

# Evacuation Time Estimates

**IMUG Meeting  
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- **ETEs** are analyses of the time required to evacuate various sectors and distances within the plume exposure pathway emergency planning zone (EPZ).



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# ETE Study

Applied research study to examine topics associated with the modeling and simulation of evacuations and independent verification of the NRC's methodology for ETE development.

## Study Areas

- Shadow evacuation analysis
- Distance of evacuation travel
- Manual traffic control
- Determination of variable importance

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# ETE Study

## Who is Performing the Study?

- Transportation and evacuation experts at Louisiana State University

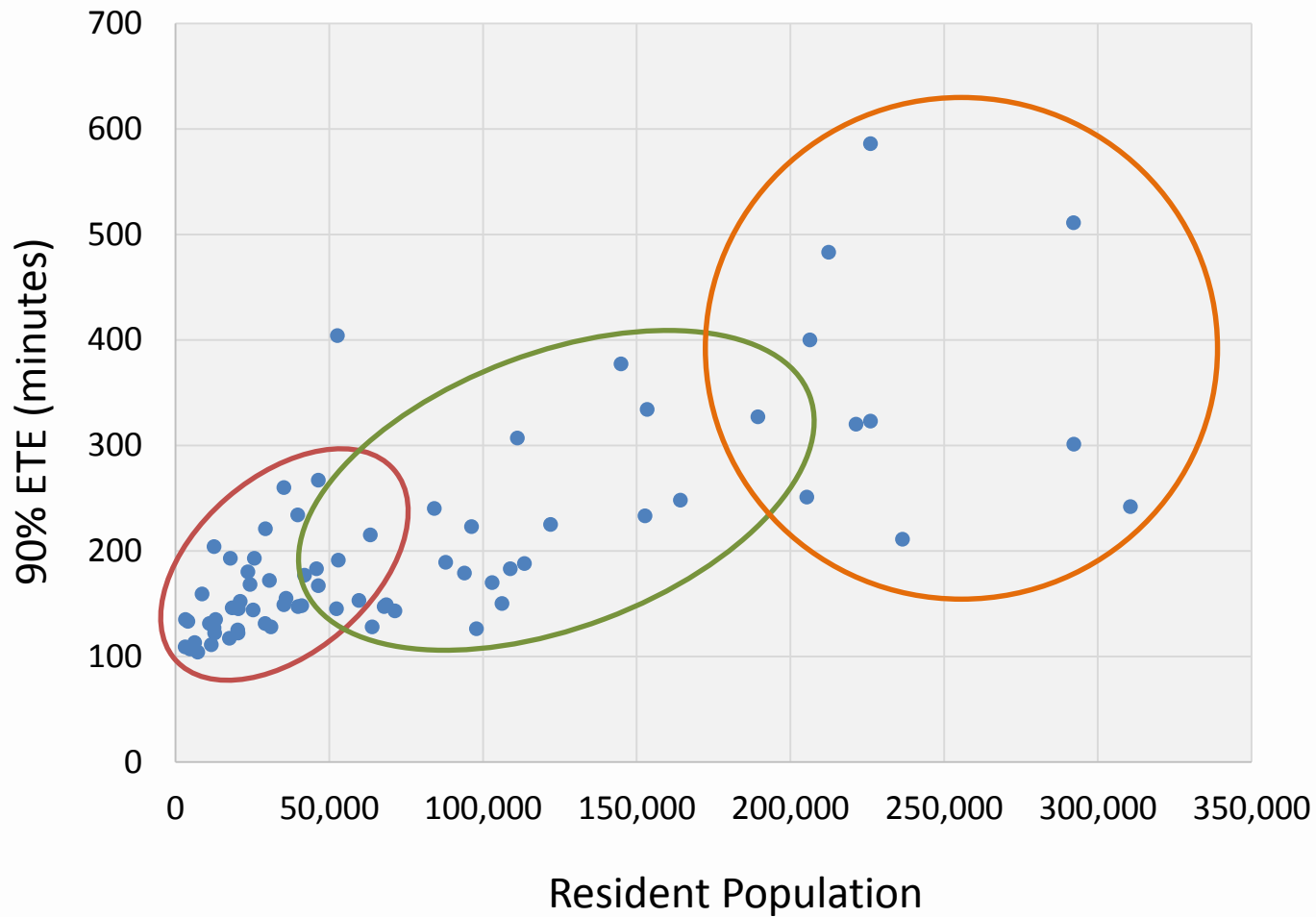
## Timeline

- 3 year study (August 2015 – August 2018)

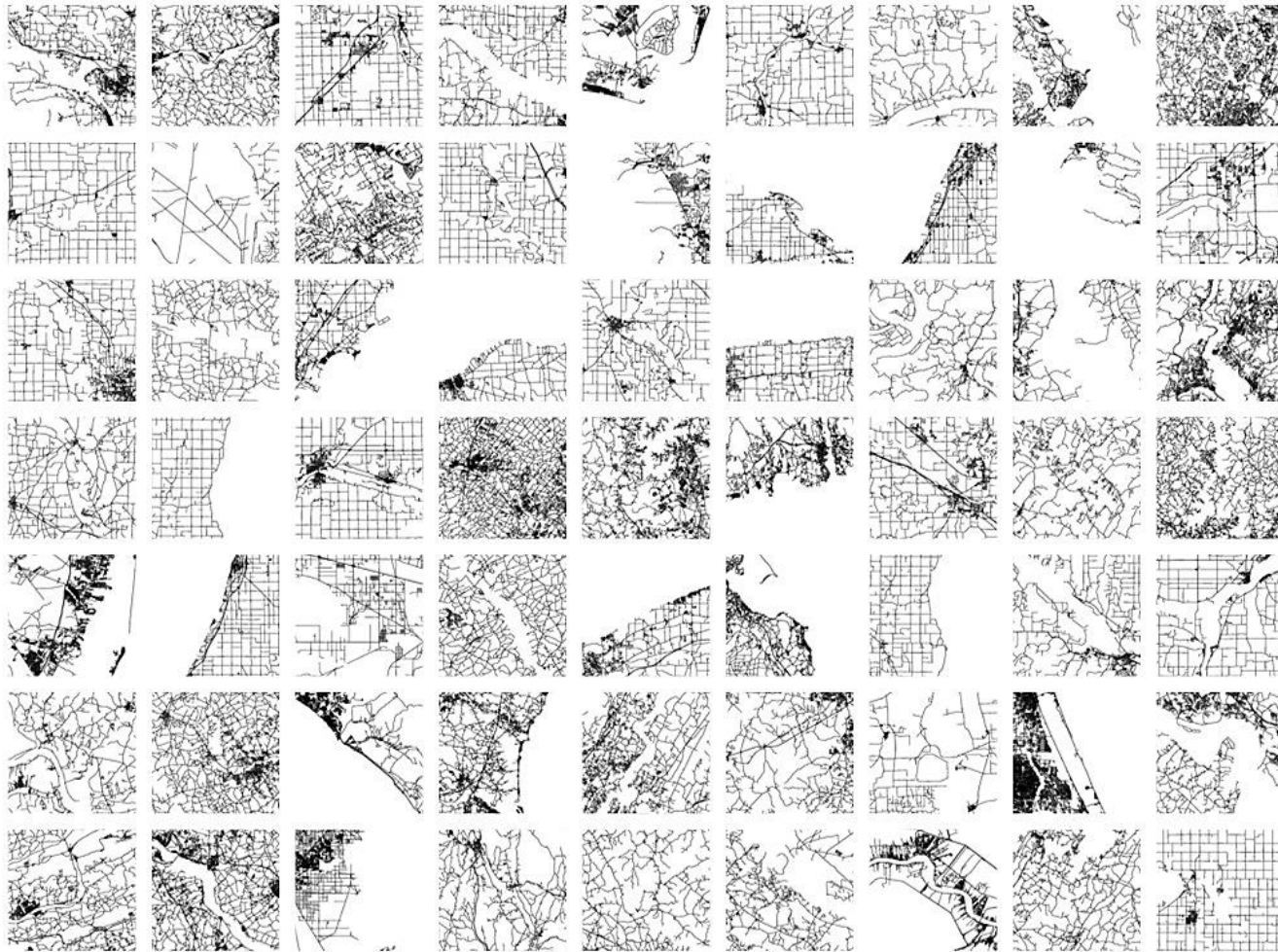
## Methodology

- Model 3 representative sites (small, medium, large population and representative roadway networks)
- Develop micro-simulation models using commercial software
- Produce generalized results that reveal effects of the study variables (impact to clearance times)

