Identification of a Response and Rescue Network for the St. Louis Region

TEAM 2024 Conference

Rick Bennett, WSP
Chris Engelbrecht, MoDOT
Praveen Edara and Daeyeol Chang, MU (Support)

Acknowledgments

MoDOT - Chris Engelbrecht, Mike White, Brian Umfleet, Joe Moore

MoDOT Project Manager – Jenni Hosey

EW Gateway - Lubna Shoaib

Members of the Technical Advisory Committee

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Project Overview

- Motivation
  - St. Louis metropolitan region is vulnerable to large earthquakes
  - Emergency response plan required in the event of an earthquake

- Project Objectives
  - Analyze and develop egress and ingress routes
  - Identify structures prone to fail due to an earthquake in the NMSZ and WVSZ zones
  - Develop a traffic simulation model for assessing evacuation
  - Develop a communication plan of evacuation directions to residents of the region

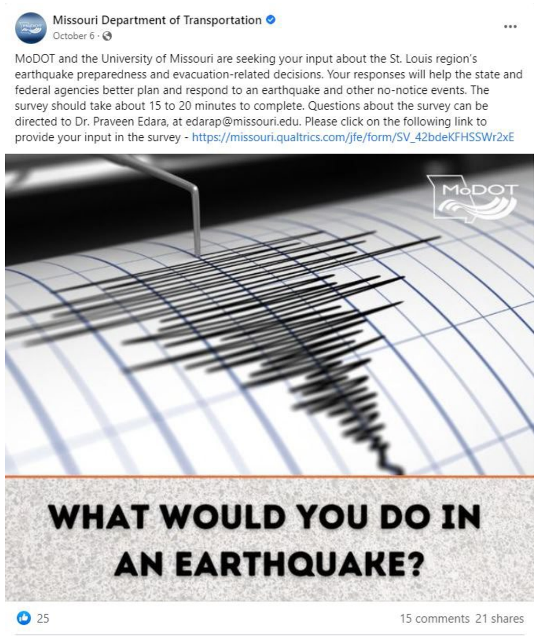
Project Overview - Objective

- Identify vulnerable links in the road network
  - MoDOT data and Other data (e.g., National Bridge Inventory Data)
  - Bridge Seismic Screening Tools
  - USGS ShakeMap and ShakeCast Data
- Identify alternative routes for each Origin-Destinations
  - Communicating detour information and real time delays via DMS
- Conduct household surveys to capture evacuee behavior
- Explore different resolutions of traffic simulation models
  - Micro/ Macro/ Mesoscopic

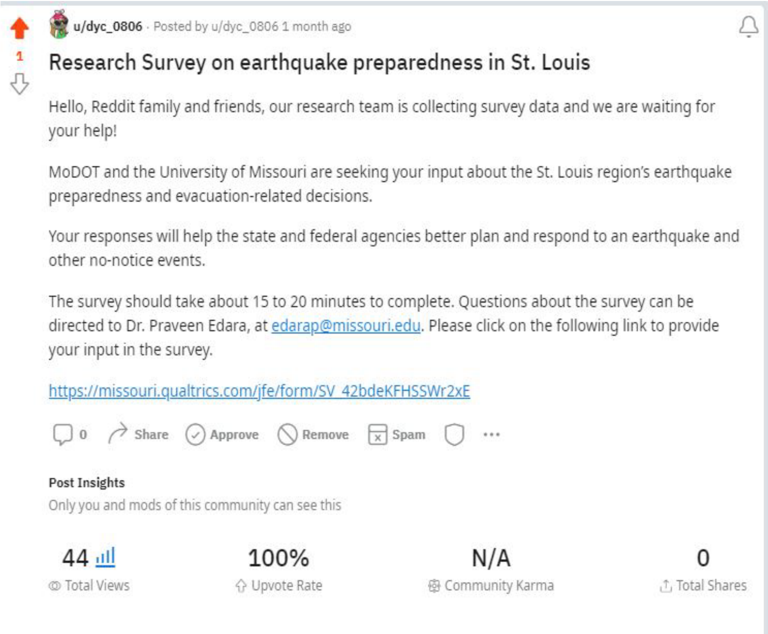
Earthquake Evacuation Survey for the St. Louis Region

