

Modeling and Simulation of Staged Evacuations:

A Case Study of Hurricane Evacuations of Galveston Island

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Outline

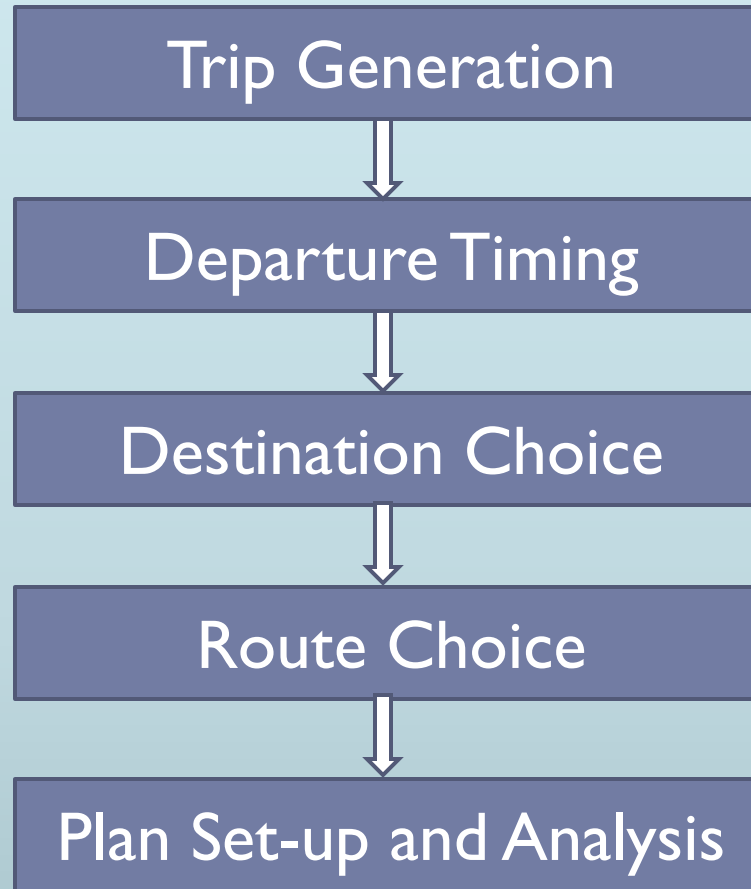
- Introduction
- Agent-based Modeling of Evacuation
- Related Work
- Hurricane Evacuation – Galveston Island
- Conclusions and Discussions

Introduction

- ▶ **Issues in Evacuation**
- ▶ **General Approaches to Modeling an Evacuation**
 - ▶ Emergency planning zone (EPZ) / Risk area
 - ▶ Evacuation Time Estimate (ETE)
- ▶ **Simulation Techniques**
 - ▶ Macro- vs. Micro-

Introduction

▶ General Steps of Evacuation Modeling (Southworth 1991)



Agent-based Modeling of Evacuation

- ▶ The complexity of modeling emergency evacuations
- ▶ Limitations of Current Methods
- ▶ Behavior of Individual Vehicles
- ▶ Emergence and System Level Behavior

Agent-Based Microsimulation

▶ Components:

- ▶ Model of the agents →
- ▶ Model of the environment → road network
- ▶ Behavior rules: accelerating, decelerating, lane changing



▶ Results

- ▶ System level behavior (emergent behavior) as a result of the interactions among its constituent units—agents through time
- ▶ The result can be represented as a value



Related work

▶ Evacuation Models

- ▶ NETwork emergency eVACuation model (NETVAC) model
- ▶ DYNamic EVacuation model (DYNEV)
- ▶ MASS eVACuation (MASSVAC)
- ▶ Regional Evacuation Modeling System (REMS)
- ▶ Oak Ridge Evacuation Modeling System (OREMS)
- ▶ Evacuation Traffic Information System (ETIS) model (PBS&J)
- ▶ NETSIM
- ▶ CLEAR
- ▶ SLAM Network Evacuation Model (SNEM)