# Representative Populations

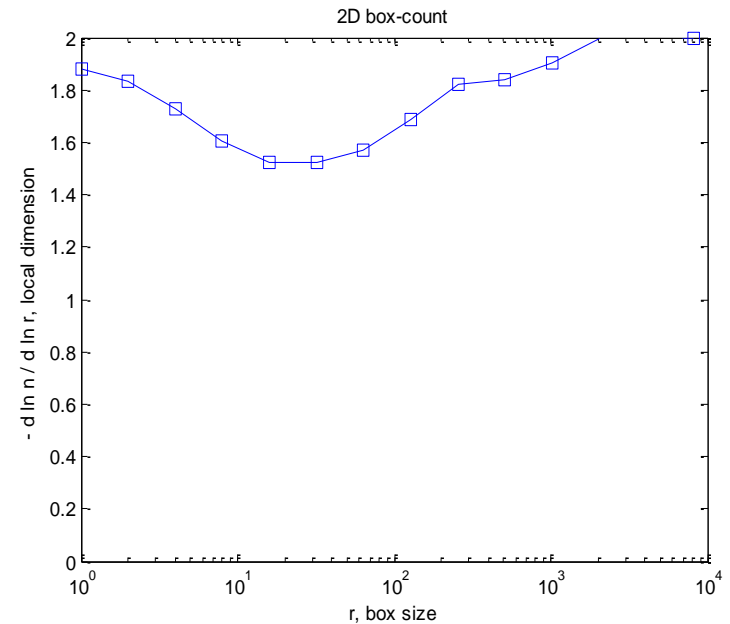


# Representative Roadways?



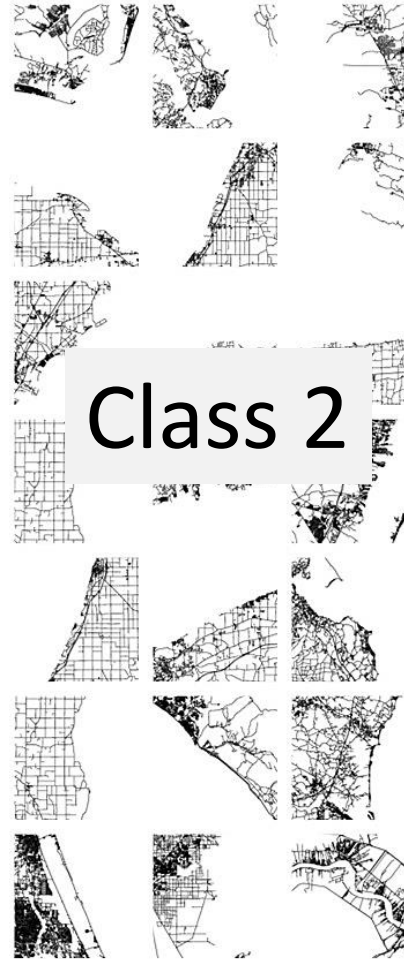
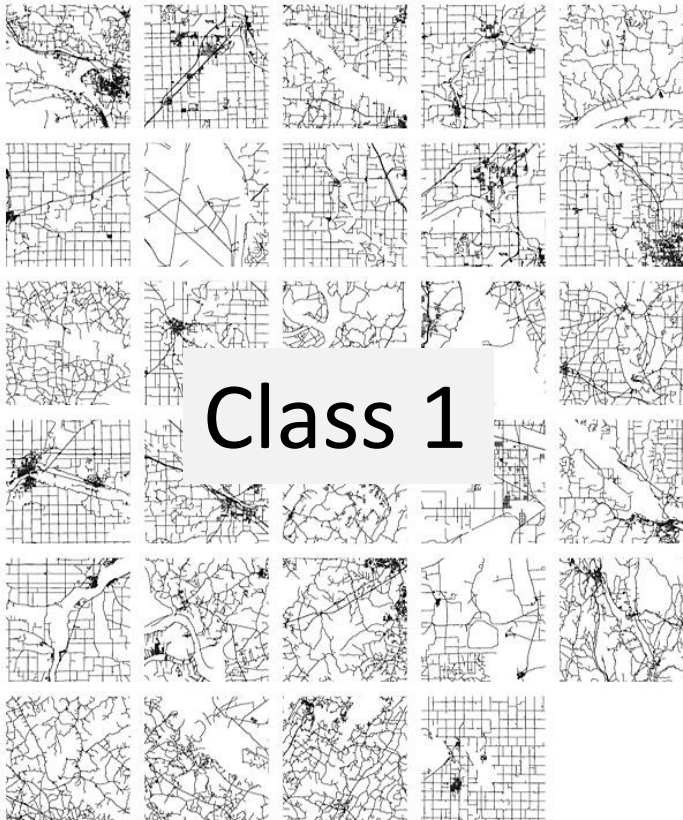