Survey overview

- Online survey was open from October 6, 2022 to November 30, 2022
- Survey area: St. Louis region
- Survey distribution: Qualtrics survey link was posted via social media



MoDOT's Facebook



Subreddit of St. Louis region

Survey response

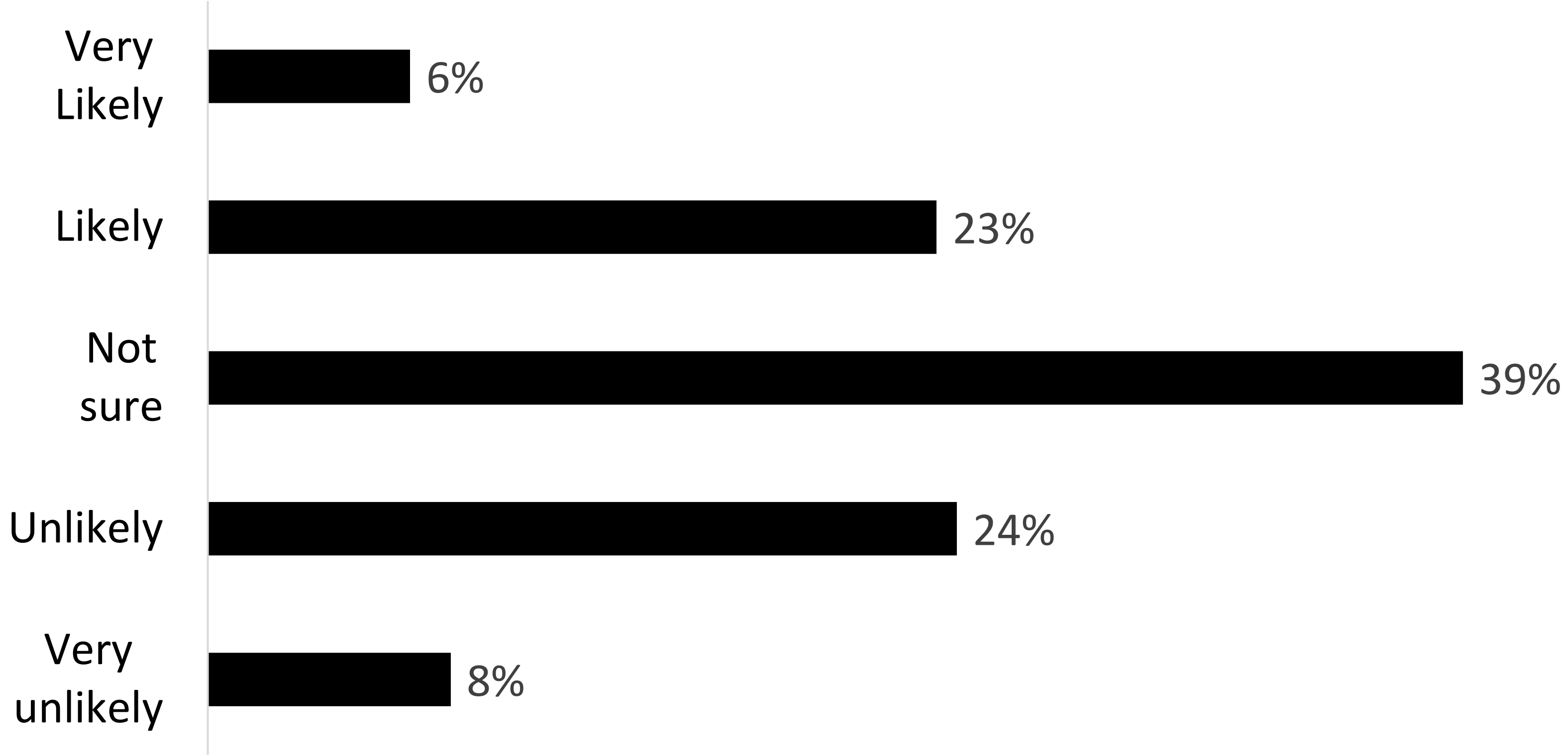
- Responses received from individuals living in eight counties