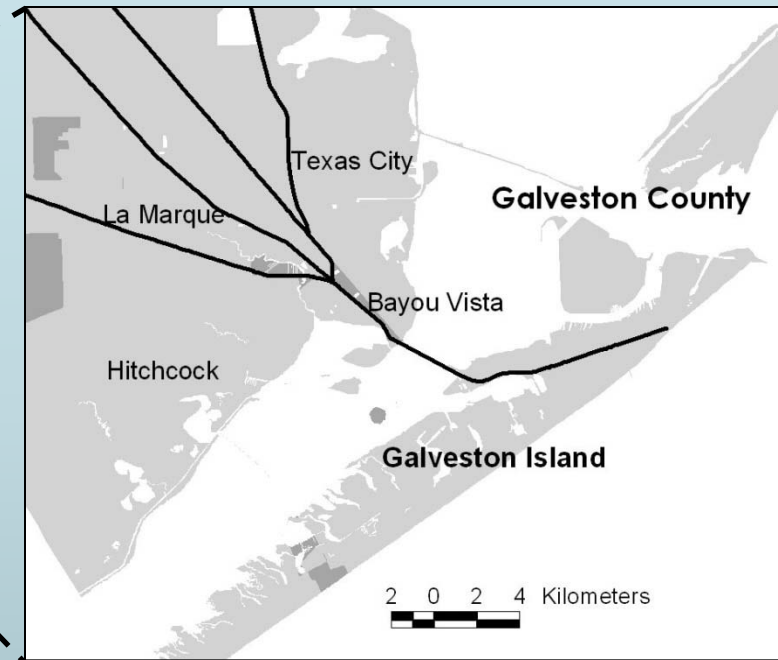
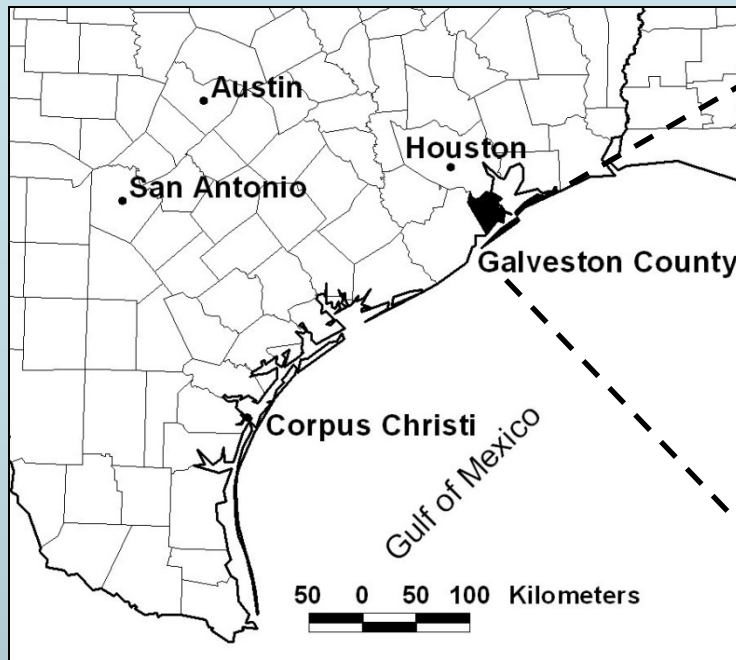
▶ Major Microsimulation Systems in Transportation

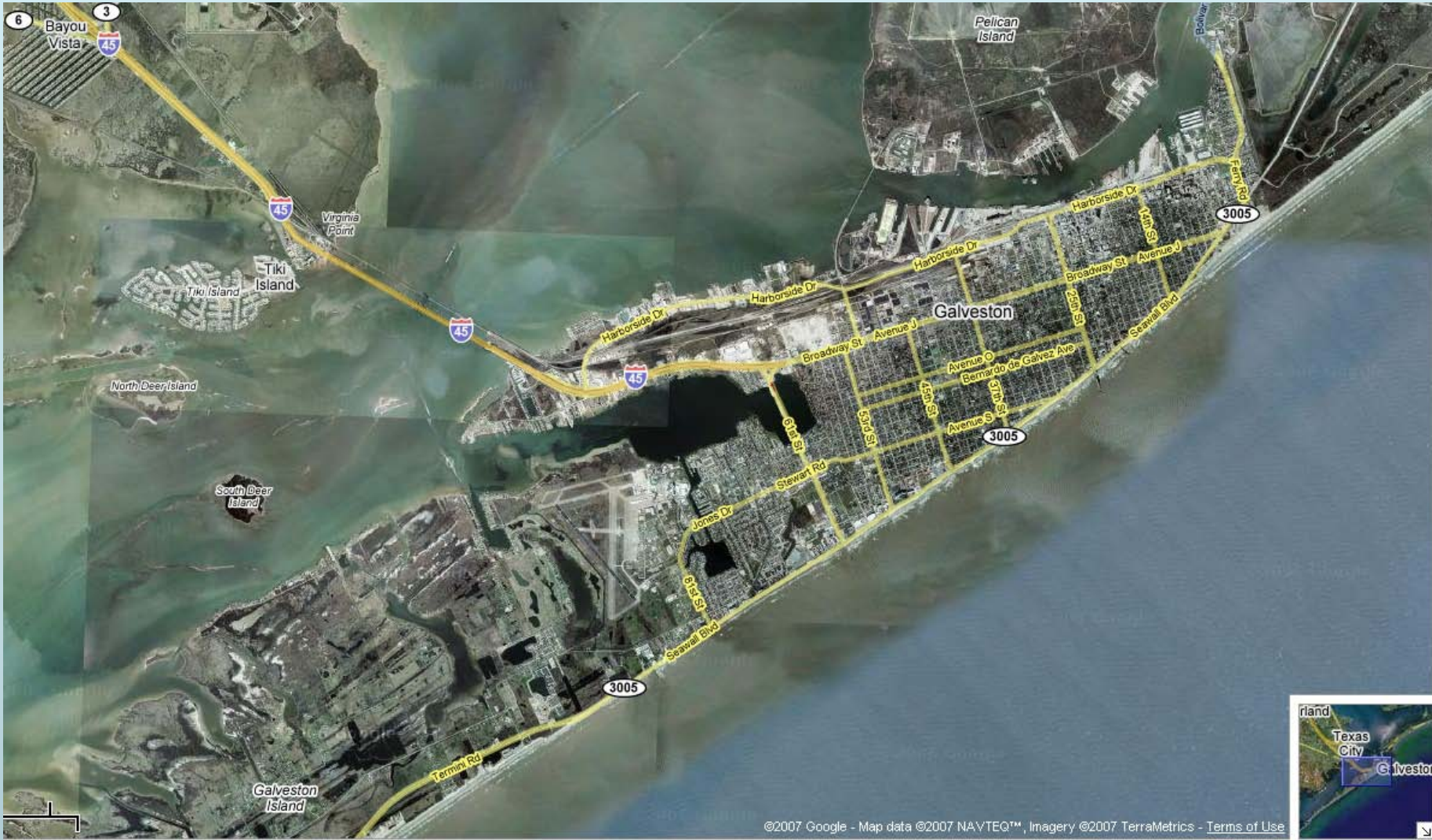
- ▶ DYNASMART-P, US
- ▶ CORSIM, US
- ▶ MITSIM, US
- ▶ TRANSIMS, US
- ▶ Paramics, UK
- ▶ VISSIM, Germany