# Fractal Analysis



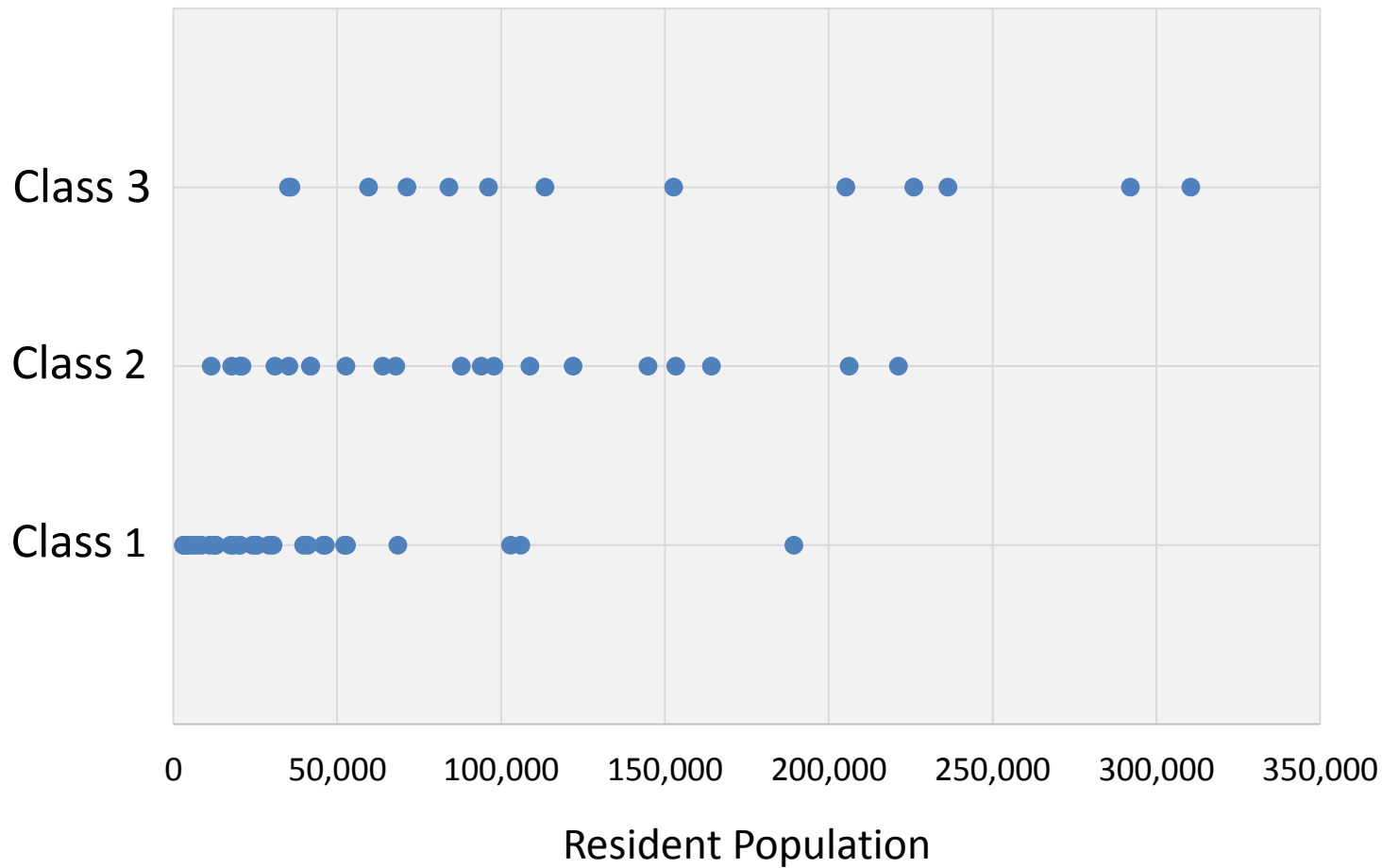
$$D_f = 1.6$$

# Neural Network Classification



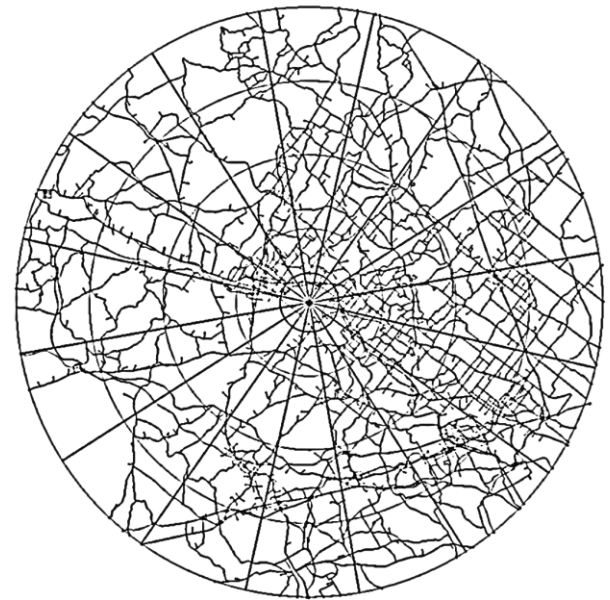
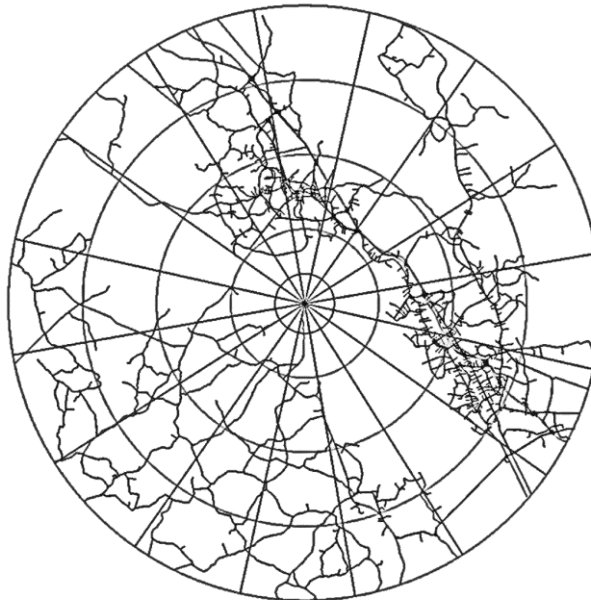
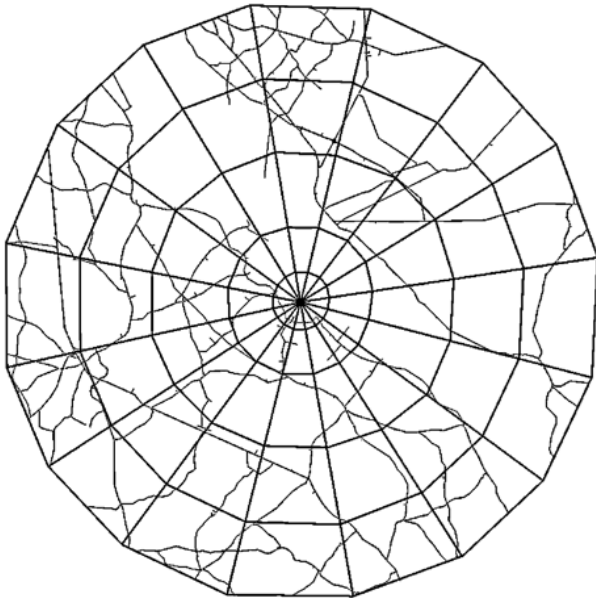


# Representative Networks



# ETE Study

Model Comparison	EPZ POPULATION	MODEL EPZ POPULATION		MODEL STATS		
	0-10 MILE	0-10 MILE	20% SHADOW	INTER-SECTIONS	MILES OF ROAD	LINKS/CONNECTORS
<b>SMALL</b>	0 – 50,000	7500	3000	174	1196	376/863
<b>MEDIUM</b>	50,000 – 200,000	200,000	30,000	449	3313	2645/3846
<b>LARGE</b>	> 200,000	325,000	60,000	974	3712	10605/14719



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# ETE Study

## **Task 1: Impact of Shadow Evacuation**

- Sensitivity of shadow participation rate on clearance times

## **Task 2: Distance of Evacuation Travel**

- Sensitivity of model extent on clearance times
- Assess travel times outside of EPZ

## **Task 3: Manual Traffic Control (MTC)**

- Simulated MTC vs. signalized intersection control

## **Task 4: Parameters of Importance**

- Sensitivity analysis to determine importance of input and process variables to clearance times

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# ETE Study

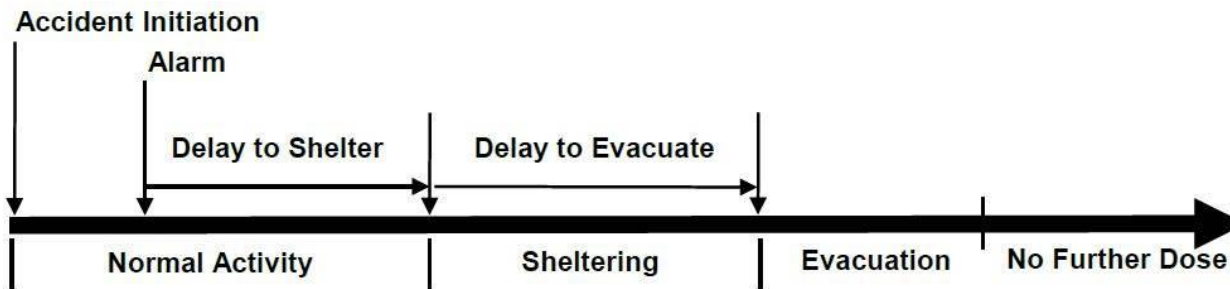
## Benefits of the ETE study

- Independent verification of NRC's methodology (NUREG/CR-7002)
- Technical basis for potential enhancements to guidance document
- Enhance understanding of evacuation dynamics (knowledge management)
- Enhance NRC's regulatory function

# MACCS

## Emergency Phase Modeling

- Protective actions (evacuation, sheltering, relocation, KI)
- Cohort timeline (general population, schools, special facilities, evacuation tail, shadow evacuees, non-evacuees)



## How parameters are informed

- Evacuation time estimate (ETE) studies and traffic simulation codes
- MACCS modeling best practices
- Discussions with state and local authorities