(5 in MO, 3 in IL)

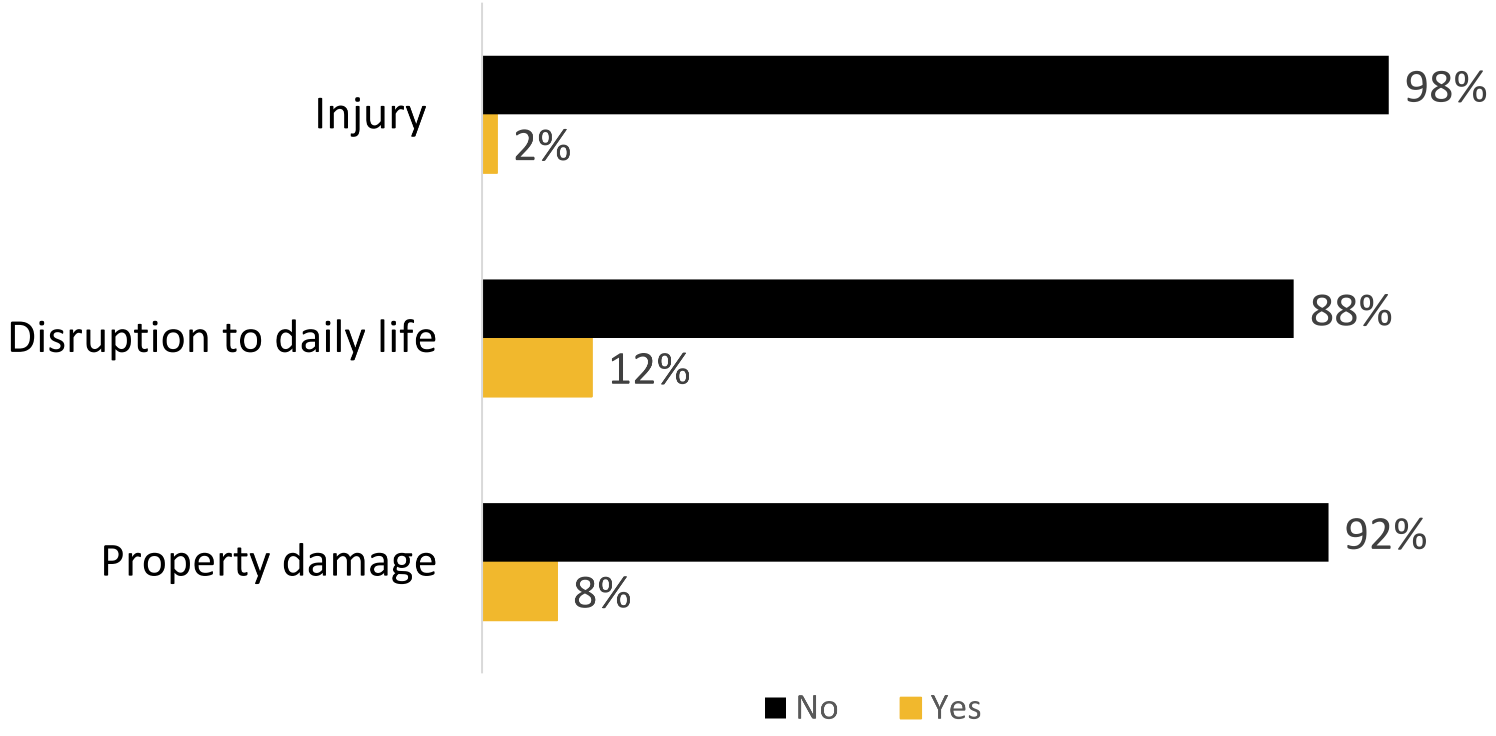
- 194 total responses, 149 completed the entire survey
- Smaller sample size than the New Madrid region survey conducted in January 2022 (900 responses)

County Name	Sample Size	Percentage of Total Responses
Jefferson (MO)	22	14.8%
Franklin (MO)	11	7.4%
St. Charles (MO)	27	18.1%
St. Louis City (MO)	14	9.4%
St. Louis (MO)	65	43.6%
Madison (IL)	3	2.0%
Monroe (IL)	0	0.0%
St. Clair (IL)	7	4.7%