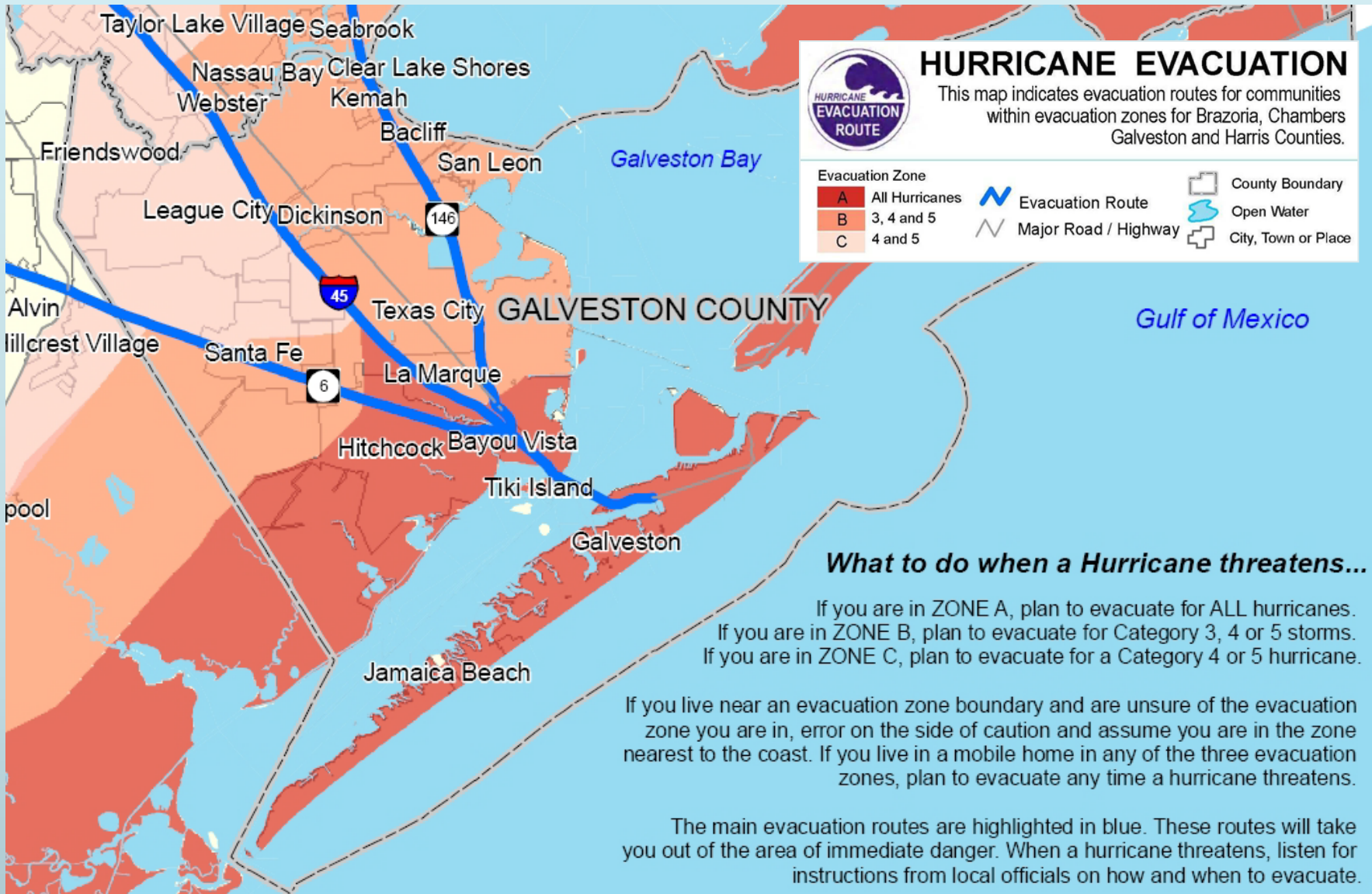
Hurricane Evacuation – Galveston Island

- ▶ Background

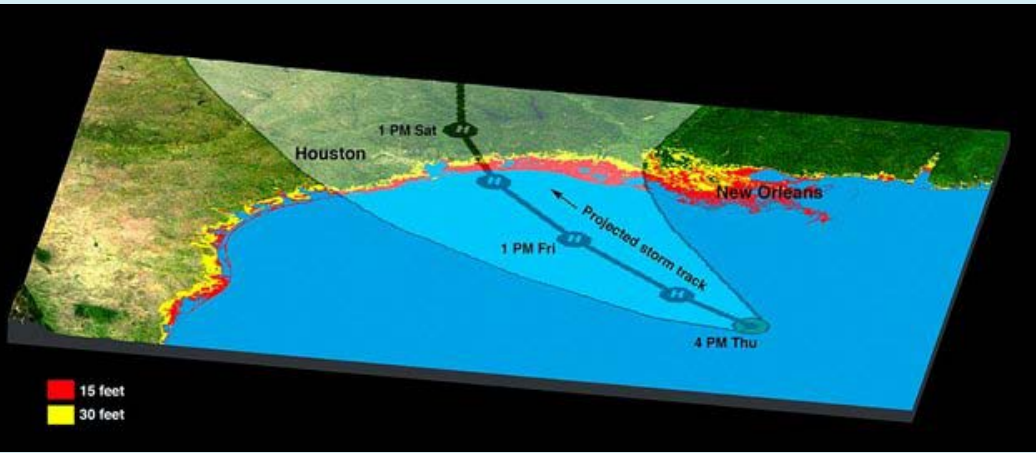
- ▶ Galveston Island







(Source: Houston-Galveston Area Council June 2006)



Hurricane Rita 2005

Hurricane Ike 2008



Past Evacuation Studies Related to Galveston Island

- ▶ Safwat and Youssef 1997
- ▶ Lindell et al. 2002
- ▶ Lindell, Pater, and Wu 2002
- ▶ PBS&J 2004
- ▶ Lindell 2006

Objective

- ▶ Identifying an effective yet feasible evacuation zoning structure for staged evacuation of Galveston Island