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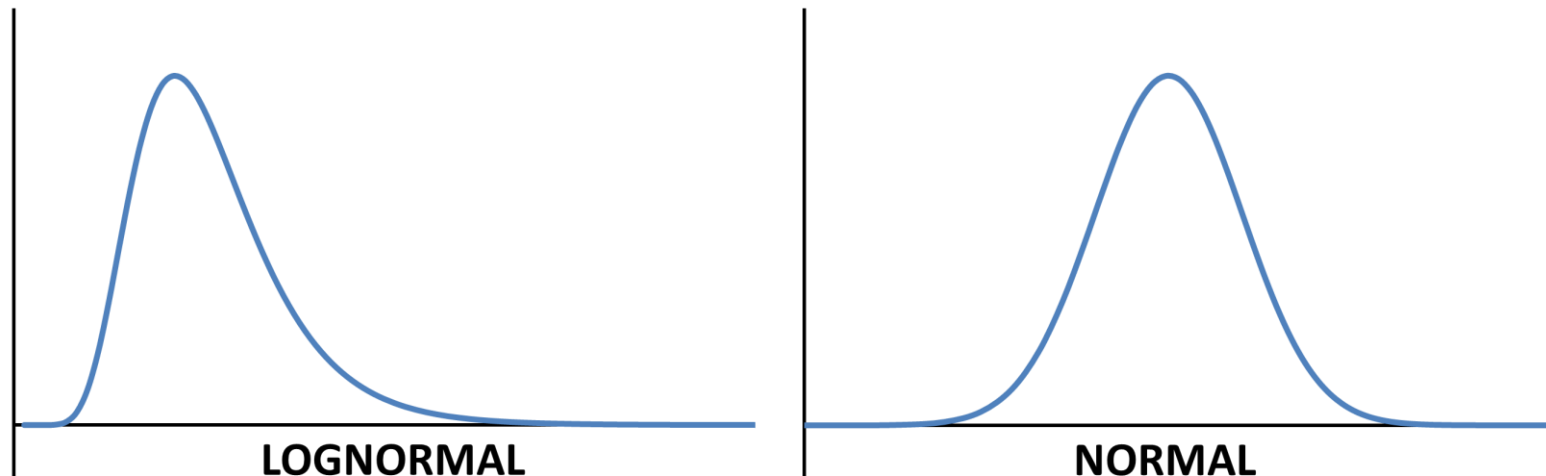
# ETE Guidance

- **NUREG/CR-7002**, “Criteria for Development of Evacuation Time Estimate Studies,” (NRC 2011) provides methodology for developing ETE studies.
  - ETEs are developed for 90% and 100% evacuation.
    - *90% ETEs support protective action decision making.*
  - ETEs submitted to the NRC are reviewed for completeness.
    - *NUREG/CR-7002, Table B-1 ETE Review Criteria Checklist.*
- Completeness review provides verification but not validation.
- Validation of ETEs against real world data is desirable.
  - however, since the accident at Three Mile Island in 1979, there have been no evacuations due to an incident at a nuclear plant in the United States.
- So how can we validate the data and the methodology?

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# Statistical Distributions

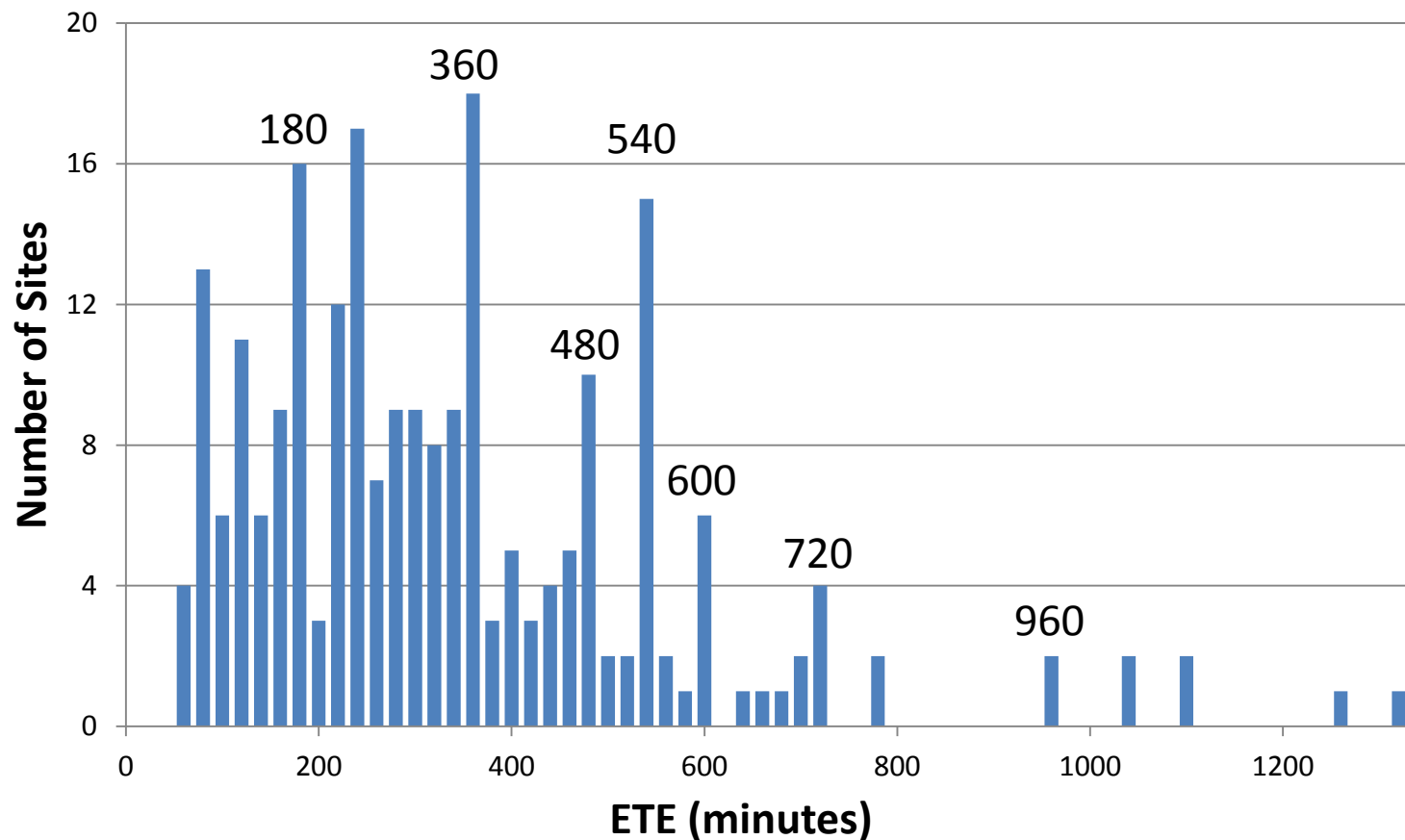
- Mathematically, the process of ***multiplying*** a series of random variables, will produce a new random variable which tends to be lognormal in character.
- Normal statistics arise from ***additive*** variables.



- So what does our ETE data look like?

