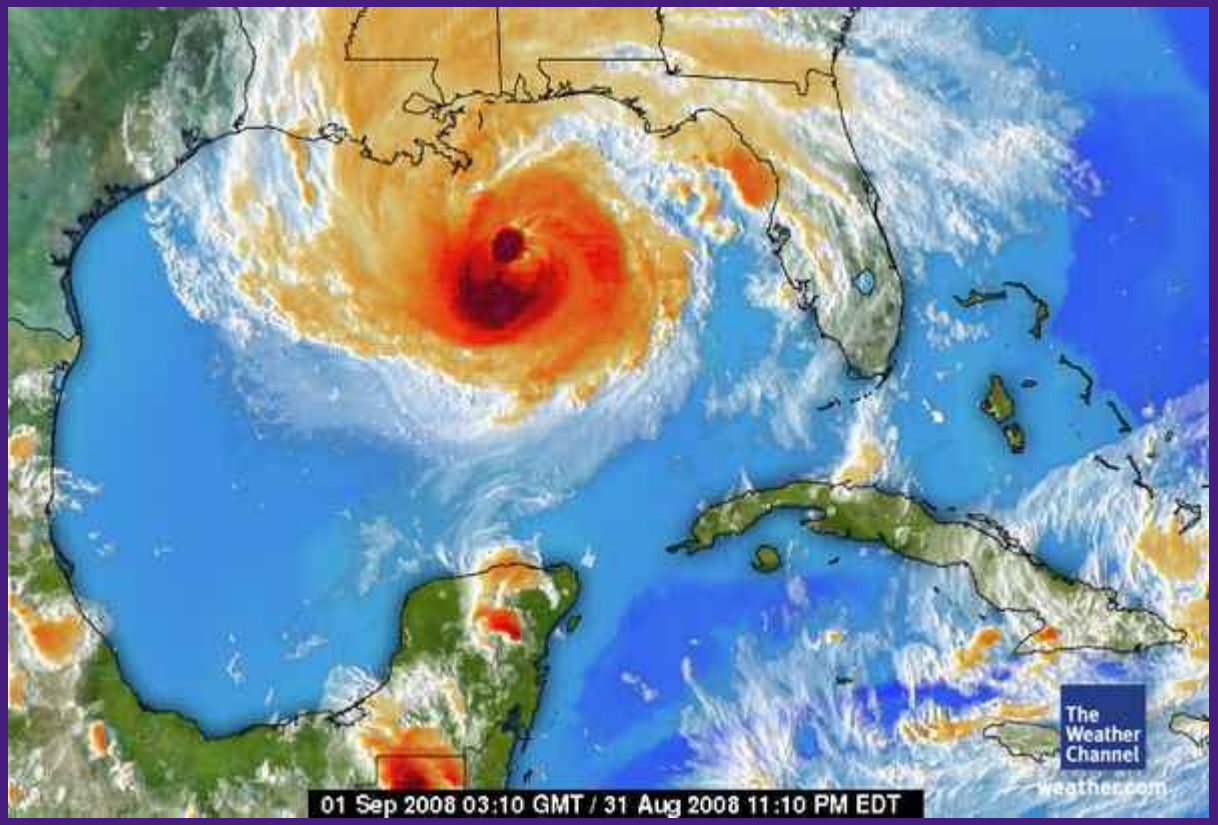
INTEGRATION OF *HOUSEHOLD DECISION MAKING* WITH *DYNAMIC TRANSPORTATION MODELING* TO EVALUATE HURRICANE EVACUATION



Thomas Montz
March 31, 2011

5th Annual DHS University Network Summit

Overview

- Dynamic Hurricane Response
- Methodology
- Household Decision Models
  - Evac Departure Time
  - Destination Choice
- Dynamic Transportation Model
  - TRANSIMS
- Results
- Conclusion

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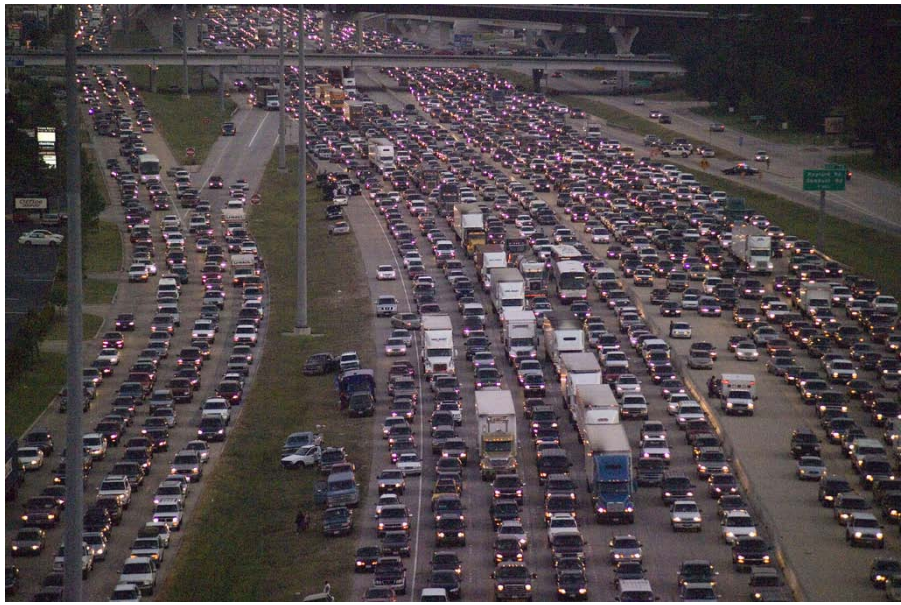
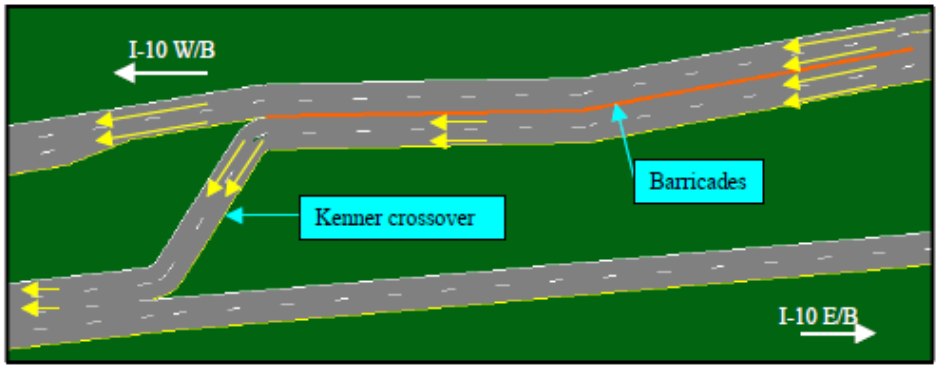
Dynamic Hurricane Response