Methodology: Overview of Simulation

- ▶ Simulation Software – VISSIM
- ▶ Driver behavior model – A discrete, stochastic psychophysical model developed by Wiedemann (1974; 1990)
- ▶ Simulations were based on a rapid response curve
- ▶ Multiple runs were performed for each simulation to eliminate the effect of randomness in the simulation models

Methodology

▶ Trip Generation

$$N_v = N_h * N_{vh} * R_p * P_{vu}$$

Where, N_v is the number of evacuating vehicles;

N_h is the number of households;

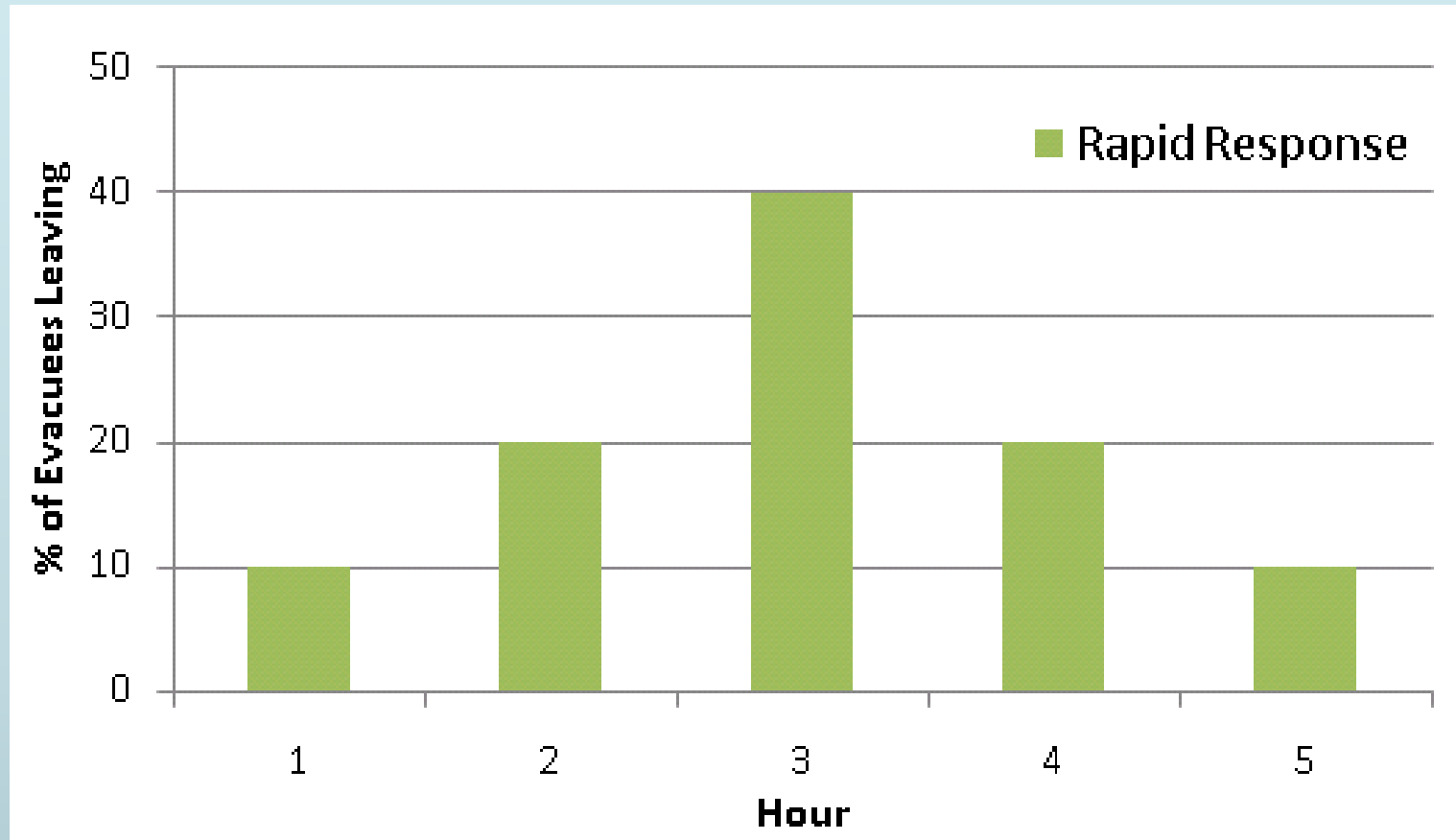
N_{vh} is the number of vehicles per household;