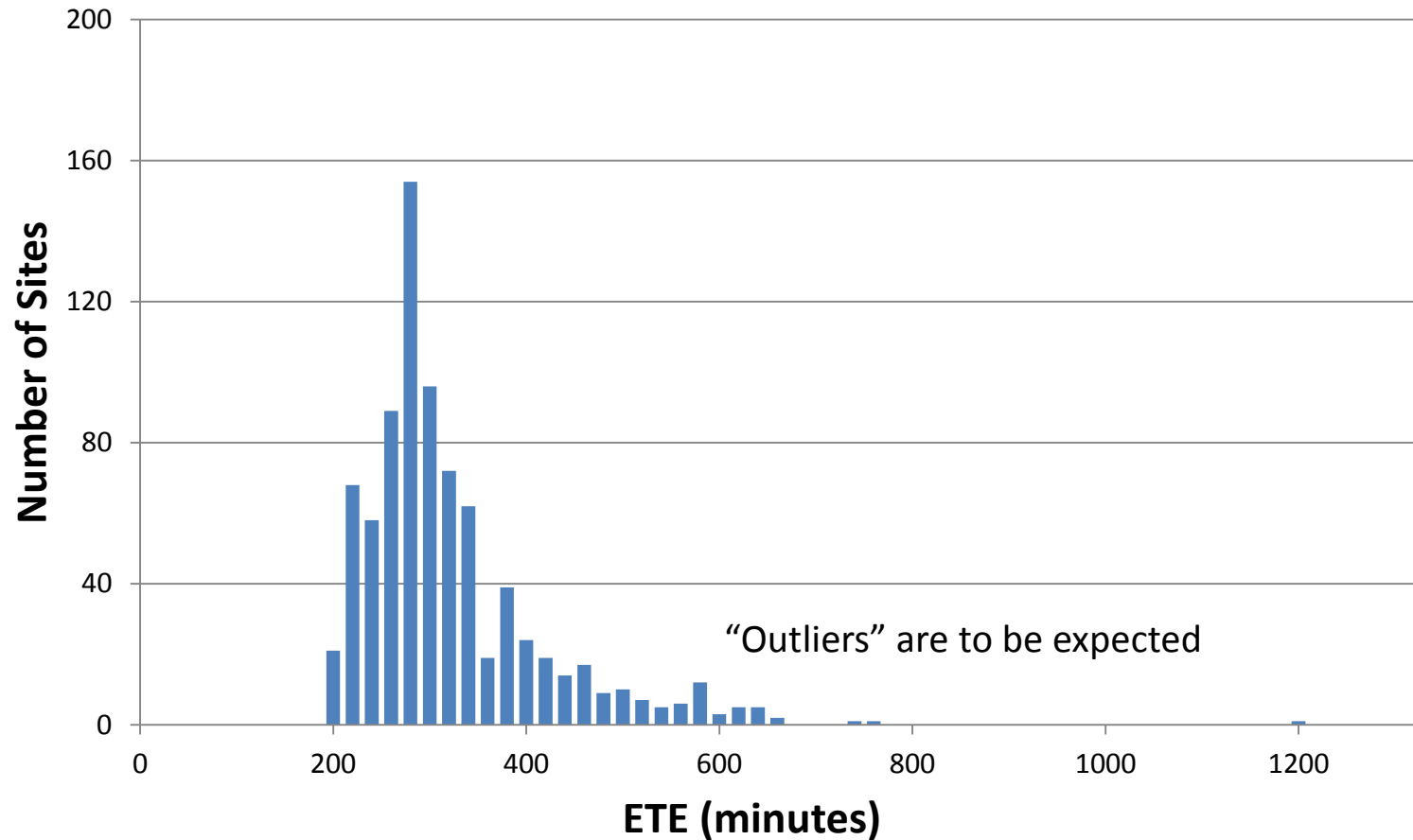
# 1980 ETE Data

## Distribution of 10 Mile 100% ETE Data

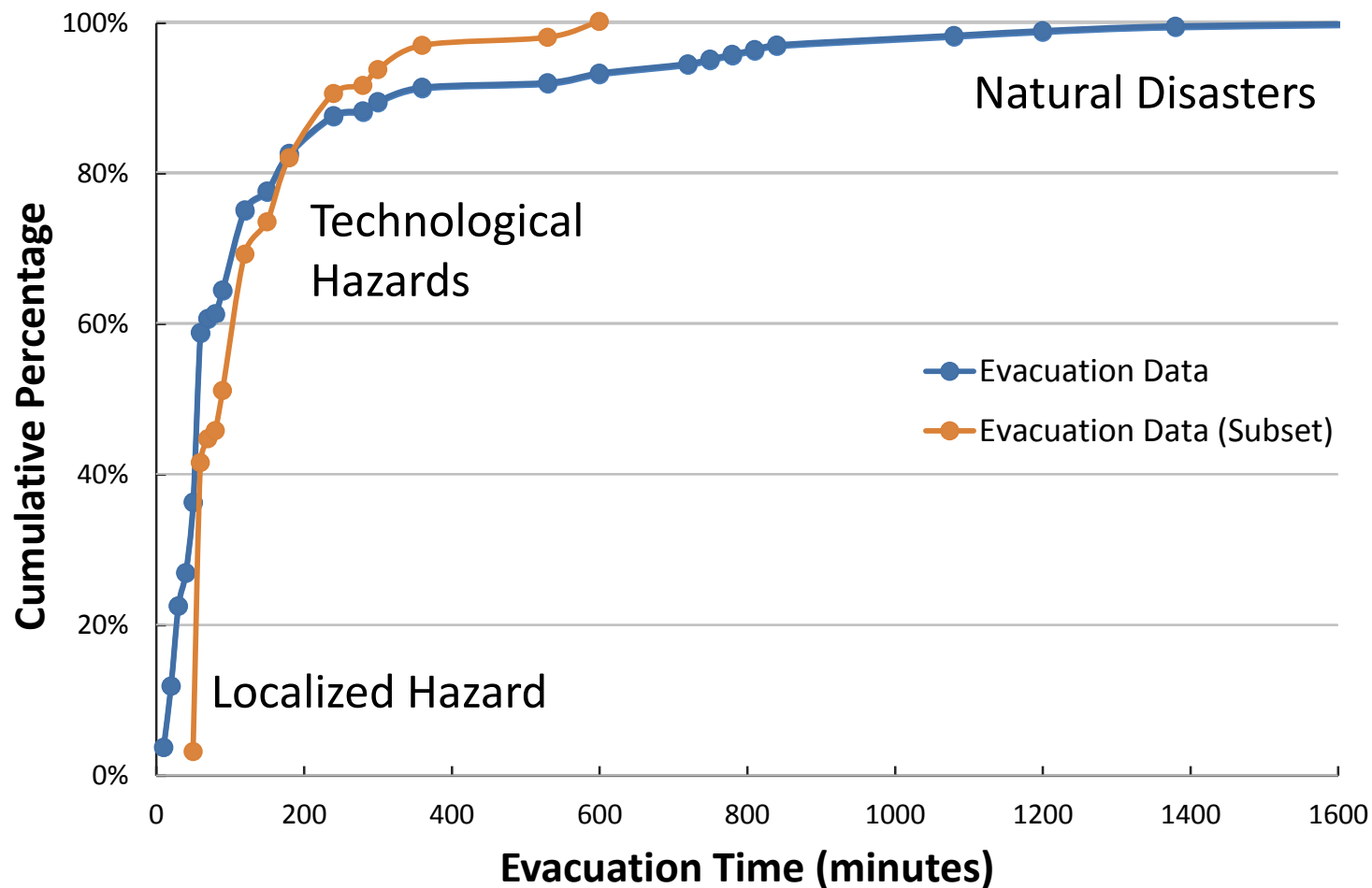


# 2012 ETE Data

## Distribution of 10 Mile 100% ETE Data

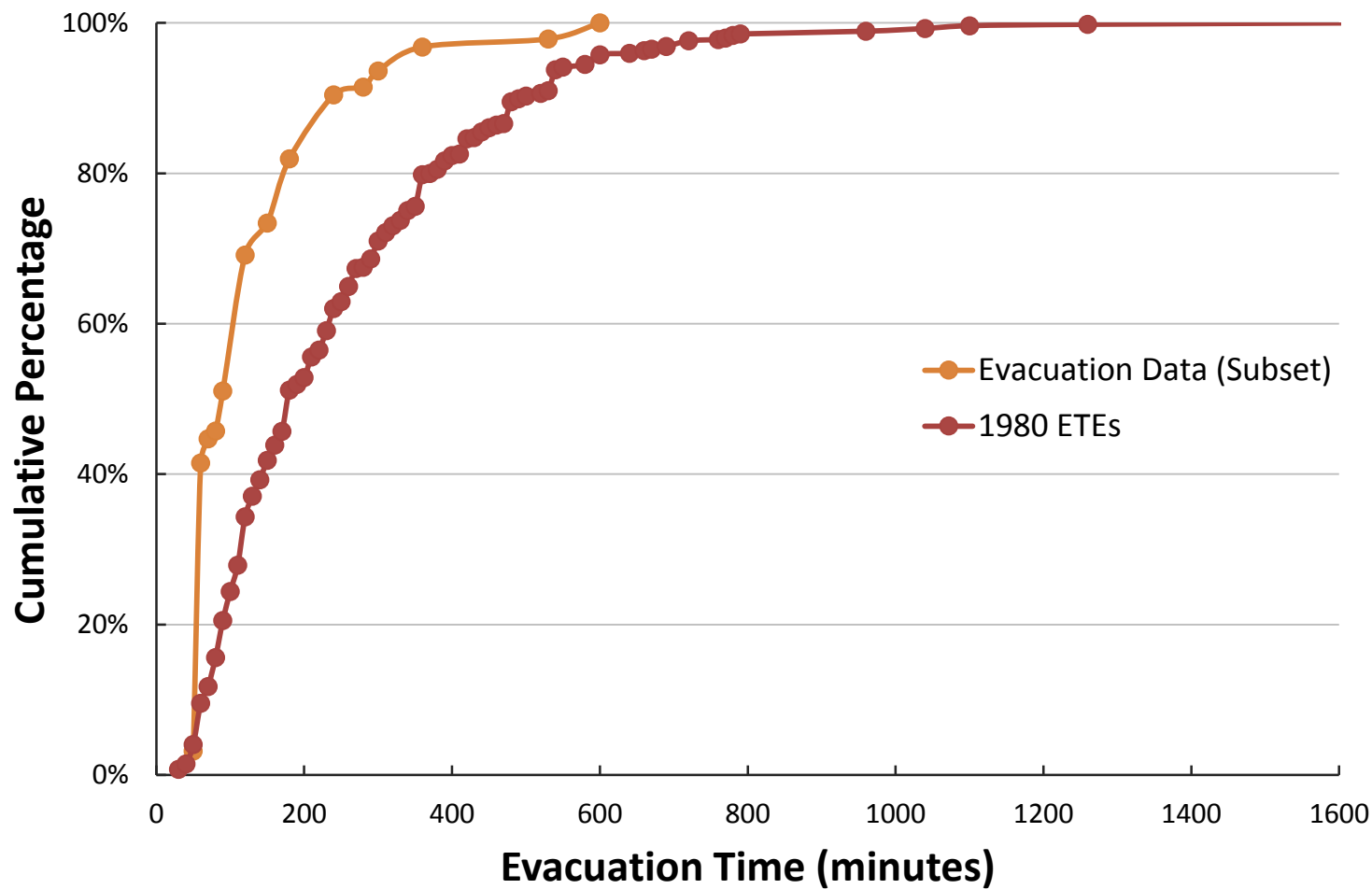


# Evacuation Data

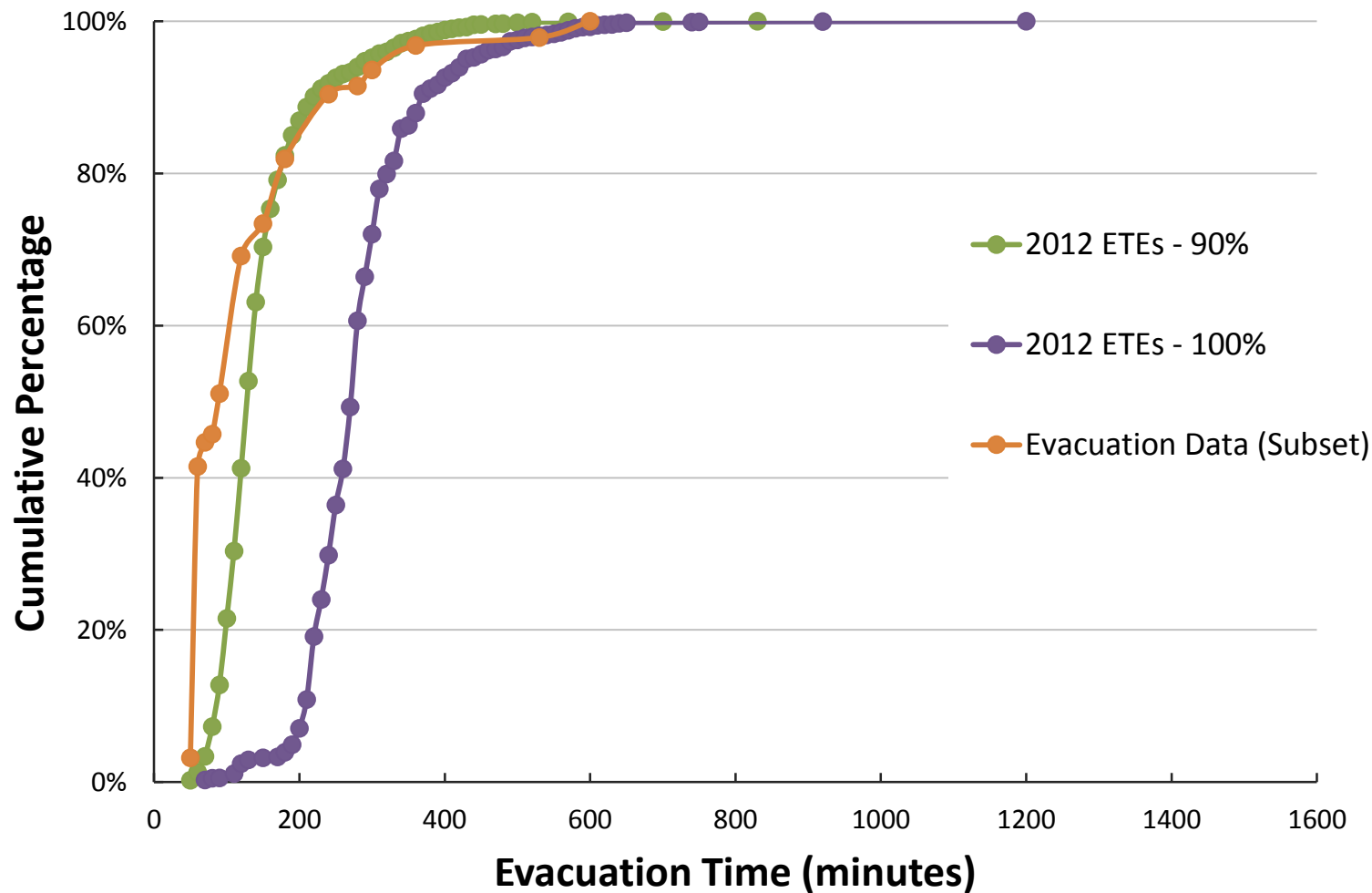




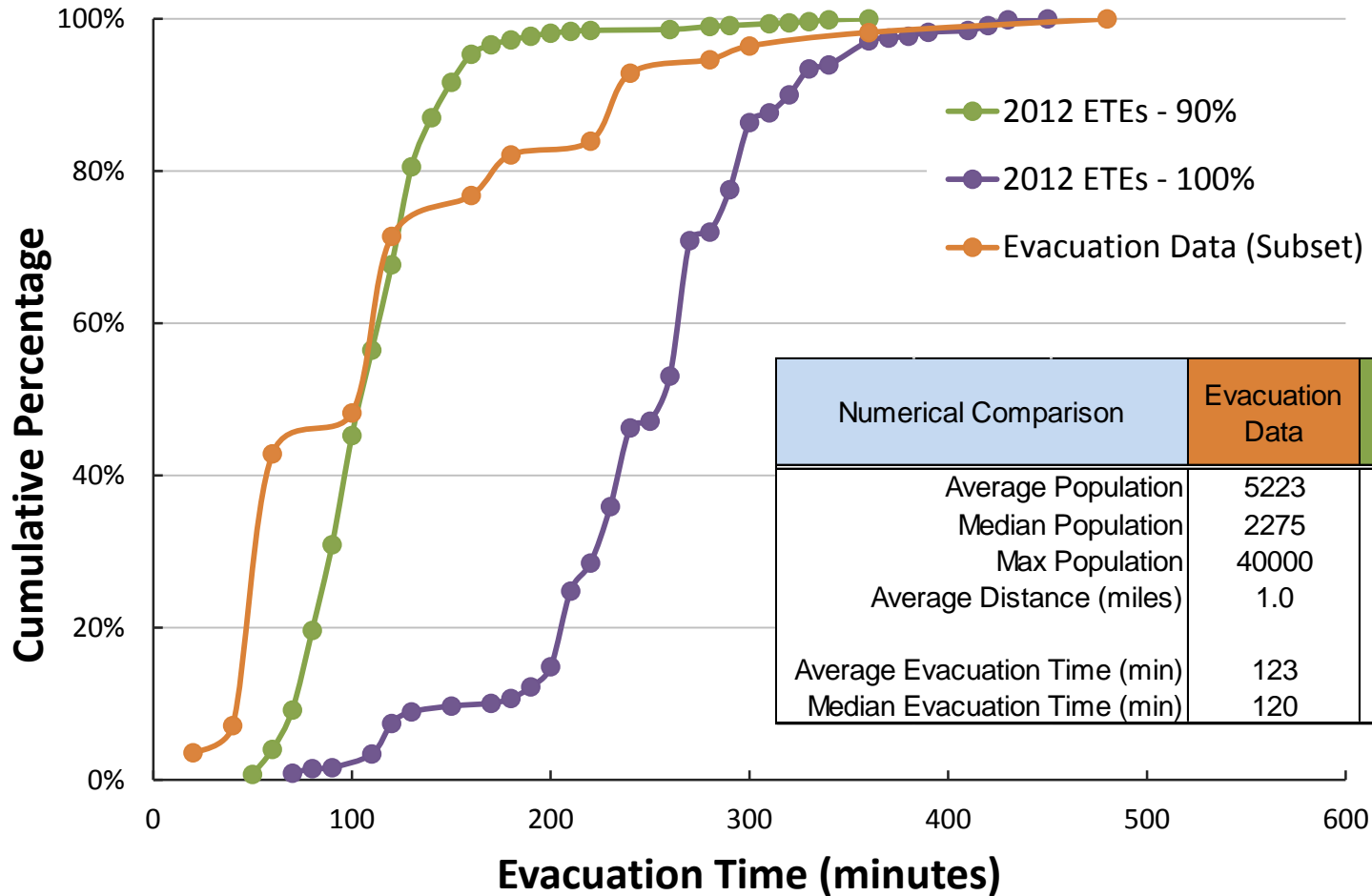