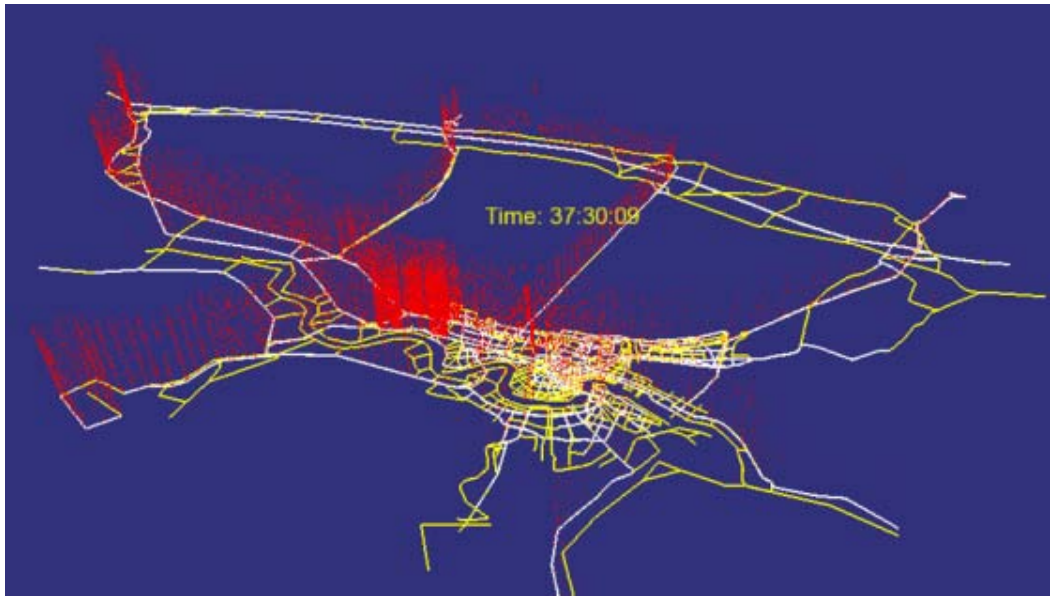
- Also called “Flexible Response”
- Different hurricane scenarios will influence the evacuation demand
- Evacuees will choose different routes based on where the storm appears to be landing



Evacuation Simulation

- Used in research at LSU involving contraflow operations at micro-level
- TRANSIMS model of New Orleans region (macro-level)
- Will be the "laboratory" to test Dynamic Hurricane Response
- But, how to generate demand?





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Household Decision Models

- Answer These Questions:
  - Will they evacuate?
  - When will they evacuate?
  - Where will they evacuate to?
- Classic transportation planning models used to answer these questions
  - Logit Models
  - Gravity Model
  - Intervening Opportunities Model (IOM)

Problem Statement

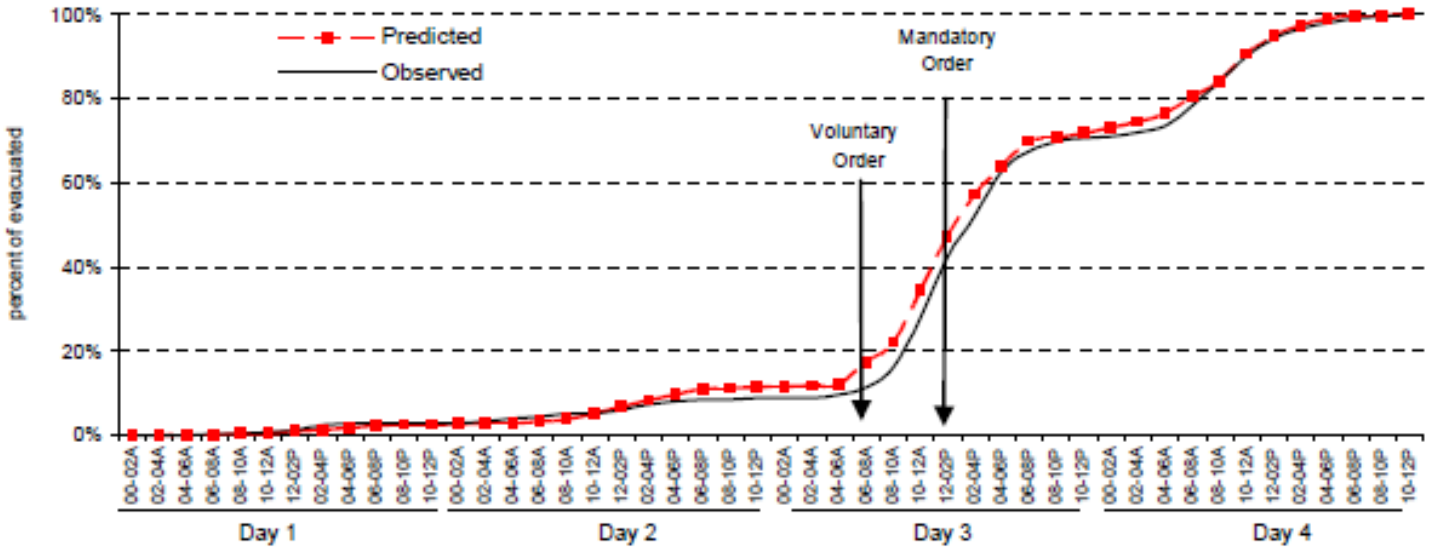
- Several critical breakthroughs have now been researched in both behavioral modeling and simulation modeling regarding evacuation operations.
- Development of flexible plans tied to the ability to accurately generate evacuation then and simulate traffic.
- The combination of these two paradigms into an integrated approach must be tested in order to further study the idea of flexible hurricane response.

Methodology

- Test the use of decision models in simulation context
- Use Household Decision models to predict demand under conditions observed during Hurricane Katrina
- Simulate this demand using existing TRANSIMS simulation model of New Orleans
- Compare results to observed traffic

Evacuation Departure Time

- Based on Logit Model (Fu, Wilmot, and Baker 2006)
- Utility functions include four variables:
  - Time of Day
  - Evacuation Order (Voluntary or Mandatory)
  - Hurricane Wind Speed
  - Time-to-Landfall



