resolution aerial photography using animations as the one shown above.

TRANSIMS is also complex, does not have its own graphical interface, and does not include a large amount of documentation and user guidance. Issues concerning its widespread adaptation include:

1) Detail and complexity of network coding requiring a significant level of effort required to code, calibrate, and validate the model. Calibration is particularly difficult for evacuations because few comparative evacuation traffic data sets exist.;

2) Detailed parcel-level demographic representation required to produce realistic outbound corridor level flows;
3) Limited user-friendliness of the system; and
4) High level of hardware and software requirements.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

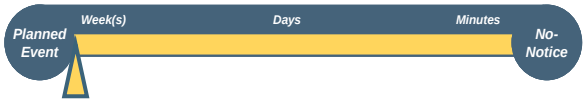
- Wolshon, Brian. "Adaptation and Application of TRANSIMS for the Simulation of Regional Model Evacuation." Paper presented at the 12th National Transportation Planning Applications Conference, Houston Texas, May 2009

Case Study 9: Daytona Beach, Florida

Location
Daytona Beach, FL

Event Type
Planned
Special Event

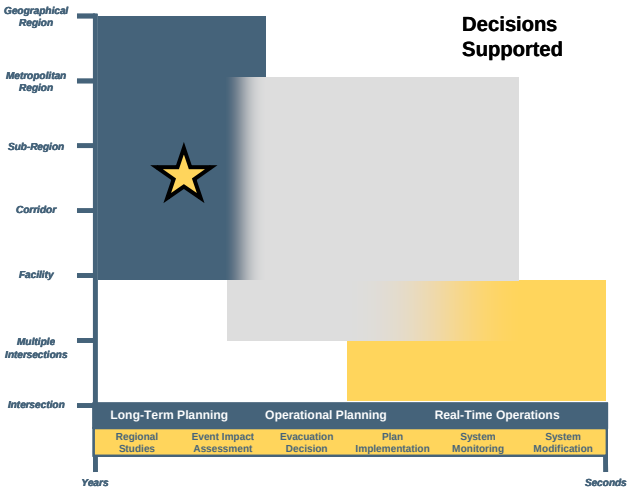
Event Planning Horizon



Researcher Affiliation
HP Consultants, Inc.

Model

Meso Simulation DYNASMART-P



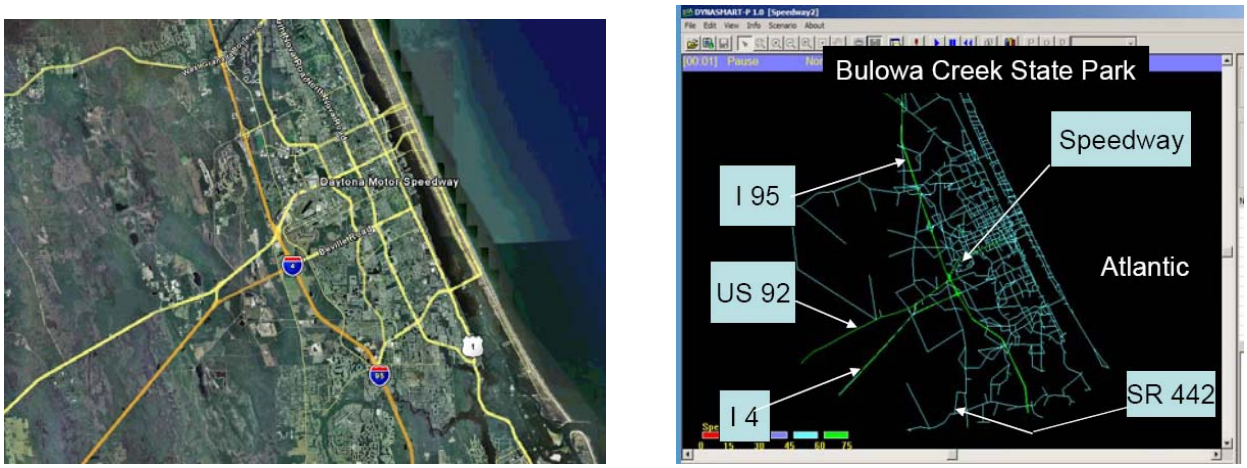
STUDY SUMMARY

Status: **COMPLETED**
Title: "Daytona Speedway Evacuation Modeling Using DYNASMART-P"
Who: Arvind Kumbhojkar, HP Consultants, Inc
Contact: Arvind Kumbhojkar, hpconsultantsinc@earthlink.net
Sponsor: Florida Department of Transportation, District 5
Timeline: 2004 - 2005
Status: Completed

STUDY ABSTRACT

The Daytona Speedway Evacuation Modeling project applied the DYNSMART-P meso-scopic simulation model to the evaluation and development of a new evacuation plan for the speedway. Existing plans existed but did not consider other properties nearby, nor account for impacts on the overall transportation network. Any new plan would need to consider regional impacts.

The purpose of this study was to develop an emergency evacuation plan for the Daytona International Speedway. The project included the review of existing plans and other regional event venues to identify recommended practices for emergency evacuations for various types of venues. The goal was to develop a plan that would support an emergency evacuation during a security threat, facilitate response logistics and minimize the impact on the surrounding transportation system.