R_p is the percentage of people participating in an evacuation;

P_{vu} is the percentage of vehicle usage.

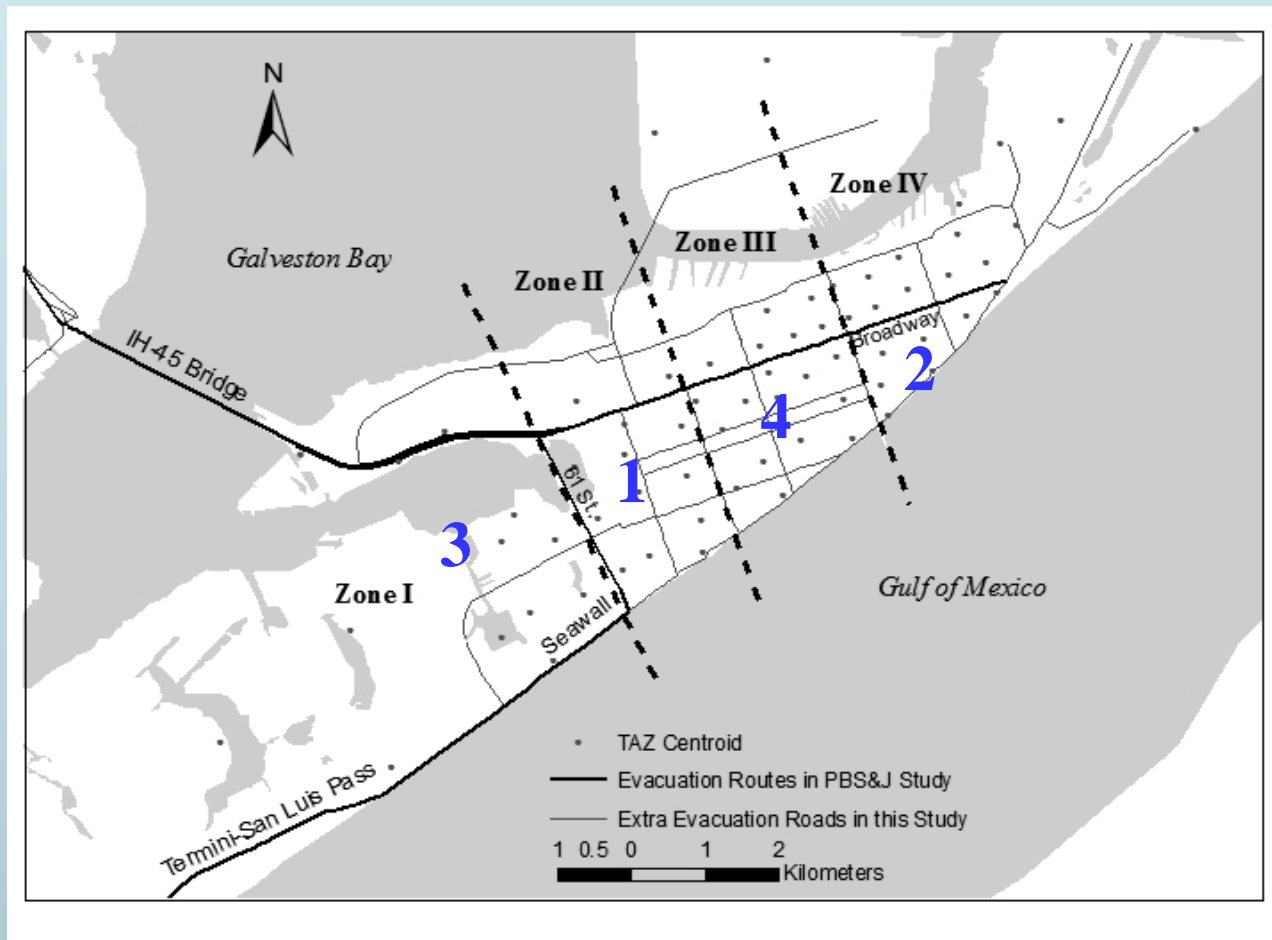
Methodology

▶ Evacuation Timing: Response Curve

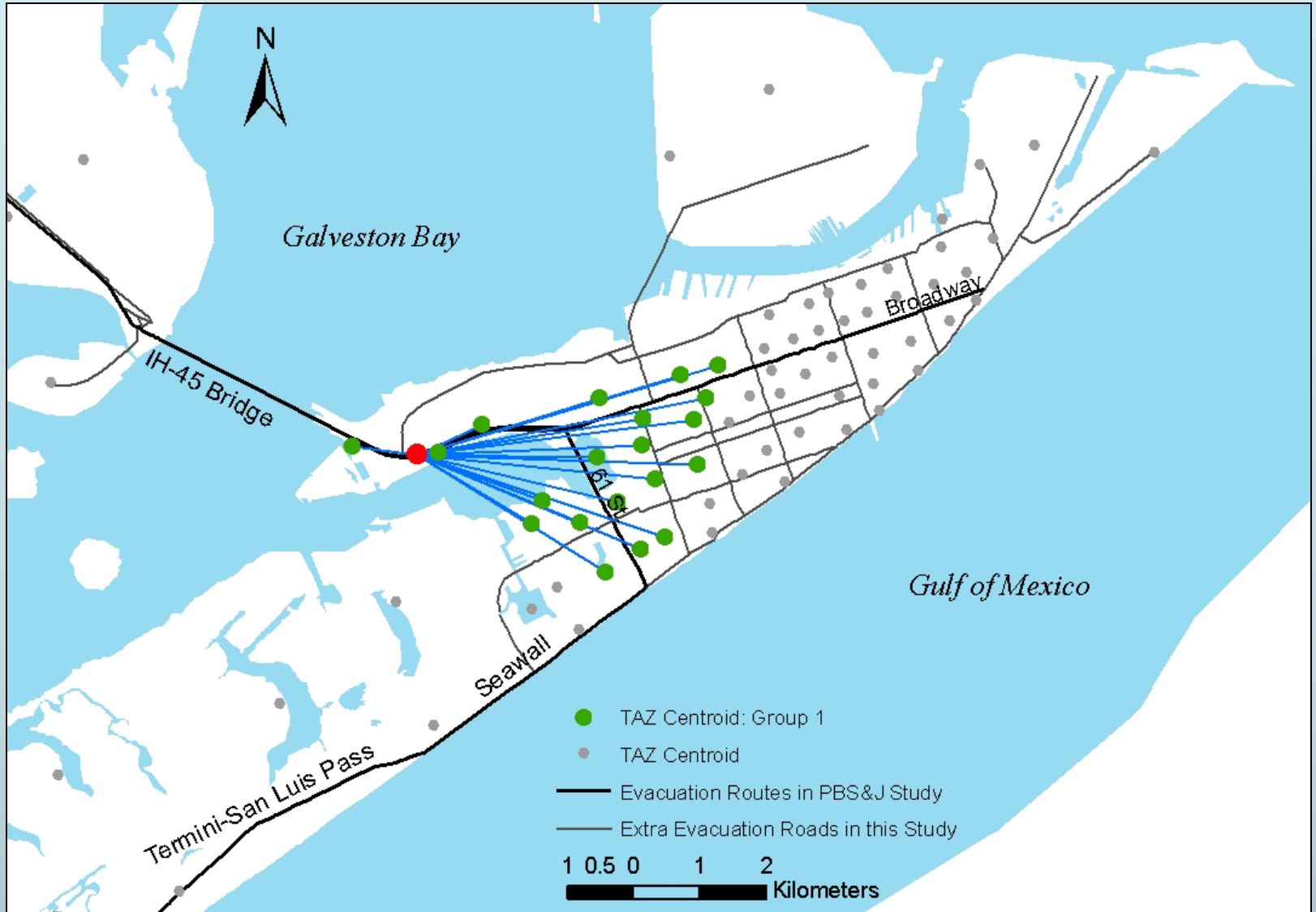