Departure Time – Effect of Wind Speed

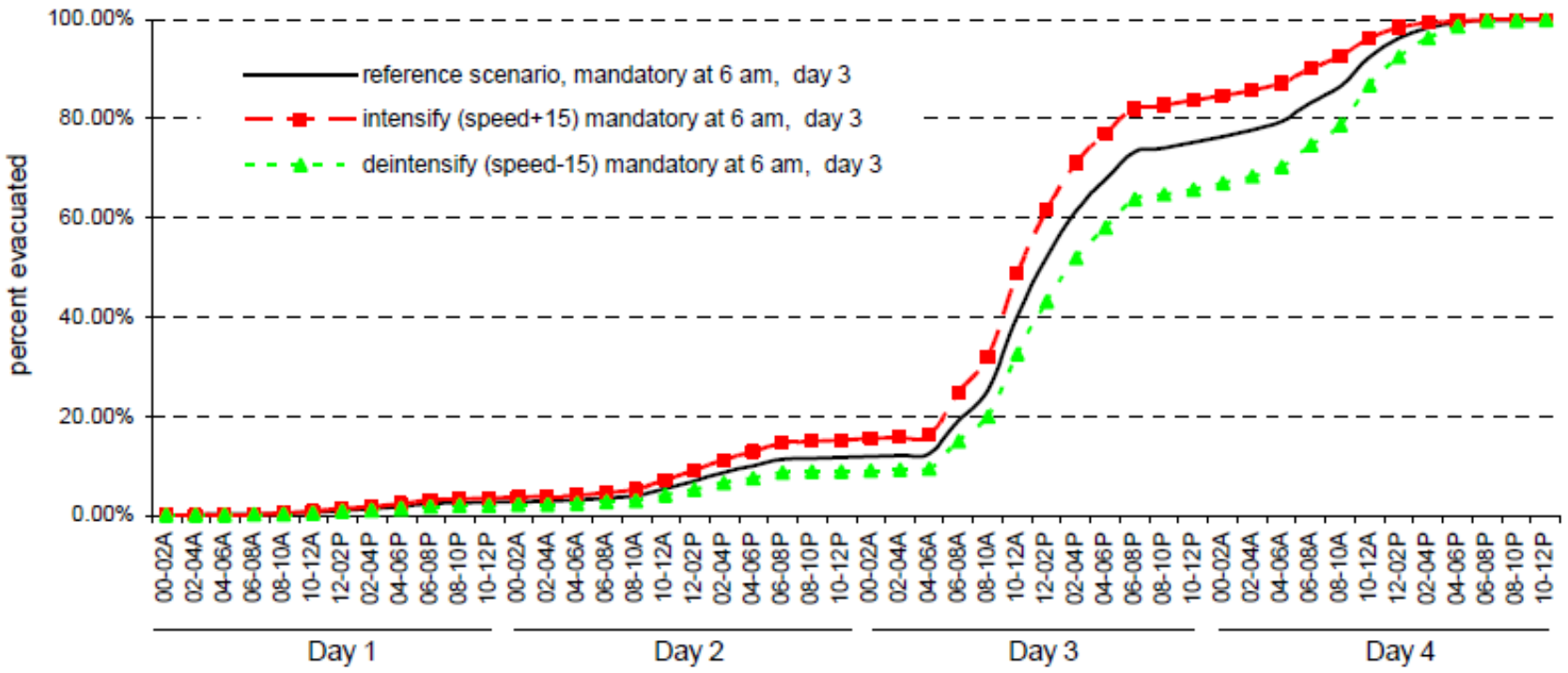


Figure 8 Impact of Wind Speed

Source: Fu, Wilmot, and Baker 2006

Departure Time – Effect of Hurricane Speed

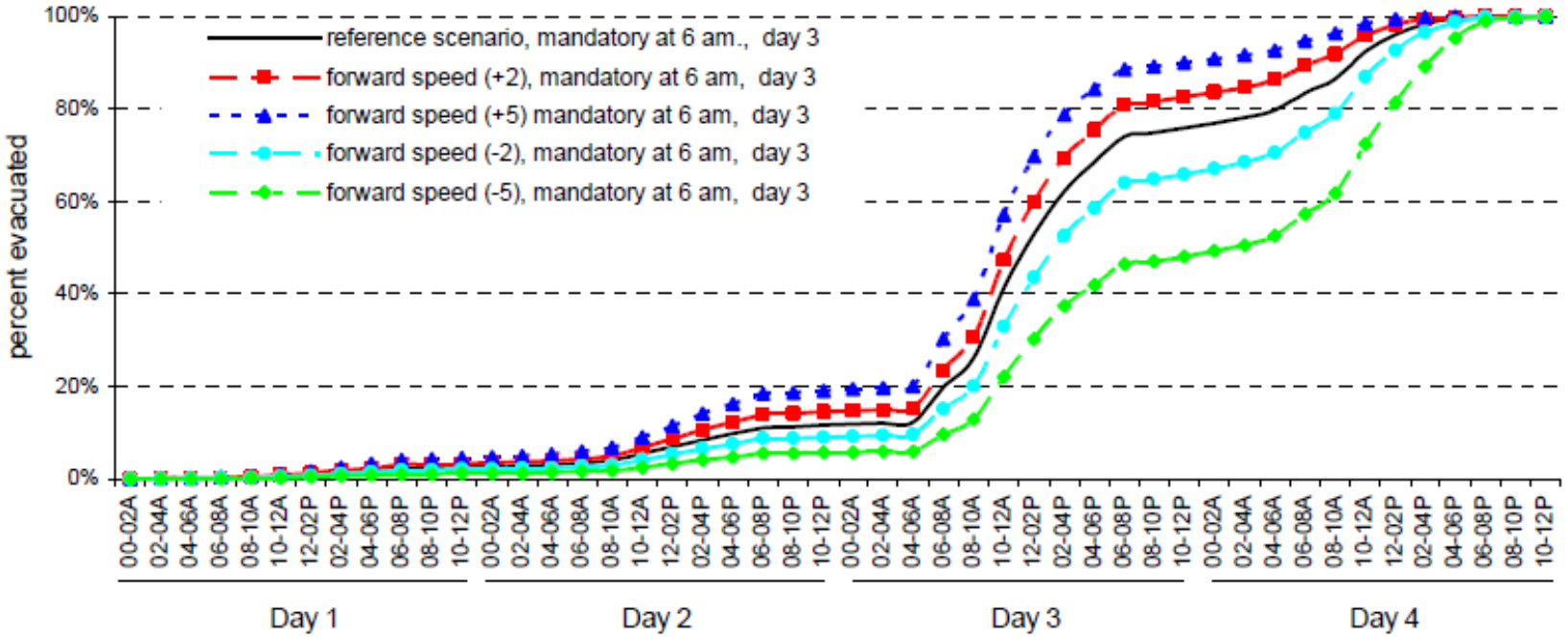


Figure 9 Impact of Hurricane Forward Speed

Source: Fu, Wilmot, and Baker 2006

Departure Time – Proximity of Hurricane Track

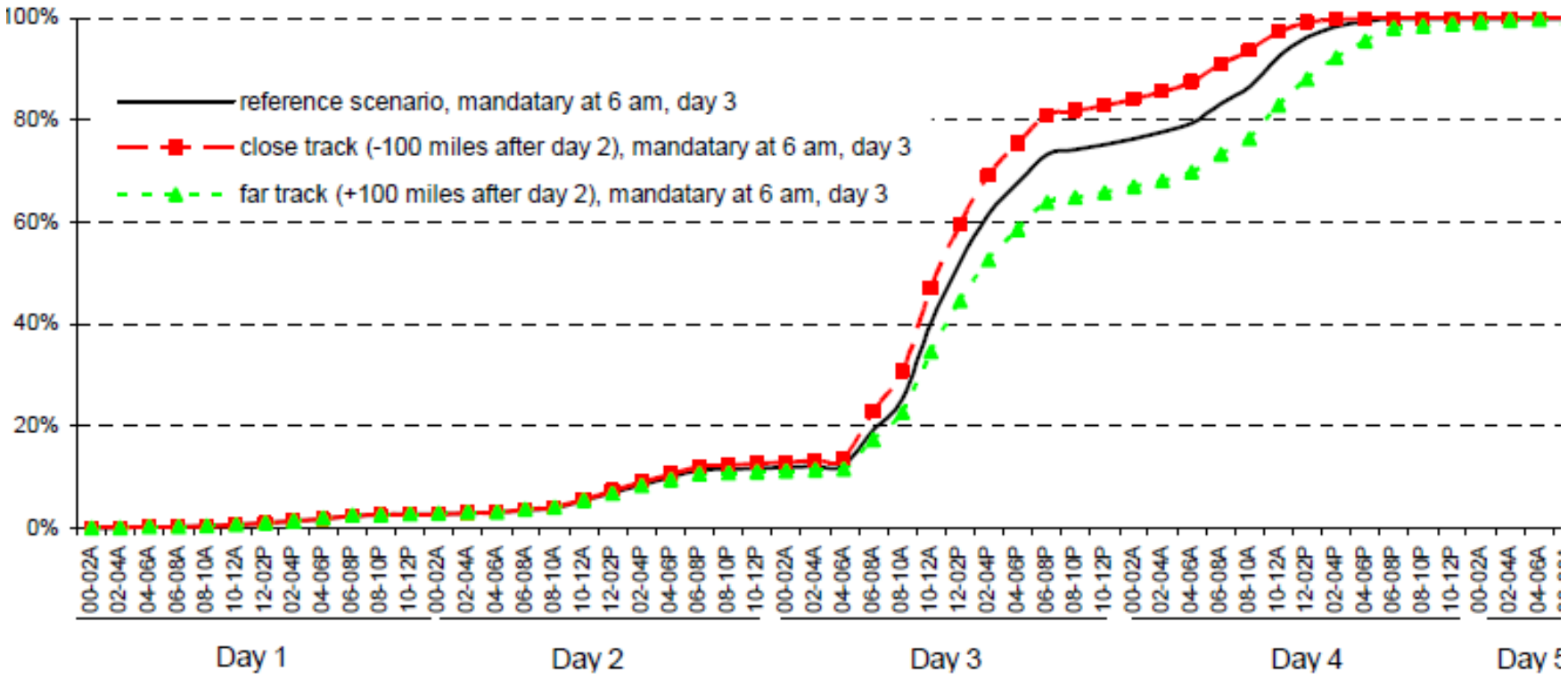


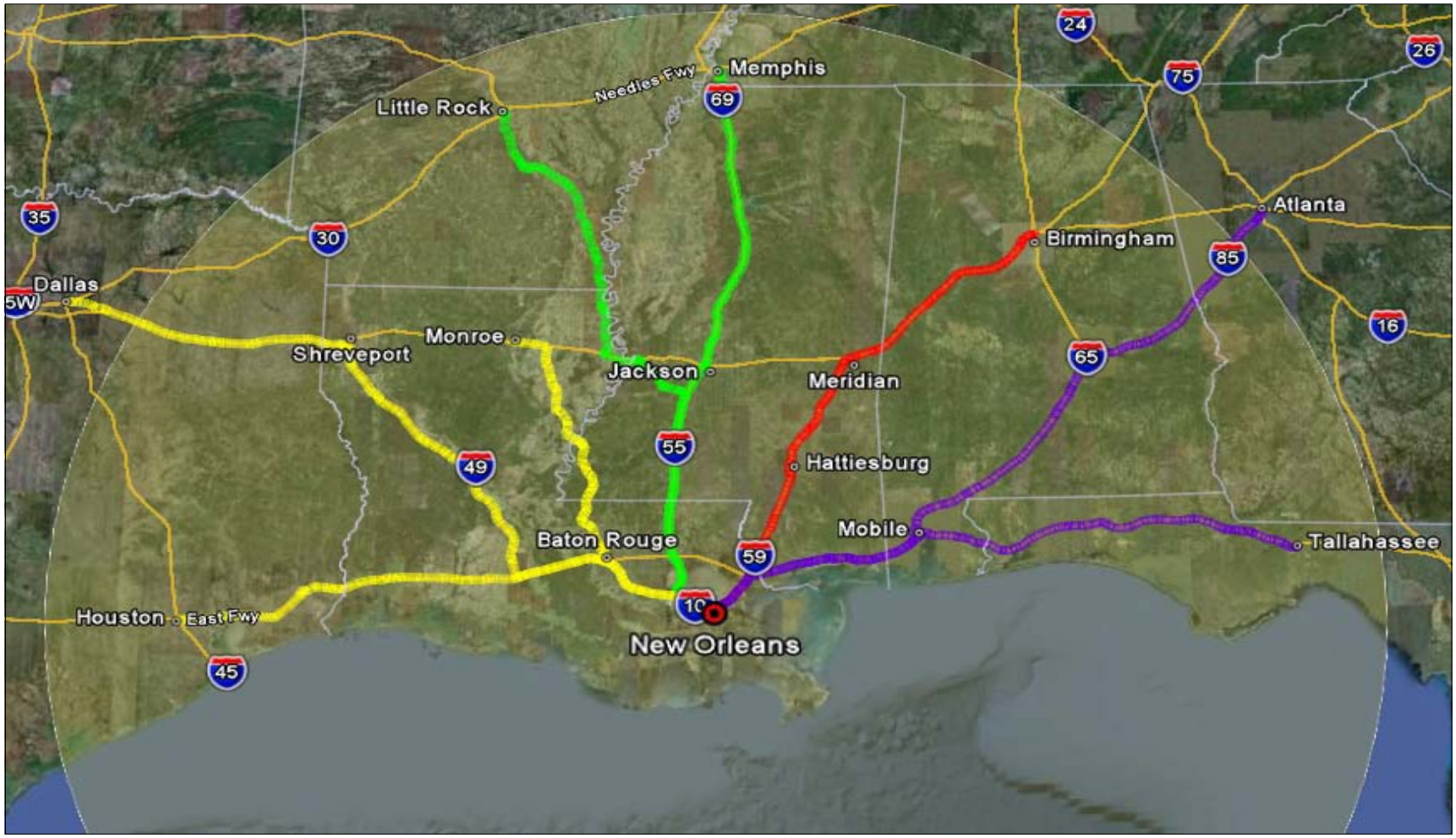
Figure 10 Impact of Hurricane Track Changes