Study Area: Daytona Beach and Surrounding Area
Source: Google Earth (left)

MODELING APPROACH

Dynamic network analysis and simulation of the Intelligent Transportation System (ITS) infrastructure are key needs for modeling the traffic flow during an emergency evacuation of the Daytona International Speedway (Speedway). An advanced dynamic traffic assignment model was needed for the study due to queues that develop during evacuations, unstable traffic flow, the need to examine ITS strategies and devices, and the desire for a graphic simulation and presentation capability. DYNASMART-P was chosen due to its ability to meet these requirements. At the time, DYNASMART-P was new and its capabilities not yet widely known.

A network consisting of 1309 nodes and 3264 links was developed covering the Daytona Speedway and its surrounding area. Background through-traffic of approximately 78,000 vehicles per day was captured moving from external station to external station. The simulation represented 97 actuated traffic signals. Within the area, 45 parking lots represented origins and 4 super zone destinations captured the direction that those leaving the raceway would travel. Each destination was pre-allocated a percentage of the demand. During an evacuation of the Speedway, the background traffic was reduced by 70 percent, and approximately 40,000 vehicles were assumed to leave the facility.

Data were collected and the model validated to match the typical outbound traffic after a major race: Verification criteria included a 3-hour clearance from around the Speedway, an overall 6-hour network clearance and typical congestion patterns. Four different scenarios were examined: baseline, evacuation baseline, evacuation optimal DTA, and evacuation optimal destination and DTA. The optimal destination and DTA produced the minimal clearance times and congestion.

DATA SOURCES

Data were collected from the following sources:

- **Highway networks**—Draft CFRPM IV networks from FDOT, and the network details from the City, FDOT, and Site visits
- **Operational details**—City, County, FDOT
- **Parking information**—City, Speedway
- **Historic information**—City, County, FDOT

FINDINGS/LESSONS LEARNED

Some findings from the modeling effort include:

- The study found that DYNASMART-P (now Dynast-T) is a valuable simulation tool for modeling complex, dynamic network analysis problems. Note, however, that one of the analysts subsequently mentioned issues with the earlier model version that have since been improved upon. These included primitive network editing features, limited variable message sign inputs, and some quirks in the signal control logic.
- The model results showed that the proposed emergency evacuation routing with road/lane closures, elimination of vehicle-pedestrian conflicts, additional one-ways and added capacity of US 92 via DeLand reduces network clearance time by 25 percent (90 minutes) and clears the Speedway 40 minutes early.
- The animation of the results was helpful in both validating and analyzing scenarios and in showing the results to others.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

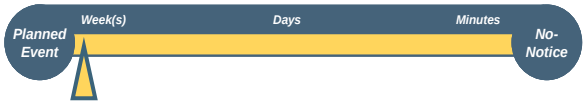
- Hass Robert, et. Al, SAIC, “iFlorida Model Deployment Final Evaluation Report,”,FHWA Report FHWA-HOP-08-050, FHWA Office of Operations, Washington DC. January 2009

Case Study 10: Dover, Delaware

Location
Dover Delaware

Event Type
Planned
Special Event

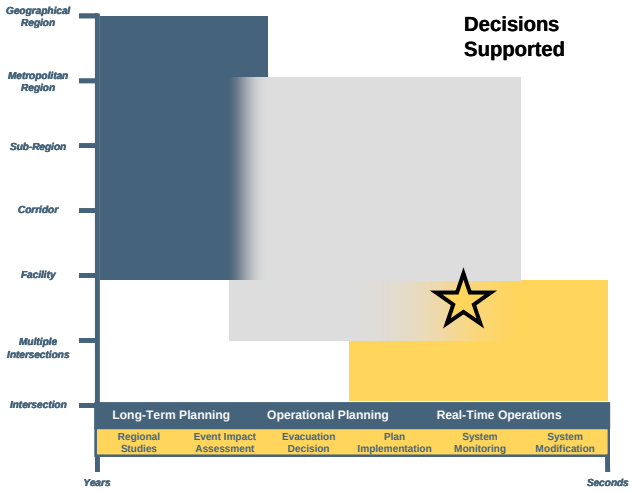
Event Planning Horizon



Researcher Affiliation
HP Consultants, Inc.

Model

Operations GIS Esri Arc Info



STUDY SUMMARY

Status: **COMPLETE in Operation**

Title: "City of Dover Delaware Deploys Ground Breaking GIS Application for NASCAR Events"

Who: City of Dover Delaware, Dover Downs Raceway

Contact: Mark Nowak mnowak@dover.de.us

Sponsor: City of Dover Delaware, Dover Downs Raceway

Timeline: 2006

Resources: 3 month initial setup plus about a man month per year to maintain changes in information.

