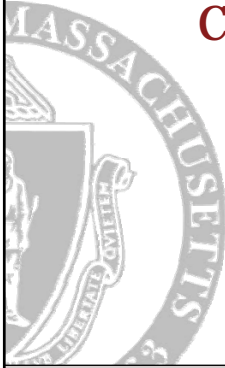


Modeling Traffic Flow under Emergency Evacuation Situations: Current Practice and Future Direction



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Overview

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 - OREMS
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 - ETIS
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Introduction

- Emergency situations generally involve unusually high levels of casualties, property damage, or disruption
- In response to emergency conditions, evacuation operations have become increasingly common
- Traffic simulation software has seen an increased use modeling traffic flow under emergency conditions
 - Assist emergency management and transportation officials in decision-making
 - Help evacuating public obtain important information regarding evacuation operations

Emergency and Transportation

- Transportation serves as the means to move an endangered public to safety
 - U.S. highway infrastructure permits movement of large numbers of people over significant distances in timely and safe manner to suitable shelters away from hazard zone
 - Population growth, however, is outpacing transportation infrastructure growth
- Evacuation efficiency factors:
 - Operational ability of highway infrastructure
 - Response of evacuating public

Issues Influencing Public Response

- Response to emergency conditions dependent upon several factors:
 - Personal perception of risk
 - Information source and type
 - Local authority action
 - Household location and structural characteristics
 - Gender and age
 - Presence of children or disability in the household
 - Storm-specific threats
 - Time of day
 - Provision of evacuation transportation assistance
 - Development and dissemination of traffic management plans
- Human response largely based on previous experience
 - Unpredictable actions difficult to accurately model

Emergency and Simulation

- Quantitative understanding of influencing factors through use of tools such as traffic simulation software
- Simulation provides low-cost, low-risk environment
 - Test various assumptions and alternatives
 - Analyze effects immediately
- Simulation software serves three main purposes:
 - Pre-planning analysis
 - Real-time operation
 - Post-planning procedures

Comparative Review of Emergency Simulation

- Several simulation software packages developed to model traffic flow specific to emergency evacuation
 - Mass Evacuation (MASSVAC)
 - Network Emergency Evacuation (NETVAC)
 - Oak Ridge Evacuation Modeling System (OREMS)
 - Dynamic Network Evacuation (DYNEV)
 - Evacuation Traffic Information System (ETIS)

- Comparative review of OREMS, DYNEV, and ETIS

Oak Ridge Evacuation Modeling System (OREMS)

- Developed by the Oak Ridge National Laboratories Center for Transportation Analysis in the late 1990's

- Microscopic model
 - Estimate evacuation time
 - Develop traffic management and control strategies
 - Identify evacuation routes, traffic control points, and traffic operational characteristics

- Capability of integrating real-time information

Dynamic Network Evacuation (DYNEV)

- Developed by KLD Associates, Inc. in the late 1970's
- Macroscopic model
 - Traditionally for simulating evacuation from sites within close proximity to nuclear power plants
 - Enhanced to model for regional hurricane planning processes
 - Analyze network capacity and evacuation demand
- Does not have capability to integrate real-time information

DYNEV

- | | |
|--|---|
| <ul style="list-style-type: none">▪ Inputs<ul style="list-style-type: none">• Urban intersections or points w/ a geometric or functional change• Urban streets or freeway sections• Traffic Analysis Zone or Evacuation Analysis Zone• Signal phasing time of intersections• Bus route, schedule, location of stops• Population• Employment / Income• Participation rate / Behavior patterns• Day of year / Time of day• Basic weather conditions | <ul style="list-style-type: none">▪ Outputs<ul style="list-style-type: none">• Estimation of evacuation time• Speed of evacuating vehicles• Density of traffic stream• Total number of vehicles using link |
|--|---|

DYNEV



Evacuation Traffic Information System (ETIS)

- Developed by PBS&J in the late 1990's
- Macroscopic model
 - Forecast large cross-state traffic volumes
 - Analyze roadway networks in southeastern section of the United States (e.g. North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas)
- Capability of integrating real-time information
- Major difference: county-based input rather than zone-based input

ETIS

- Inputs
 - Urban streets or freeway sections
 - Link volumes and speeds
 - Population
 - Tourists
 - Participation rate / Behavior patterns
 - Destination percentage of evacuees for each county
 - Day of year / Time of day
 - Basic weather conditions
- Outputs
 - Evacuating counties
 - Shelter capacity by state
 - Traffic count by state
 - Traffic volumes by corridor
 - Destination percentages by city
 - Estimated state-to-state traffic

ETIS

The screenshot displays the ETIS software interface. On the left, there is a map of the United States with a 'Map Frame' label. To the left of the map are three panels: 'County Information', 'Route Lane & Information', and 'Route Class Information'. On the right, a table titled 'Evacuation' is shown, listing data for various states and counties. The table includes columns for STATE, COUNTY, SALVAGE, POPULATION, EVACUATION, TYPE, STATUS, and DATE TIME.