Source: Fu, Wilmot, and Baker 2006

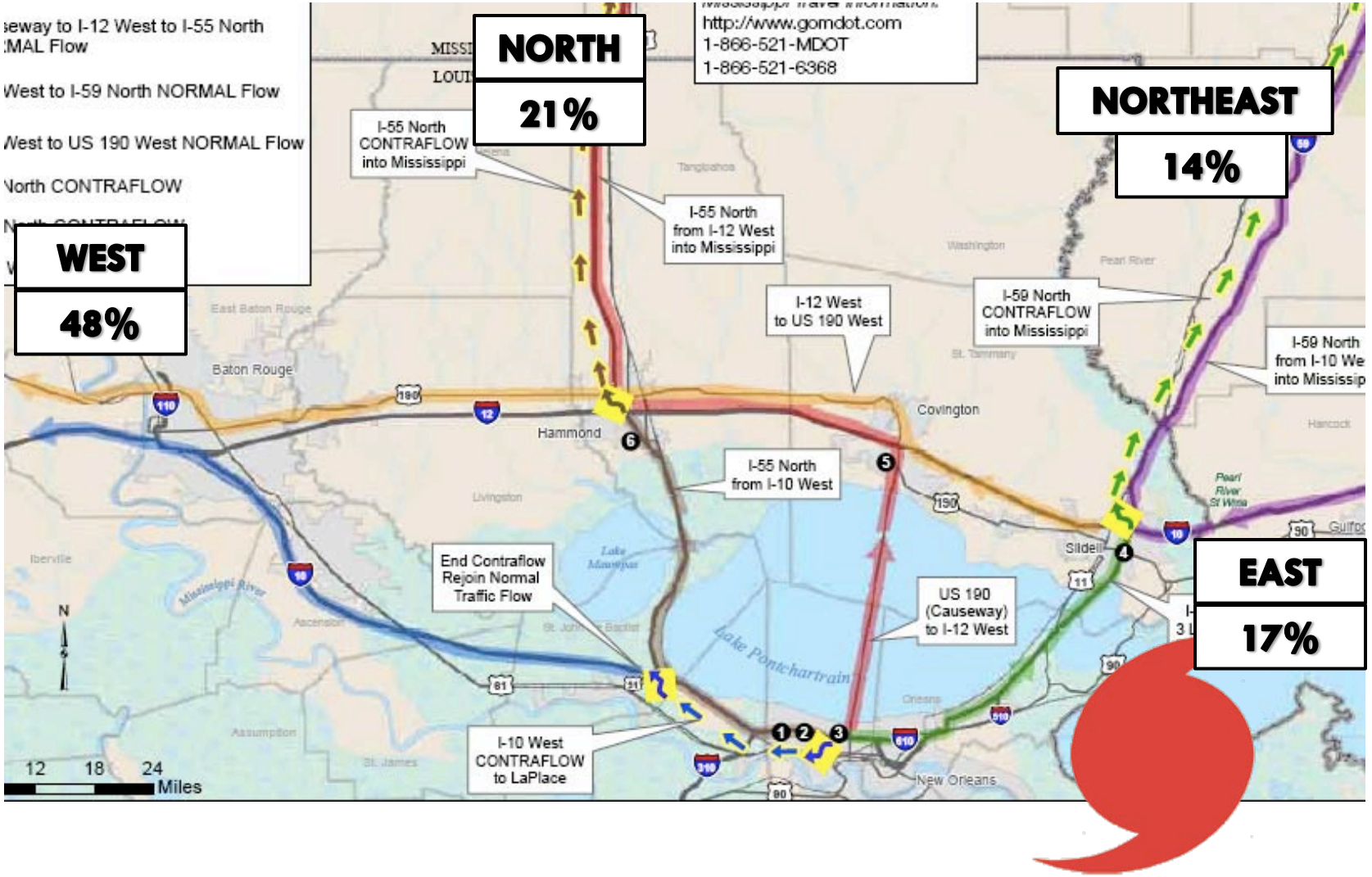
Destination Choice

- Logit Model (Cheng, Wilmot, Baker 2008)
- Assigns each destination a probability based on
  - Distance from origin
  - Safety from Storm (Wind)
  - Population Size
  - Ethnicity Proportions
- 14 destination cities selected
  based on 400 mile likely drivable radius