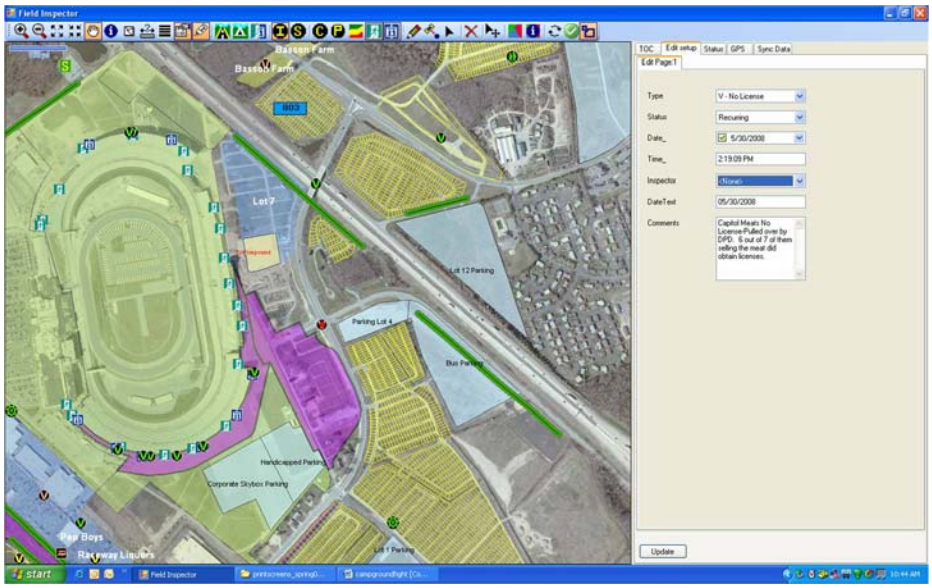
Status: Compete – In operation

STUDY ABSTRACT

Arc GIS Server with mobile applications used to help manage Nascar Race special event every June and September in Dover Delaware. On race weekends, the population grows from 35,000 to between 200,000 and 250,000 people. A method was needed to help manage the crowds.

The City GIS manager was asked by the Fire Marshall to develop a real time GIS application to monitor the Dover Downs Raceway and its surrounding area. They developed an in-house application using Esri's Arc Server and Arc Mobile applications to monitor and respond to changing conditions such as incidents, inspections, parking, and vending status. Seventeen race specific layers (campgrounds, vending locations, incidents, etc.) were created on top of the other information maintained by the city (streets, building footprints, etc.)

The system was first deployed in 2006 and was well received. It is now used for every race event and is being expanded.



Study Area: Dover Downs and surrounding areas including camp grounds
Source: Arc Watch May 2008 (see Reference)

MODELING APPROACH

Without having to purchase any additional equipment the GIS Manager for the city began writing a mobile GIS application to help public safety officials improve their emergency response capability. Utilizing ArcPad software, a laptop computer and a Trimble ProXT GPS receiver, the fire marshal had detailed maps available to him that could be updated in real time with mission-critical information.

After the initial development and deployment in 2006, the system was expanded to use the Esri Arc Server platform and mobile client allowing real time display of the information on mobile laptops at various locations around the city and raceway. This included tracking of incidents, inspections, parking, and vending activities, as well as conditions throughout the area. There are three operations periods per day where inspections occur.

The platform is now expanding to include ambulance services and pinpointing of 9-1-1 calls within the campgrounds.

DATA SOURCES

Dover City GIS information included approximately 30 layers of GIS spatial data at the command center and in the field including streets, building footprints, elevation contours, parcel data, and county address points. An additional 17 layers related to the NASCAR were created and maintained by the city's GIS group. All NASCAR event layers were created in-house as well. These include:

- Camp Road Centerline;
- Campsites;
- Center of Speedway;
- Speedway Gates;
- Emergency Operations Areas;
- Hydrants;
- Incidents;
- Outdoor Events;
- Power Lines;
- Code Violations;
- Substations; and
- Vending Areas.

FINDINGS/LESSONS LEARNED

- GIS was one of the only tools that provided support for real time operations. While emergency and evacuation personnel don't always understand the usefulness of transportation models, they understand and see immediate benefits to having a real time integrated GIS platform that brings all of the sources of information that they use together and displays it in an integrated way.
- "Overall operational awareness is the greatest benefit to this project," says Mark Nowak, GIS coordinator for the City of Dover. "All aspects of the operations are greatly improved using GIS. Communications are improved because now everything goes through the mobile command post on race weekends and decisions are made using information collected in the ArcGIS NASCAR event solution. Prior to this, decisions were made by field personnel without a clear understanding of the overall operational picture."
- The GIS platform provided the ability to update and monitor the status of facilities and their characteristics in real time.
- One manager stated that Speedway would not know how they would run operations without it.

- A quote from one of the users: “When you can look at a screen and see everything that is going on, it is really useful.
- Even though the transportation analysis capability is limited, having a display of conditions along with everything else is helpful during the event.

ADDITIONAL SOURCES OF INFORMATION/REFERENCES

- Arc Watch May 2008, “City of Dover Delaware Deploys Ground Breaking GIS Application for NASCAR Events”

US Department of Transportation
Research and Innovative Technology Administration

ITS Joint Program Office
1200 New Jersey Avenue, SE
Washington, DC 20590

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EDL NO.: 14940