STATE	COUNTY	SALVAGE	POPULATION	EVACUATION	TYPE	STATUS	DATE TIME
AL	Baldwin	5	90%	36,844	Mandatory	None	12/30/2004 15:11 PM
FL	Alachua	1	90%	1,443	Mandatory	None	2/22/2005 16:38 PM
FL	Alachua	5	80%	8,294	Mandatory	None	3/15/2005 9:28 AM
FL	Alachua	4	80%	8,294	Mandatory	None	3/14/2005 18:53 PM
FL	Brevard	4	90%	44,402	Mandatory	None	3/15/2005 15:38 PM
FL	Bay	3	20%	4,843	Recommended	None	3/15/2005 17:44 PM
FL	Clay	2	90%	688	Mandatory	None	3/14/2005 16:20 PM
AR	Baldwin	5	90%	38,605	Mandatory	None	12/24/2004 10:48 AM
FL	Monroe	5	90%	27,900	Mandatory	None	1/8/2004 7:51 AM
DC	Washington	5	90%	4,432	Mandatory	None	1/29/2005 16:12 PM
FL	Alachua	1	90%	1,443	Mandatory	None	2/22/2005 13:29 PM
AL	Baldwin	5	90%	34,954	Mandatory	Full	4/24/2005 10:30 AM
GA	Monroe	3	90%	1,620	Mandatory	None	3/19/2004 18:13 PM
AL	Baldwin	5	90%	34,954	Mandatory	None	4/25/2005 16:13 PM
MD	Talbot	2	90%		Mandatory	None	11/29/2004 13:20 PM
DE	New Castle	1	80%		Mandatory	None	11/29/2004 13:18 PM
AL	Baldwin	5	90%	34,954	Mandatory	None	4/25/2005 16:40 PM
FL	Bay	3	20%	4,843	Recommended	None	3/15/2005 16:44 PM
AL	Mobile	4	10%	14,250	Recommended	None	4/25/2005 14:11 PM
FL	Harrison	3	90%	15,171	Mandatory	None	11/22/2004 11:40 AM
AL	Mobile	4	90%	42,750	Mandatory	None	11/12/2005 16:12 PM
AL	Mobile	4	10%	14,250	Recommended	None	1/28/2004 14:37 PM
FL	Brevard	5	90%	601	Mandatory	None	1/24/2005 16:11 PM
FL	Brevard	4	90%	601	Mandatory	None	2/22/2005 16:40 PM
GA	Bryan	5	90%	1,800	Mandatory	None	11/29/2004 13:17 PM
AL	Mobile	4	90%	42,750	Mandatory	None	11/29/2004 15:11 PM
LA	Orleans	2	90%	11,247	Mandatory	None	11/29/2004 13:24 PM
AL	Baldwin	5	90%	34,954	Mandatory	None	4/25/2005 14:50 PM
FL	Baker	1	90%	86	Mandatory	None	1/21/2005 17:30 PM
FL	Clay	2	90%	688	Mandatory	None	2/22/2005 16:20 PM
FL	Franklin	3	90%	940	Recommended	None	11/29/2004 9:47 AM
FL	Brevard	4	90%	601	Mandatory	None	2/22/2005 16:20 PM
FL	Alachua	1	90%	1,443	Mandatory	None	1/21/2005 17:45 PM
FL	Brevard	5	90%	514	Mandatory	None	3/11/2005 15:38 PM
FL	Alachua	1	90%	1,443	Mandatory	None	2/15/2005 15:30 PM
FL	Clay	2	90%	688	Mandatory	None	1/24/2005 14:41 PM

Future Directions and Potential Enhancements

- **Ability of Models to Account for Special Travel Behaviors**
 - Are drivers willing to sacrifice personal safety for faster mobility?
 - Are drivers willing to accept a smaller margin of error?
 - How do current weather conditions impact visibility, driving comfort, etc?

- **Ability of Models to Account for Special or Loss of Travel Rules**
 - Do drivers obey stop signs and traffic signals?
 - Do drivers observe lanes markings such as passing zones and turning lanes?
 - Do drivers follow right-turn-on-red and yielding procedures?

Future Directions and Potential Enhancements

- **Ability of Models to Account for Occurrence of Accidents or other Traffic Obstructions**
 - Further prolong evacuation time and cause for increased tensions in human behavior
 - Emergency response personnel must be able to respond to scene
 - New conditions create necessity to quickly develop alternative plans based on altered highway characteristics

- **Ability of Models to Account for Public Transit**
 - Personal passenger vehicles
 - Rail, air, bus, and water

- **Ability of Models to Account for Special or Unusual Highway Operation**
 - Contraflow
 - Use of breakdown lanes, shoulders, or median strips as means of travel

Future Directions and Potential Enhancements

- **Data Needs and Requirements**
 - Static models assume conditions of highway network at beginning of simulation consistent throughout entire evacuation period
 - Existing models rely heavily upon historical data to generate estimates of evacuation population, departure times, and destinations
 - Dynamic models account for changes in conditions of highway network over time
 - ITS detectors located along evacuation routes collect data (e.g. traffic flow rates and speeds, lane closures, weather conditions, traffic accidents)
 - Models receive data, re-evaluate current situation, and disseminate updated travel information to evacuees

Future Directions and Potential Enhancements

- **Model Calibration and Validation**
 - Limited ability to accurately describe human response and driving behavior
 - Estimates of constants and parameters with regards to car following cannot be made due to unique driving behavior
 - Require larger data sets and more understanding with regards to human behavior
 - Account for vehicle mix (e.g. passenger car, truck) to better estimate parameters regarding traffic flow
 - More experience in certain geographical areas than others

Conclusions

- Evacuation is, and most likely will continue to be, the most common and efficient emergency management strategy to protect a large number of people from danger
- Need exists to more accurately model evacuation behavior by either enhancing existing emergency evacuation simulation software or developing new software
- New models need to have ability to accurately represent erratic, unusual, and unpredictable actions and reactions exhibited under emergency conditions

Conclusions

- Various modes of public transit must be addressed as possible means of evacuation
- Consideration needs to be given to state-to-state traffic flow, as effects of evacuation operations not experienced solely within area at risk
- Recommended that emergency planning agencies explore potential investments into real-time data integration capabilities