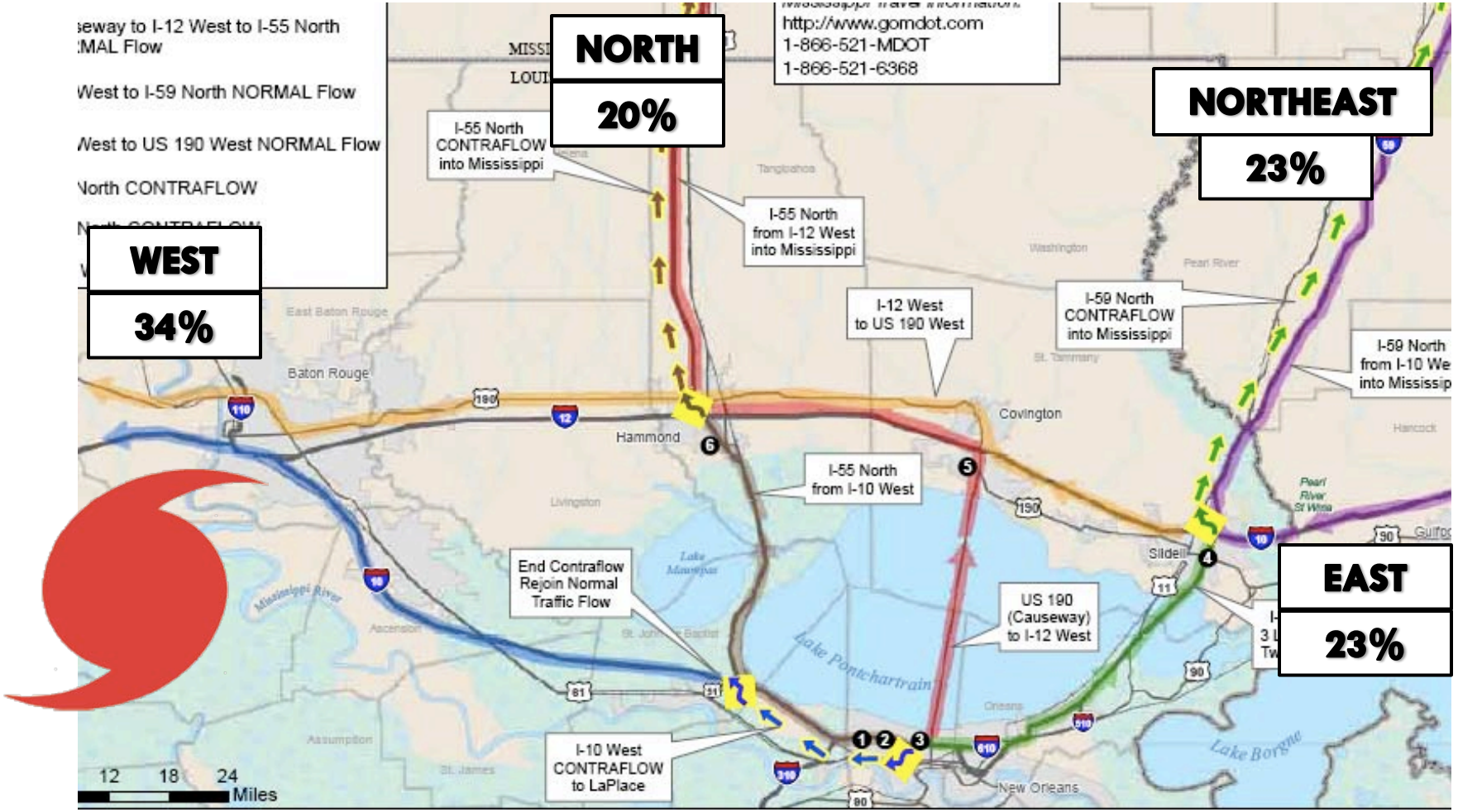
Likely Routes and Destinations



Storm Landing East

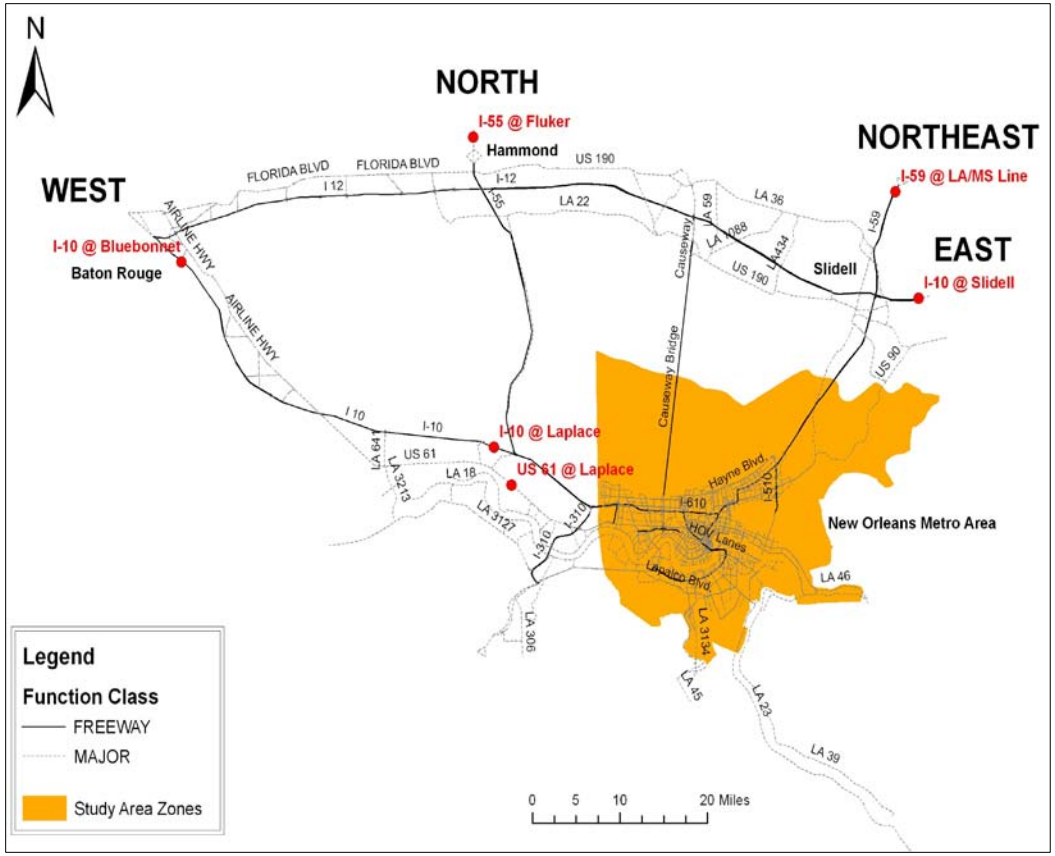


Storm Landing West



Dynamic Transportation Model

- TRANSIMS platform used to simulate evacuation demand generated
- Based model for New Orleans evacuation created previously