# Evacuation Data



# ETE vs. Evacuation Data



# 2 Mile ETE vs. Evacuation Data



# Comparative Validation

- Validated site specific ETEs against independent model.
  - Real time evacuation Planning Model (RtePM) – online evacuation clearance time tool for self-evacuees.  
<http://rtepm.vmasc.odu.edu/>
  - Modeled 63 sites.
  - Matched resident population, vehicles, and mobilization times.
  - Results for 10 mile, 100% evacuation.
  - RtePM compared against evening, fair weather ETE and an average ETE.



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# Comparative Validation

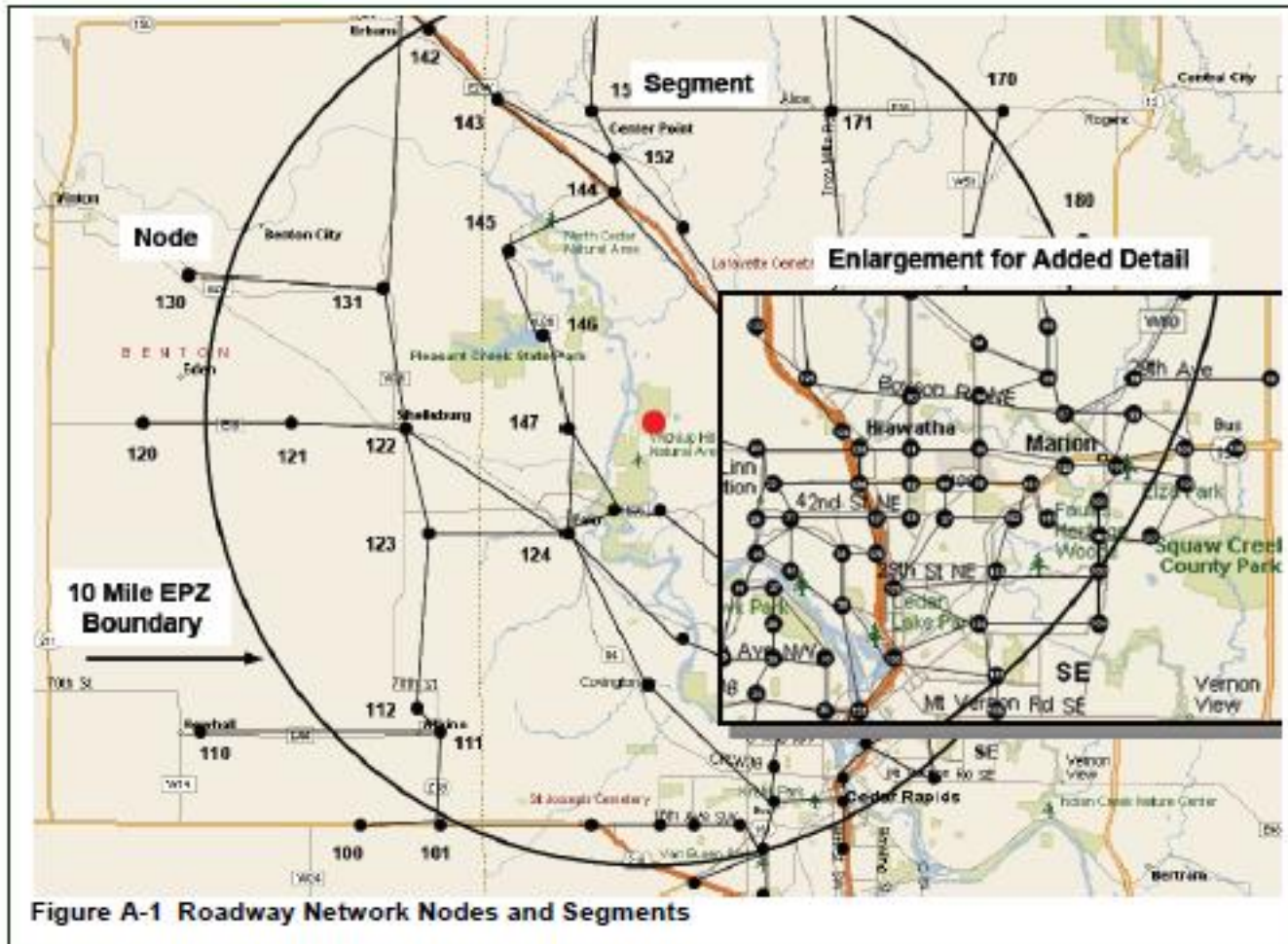
- Comparison of 63 individual site ETEs to RtePM clearance times:

RtePM Time Difference (minutes)	vs. Evening, Fair Weather ETE	vs. Average ETE
Average	30	31
Median	17	15
Mode	8	2