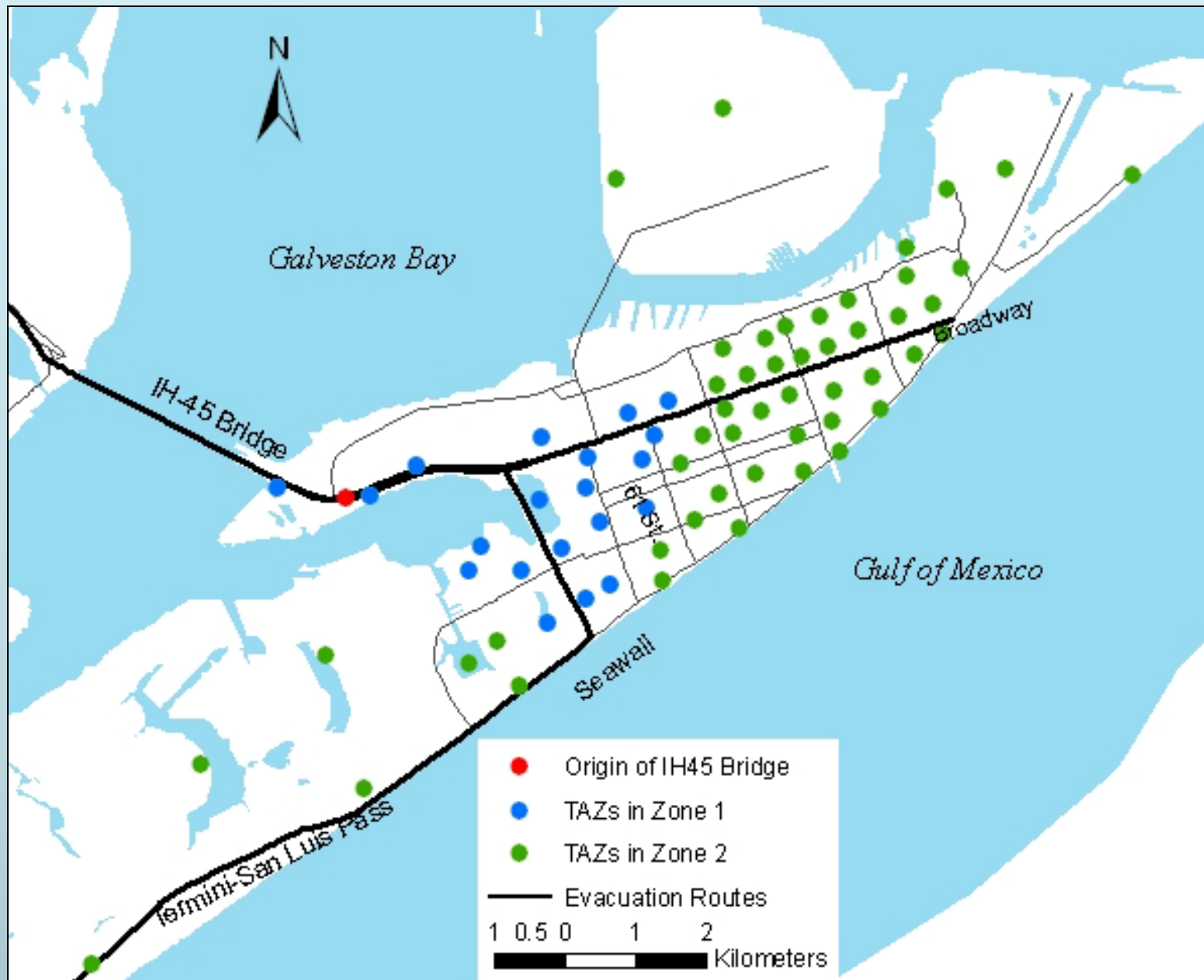
▶ Route and destination choice

Staged Evacuation: an arbitrary zoning structure

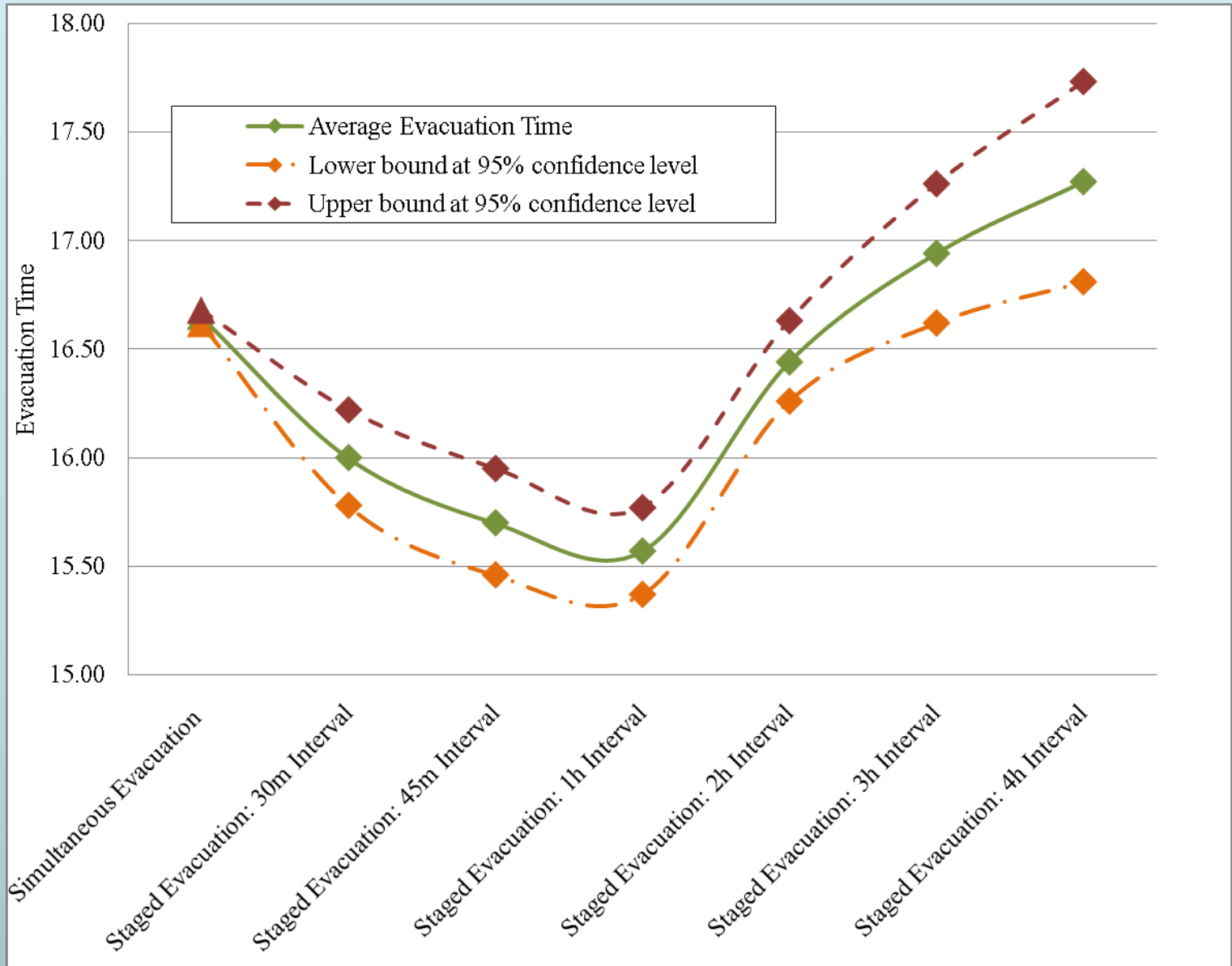


(Chen 2008)

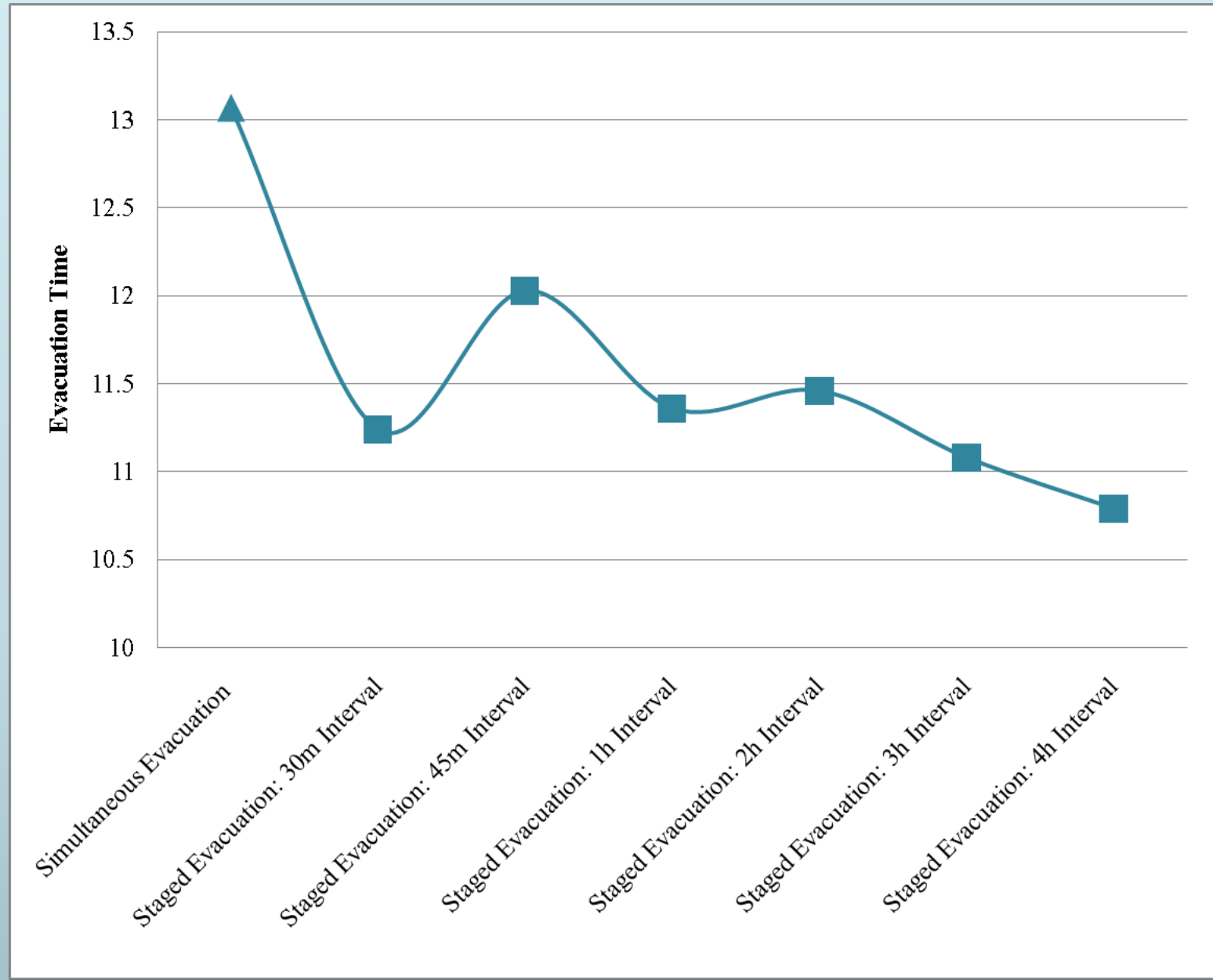




Results:



Results: Continued



Conclusion and Discussion

- ▶ Agent-based modeling and simulation can serve a means to gain a better understanding about possible outcomes of different scenarios in an evacuation.
- ▶ It can help assess a range of options available
- ▶ Traffic control strategies
- ▶ Multi-modal evacuations
- ▶ Emergency evacuation behavior
- ▶ Traffic accidents

Thanks for your time!

Questions? Comments?