- Observed traffic count stations (in red) in operation during Hurricane Katrina used for comparison



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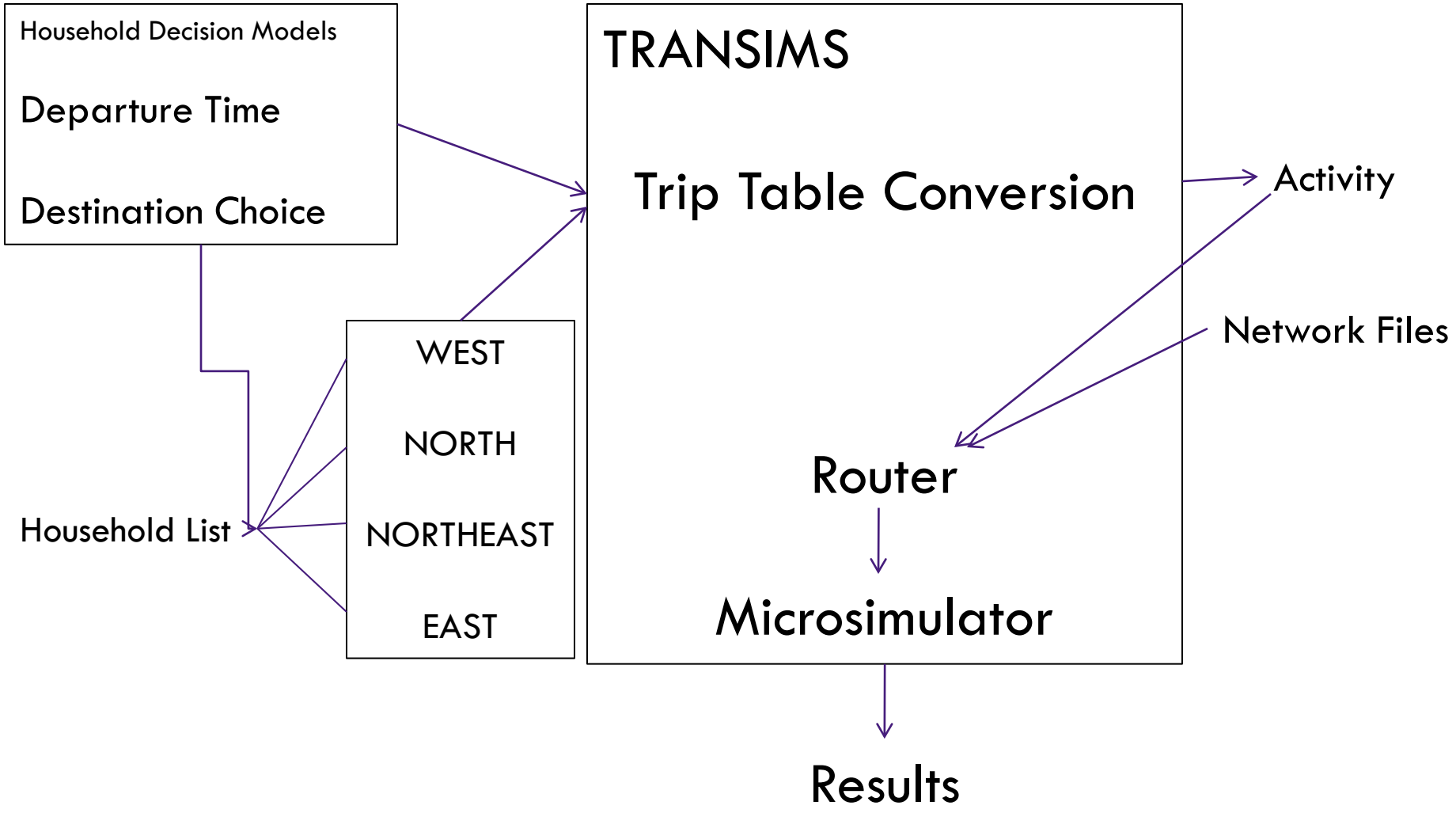
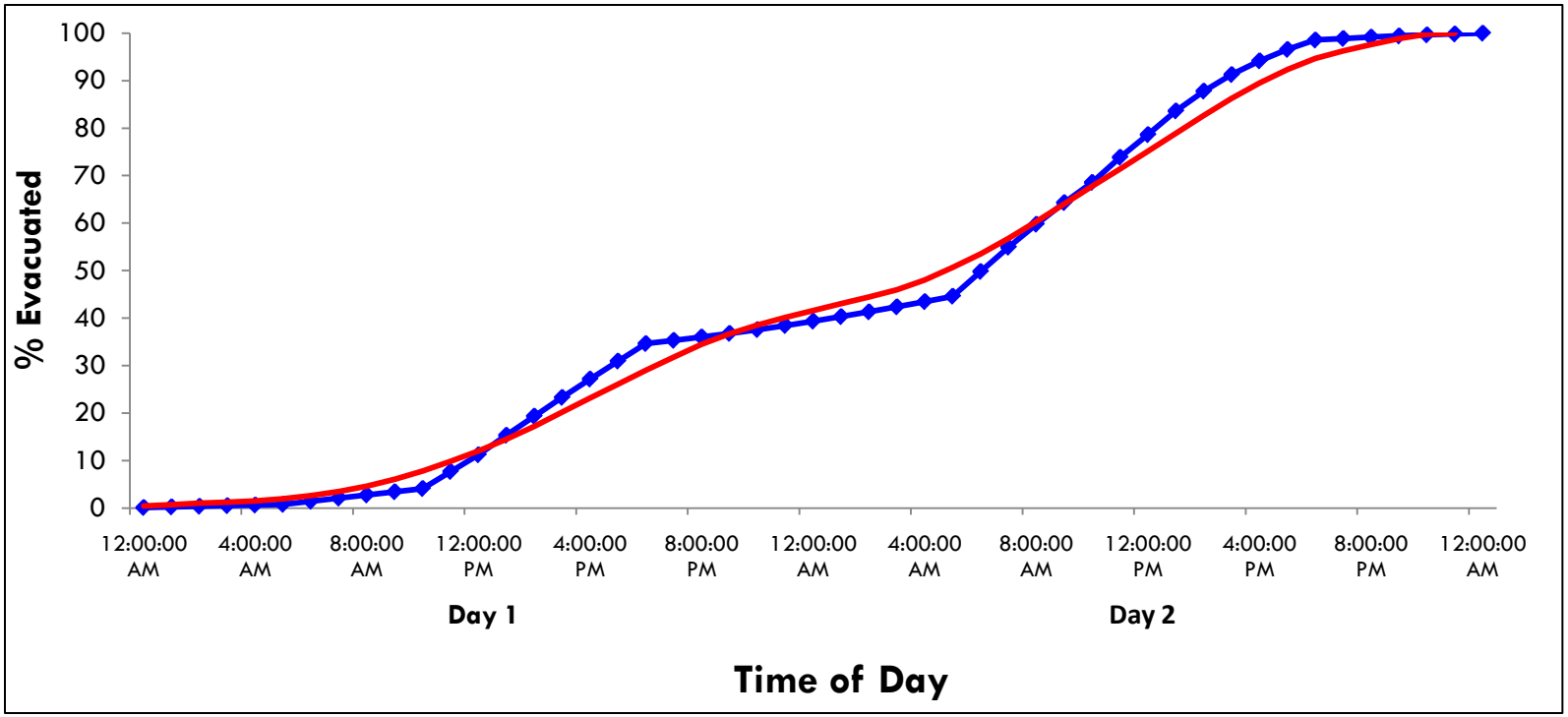
Combined Model Process