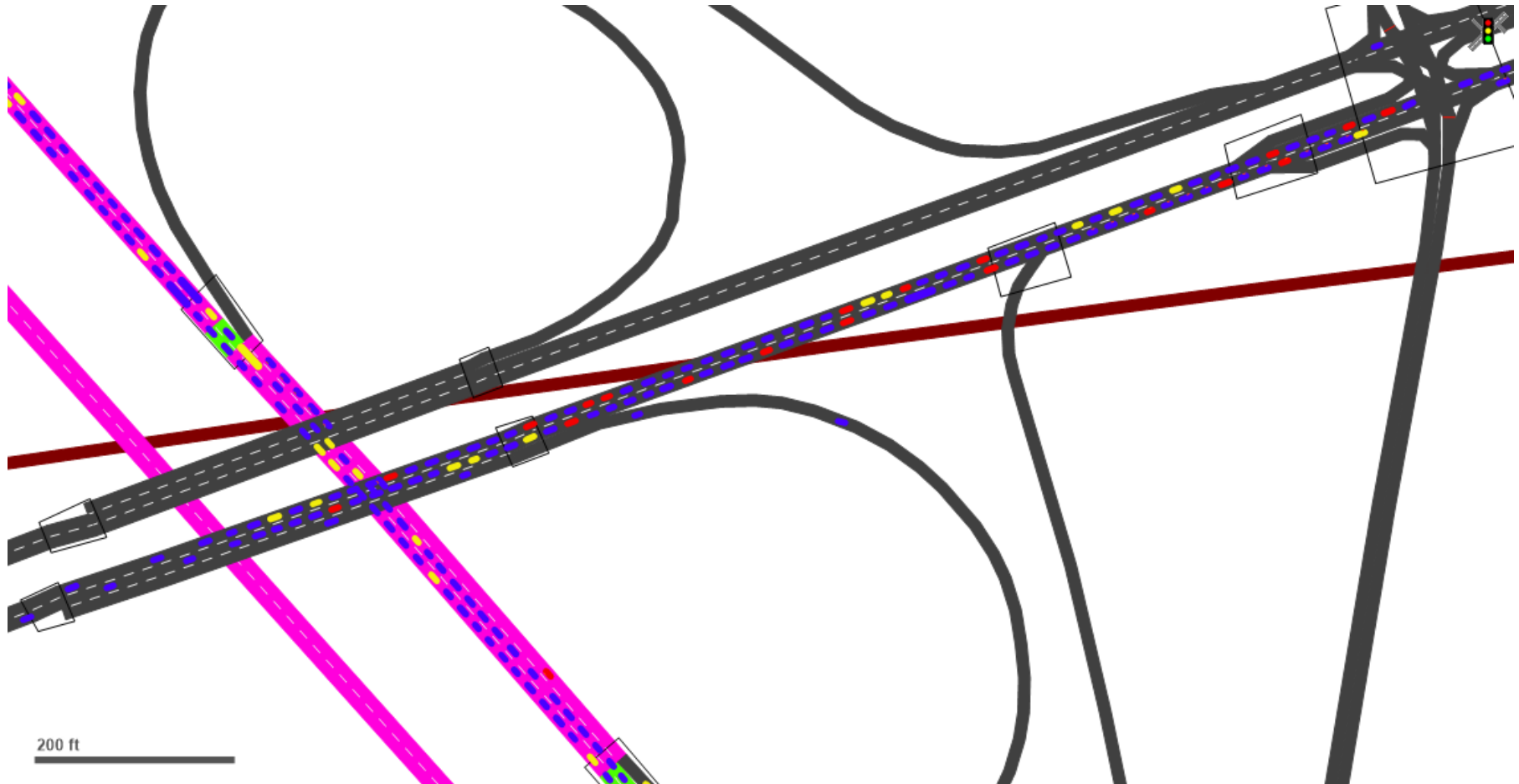
- Only 8 of 63 sites had greater than 1 hour difference.
  - Typically large population sites.
  - Accounted for due to parameters such as transient and shadow populations, mobilization curves, roadway capacity, vehicle demand, and simulation scale.



# Traffic Simulation Models

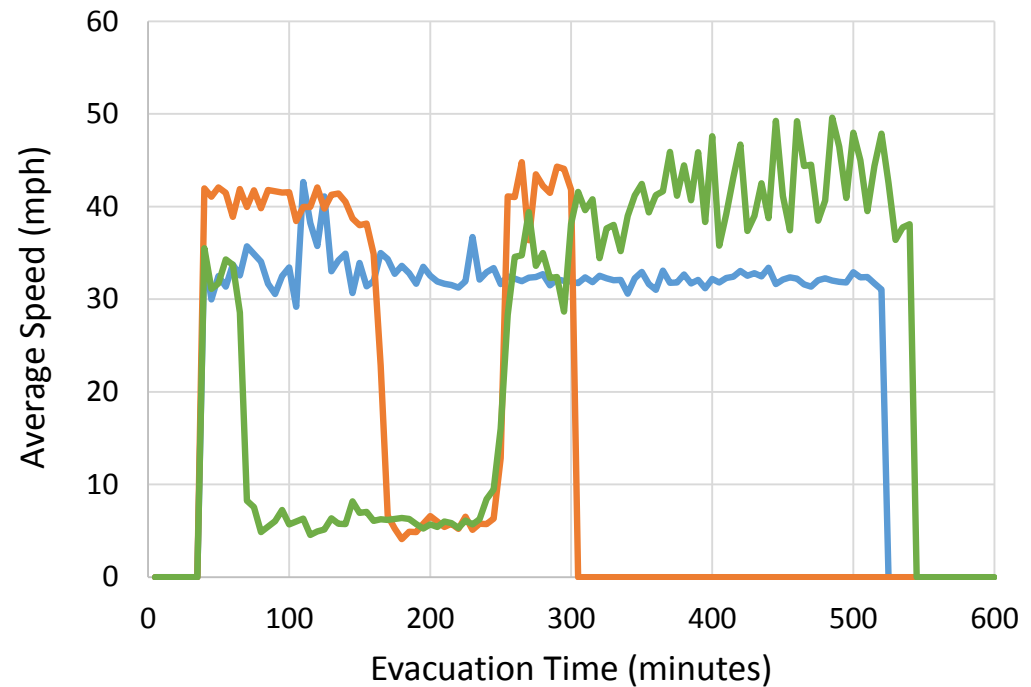
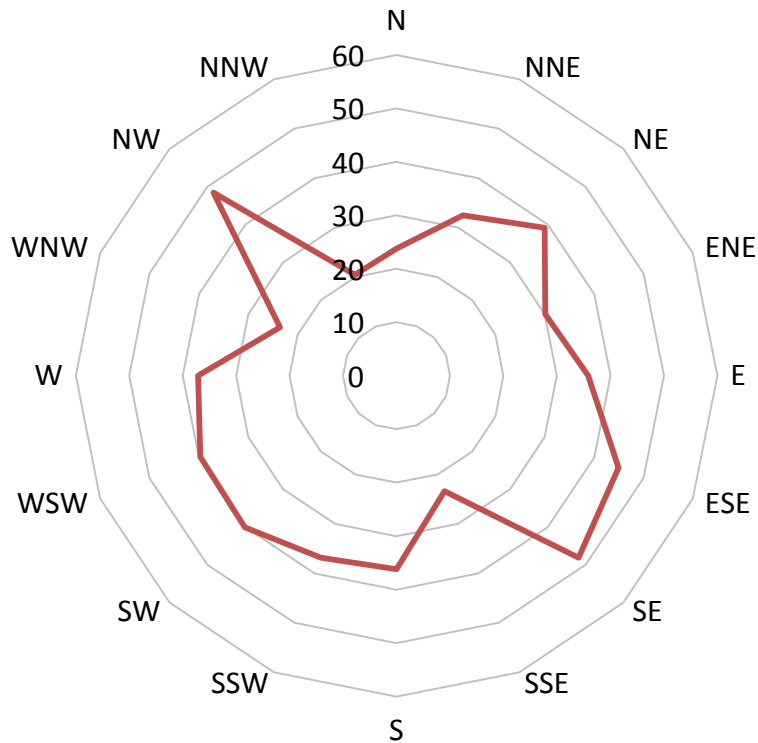


# Cohort Modeling



# Speed Data

## Spatial and Temporal Data Representations



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# Summary

- ETEs and traffic simulation models can inform modeling of evacuations in MACCS
- ETEs developed using NRC guidance have been verified and validated
- Microsimulation models offer flexibility and fidelity

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# Point of Contact

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