Results – Departure Time



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Results – Destination Choice

			Probability	
Destination	City	Utility	Predicted	Observed
WEST:	Baton Rouge	0.9899	0.4565	0.4427
	Houston	0.5801		
	Shreveport	0.4385		
	Monroe	0.5565		
	Dallas	-0.1915		
NORTH:	Jackson, MS	0.9037	0.2389	0.2671
	Memphis	0.0303		
	Little Rock, AK	0.0006		
NORTHEAST:	Hattiesburg	-0.6850	0.1186	0.1590
	Meridian	-0.6198		
	Birmingham	0.1749		
EAST:	Mobile	0.7193	0.1860	0.1312
	Atlanta	-0.3411		
	Tallahassee	-0.3021		

*Observed based on count stations recording during Katrina Evacuation

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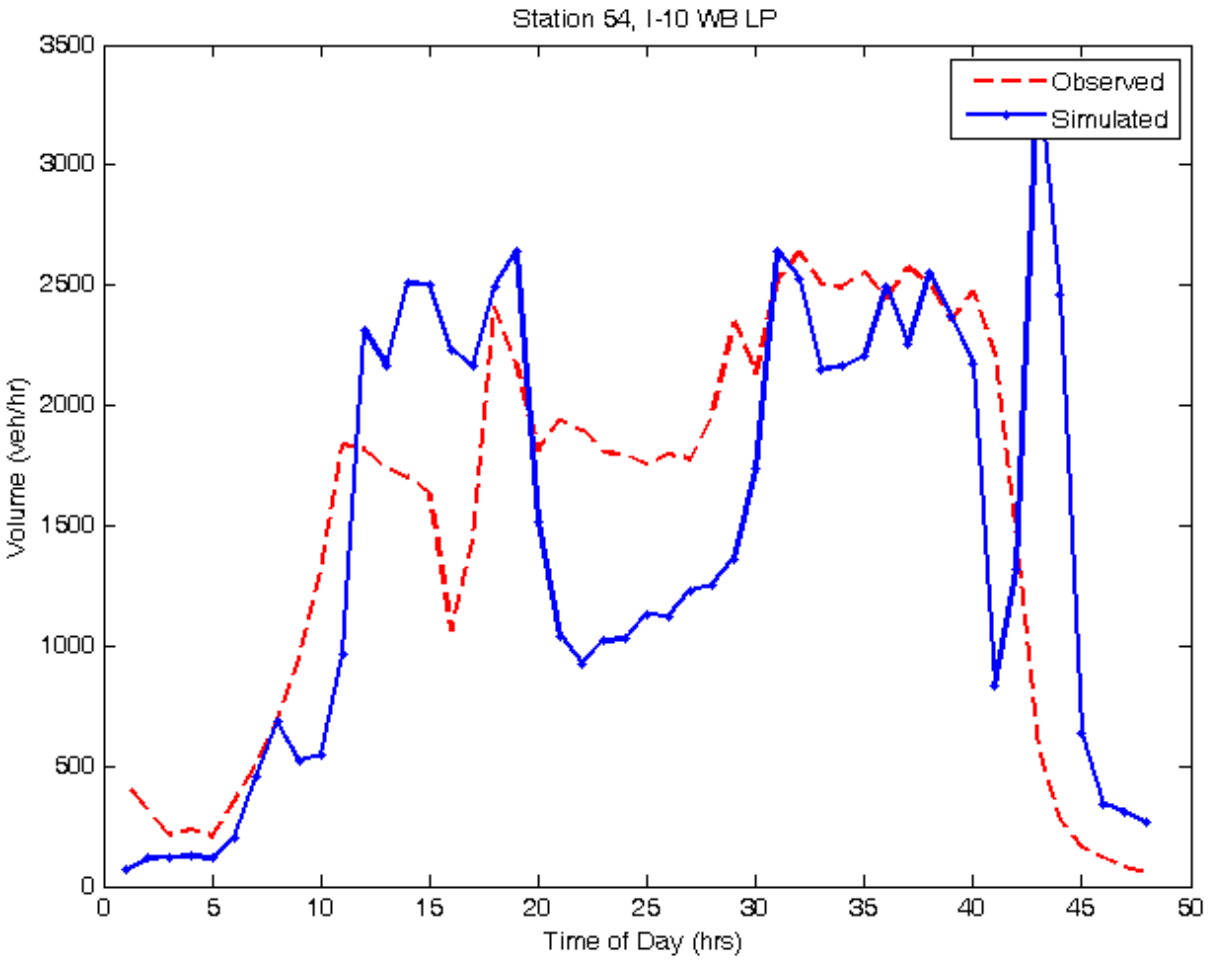
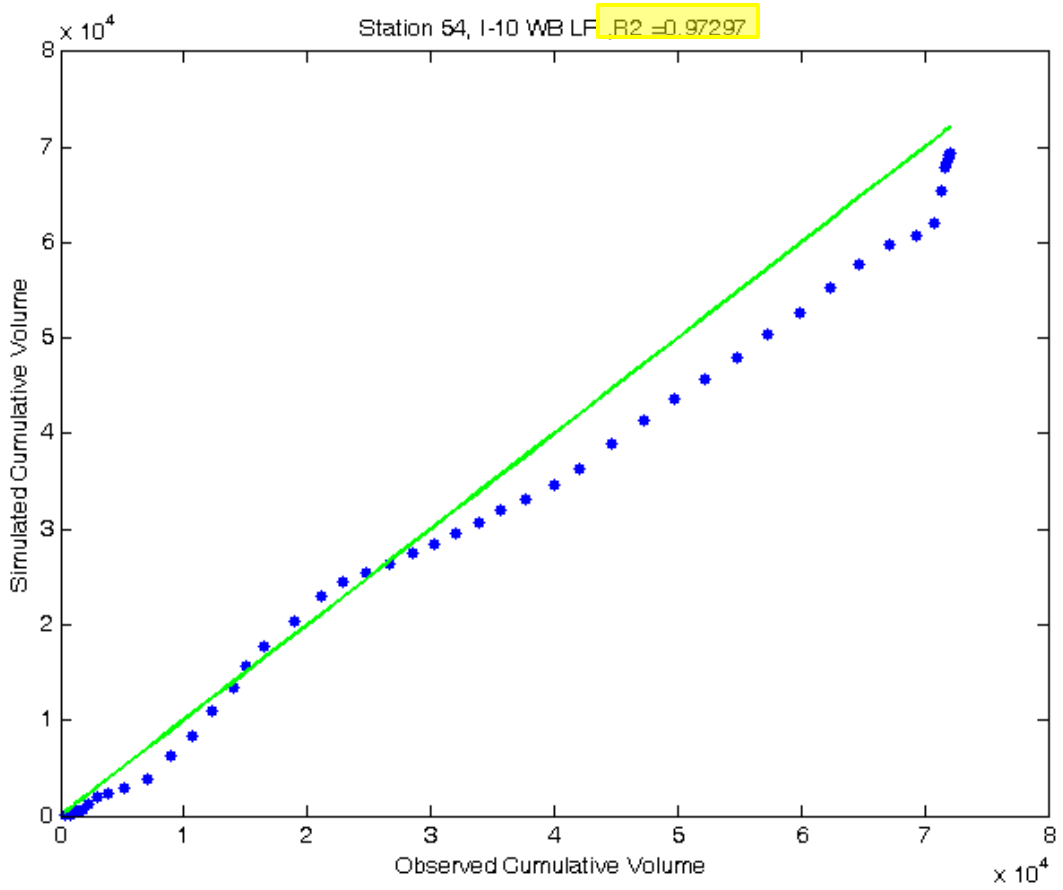
Results – Simulation Model



Qualitative Time-Series Analysis

Results – Simulation Model

- Used for model comparison



Cumulative Volume R^2 Fit Analysis

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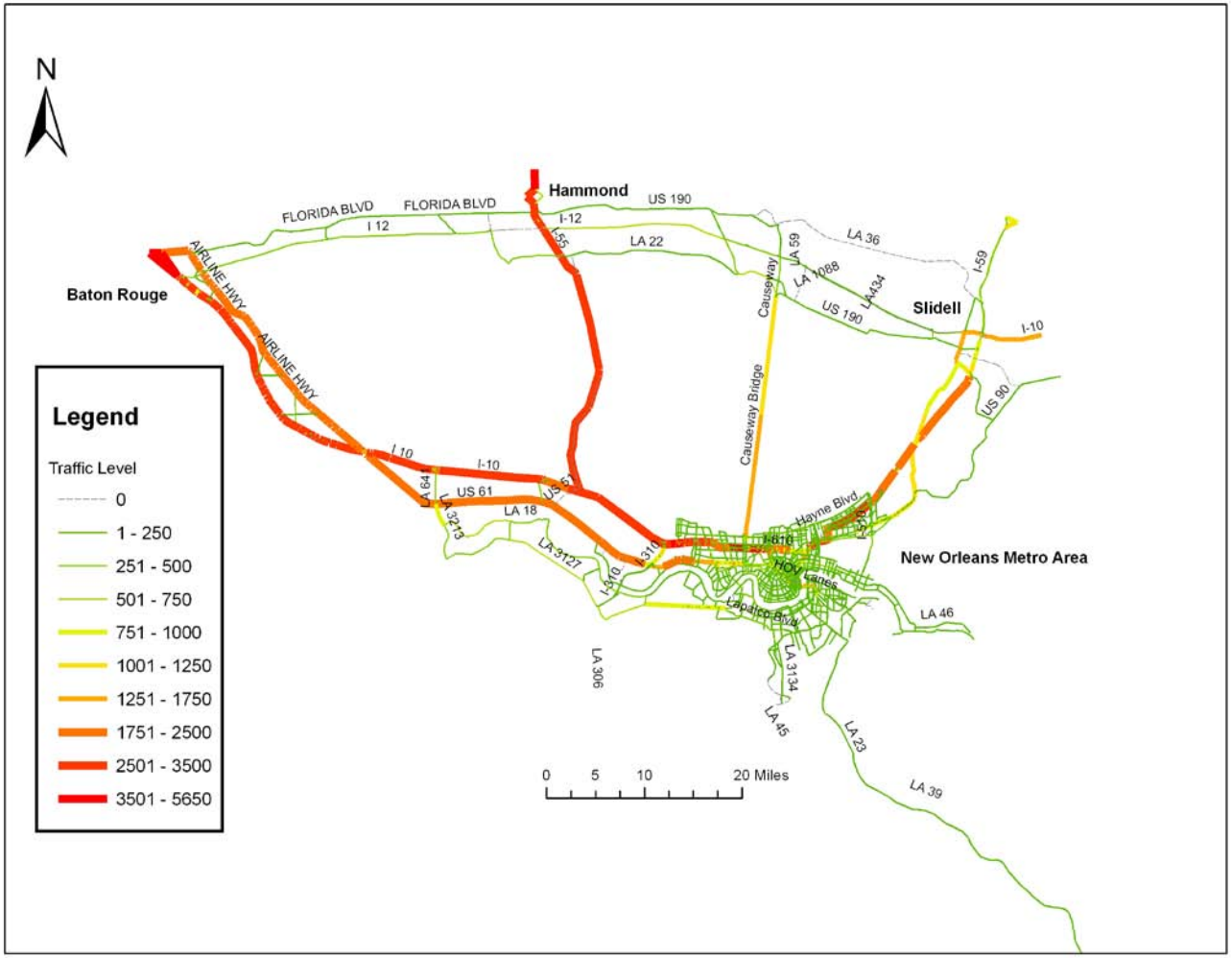
Results – Simulation Model

R^2 Results at each station

Count Station	Location	R^2 Value
27	NB US 61 Laplace	0.90
67	EB I-10 Slidell	0.93
15	NB I-55 Hammond	0.69
15	SB I-55 Hammond (Contraflow)	0.64
54	WB I-10 Laplace	0.97
79	WB I-10 Bluebonnet	0.82
MDOT Station	NB I-59 LA/MS Line	0.74
MDOT Station	SB I-59 LA/MS Line (Contraflow)	0.67

Traffic Volume Picture



*for Simulation Hour with most vehicles on the network

Conclusions

- Logit models and corresponding simulation yielded results essentially accurate from the evacuation planning perspective
- Proposed methodology able to fairly accurately predict evacuation traffic observed during Hurricane Katrina
- Methodology has potential to be utilized to predict evacuation operations under different storm scenarios and evacuation orders
- Method useful toward simulating Dynamic Hurricane Response

Acknowledge

- Work funded by DHS through DIEM COE
- Also funded by grant from U.S. DOT

- Questions?

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