Q. How likely do you think that you and your family will be impacted by an earthquake in the next five years? (N=157)



Q. If you have experienced an earthquake before, did you have any of the following happen to you ? (N= 157)



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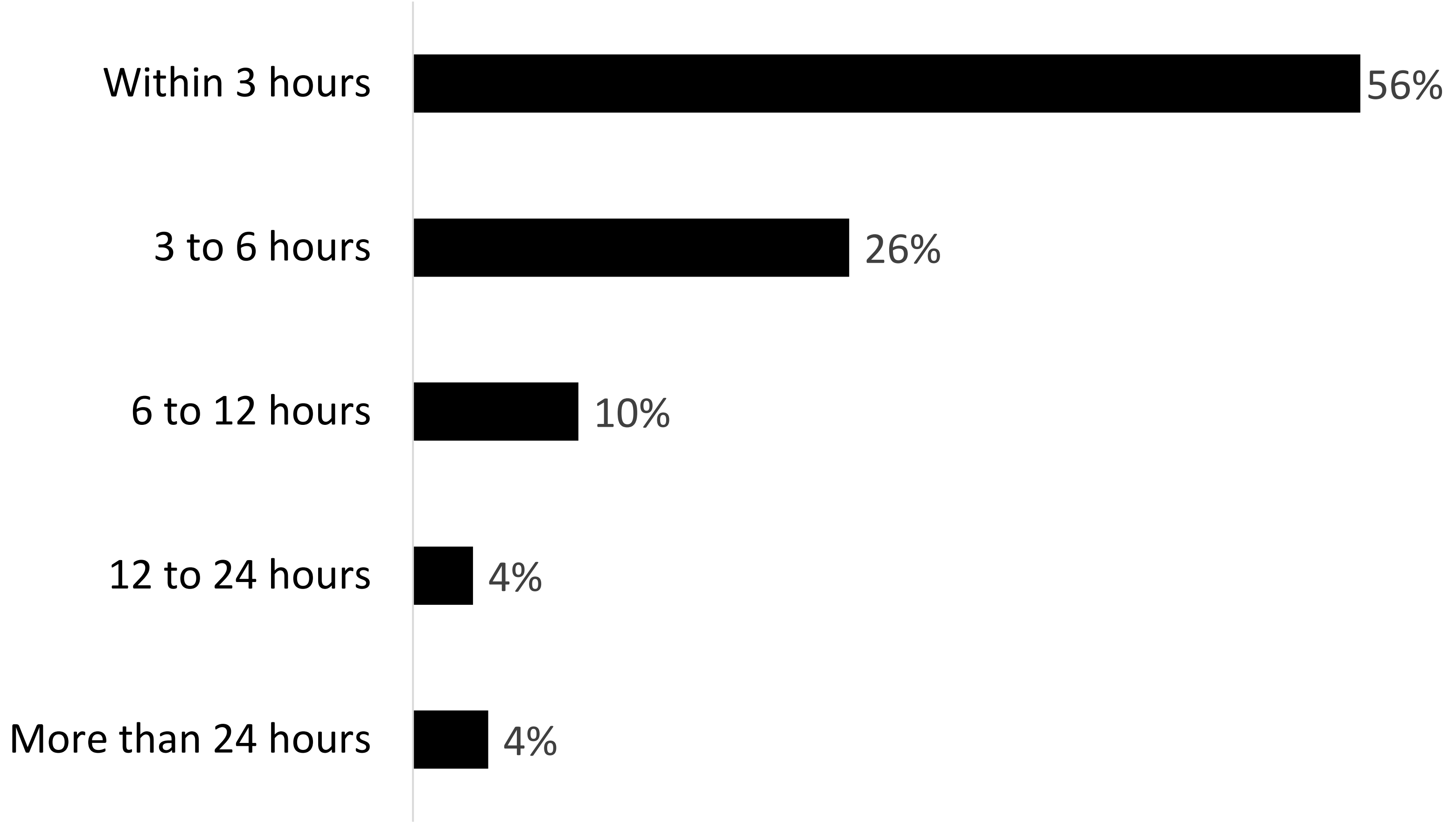
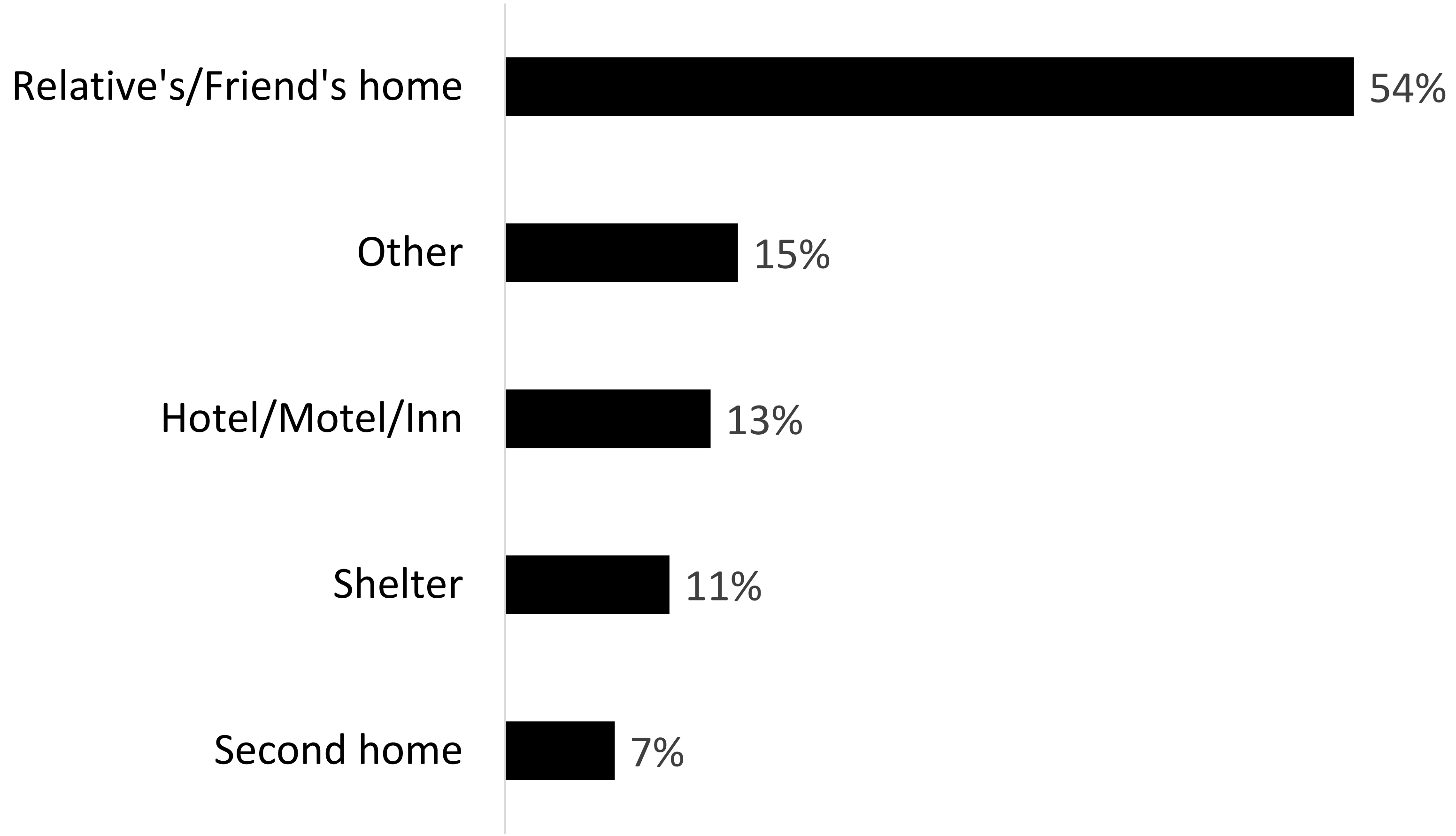
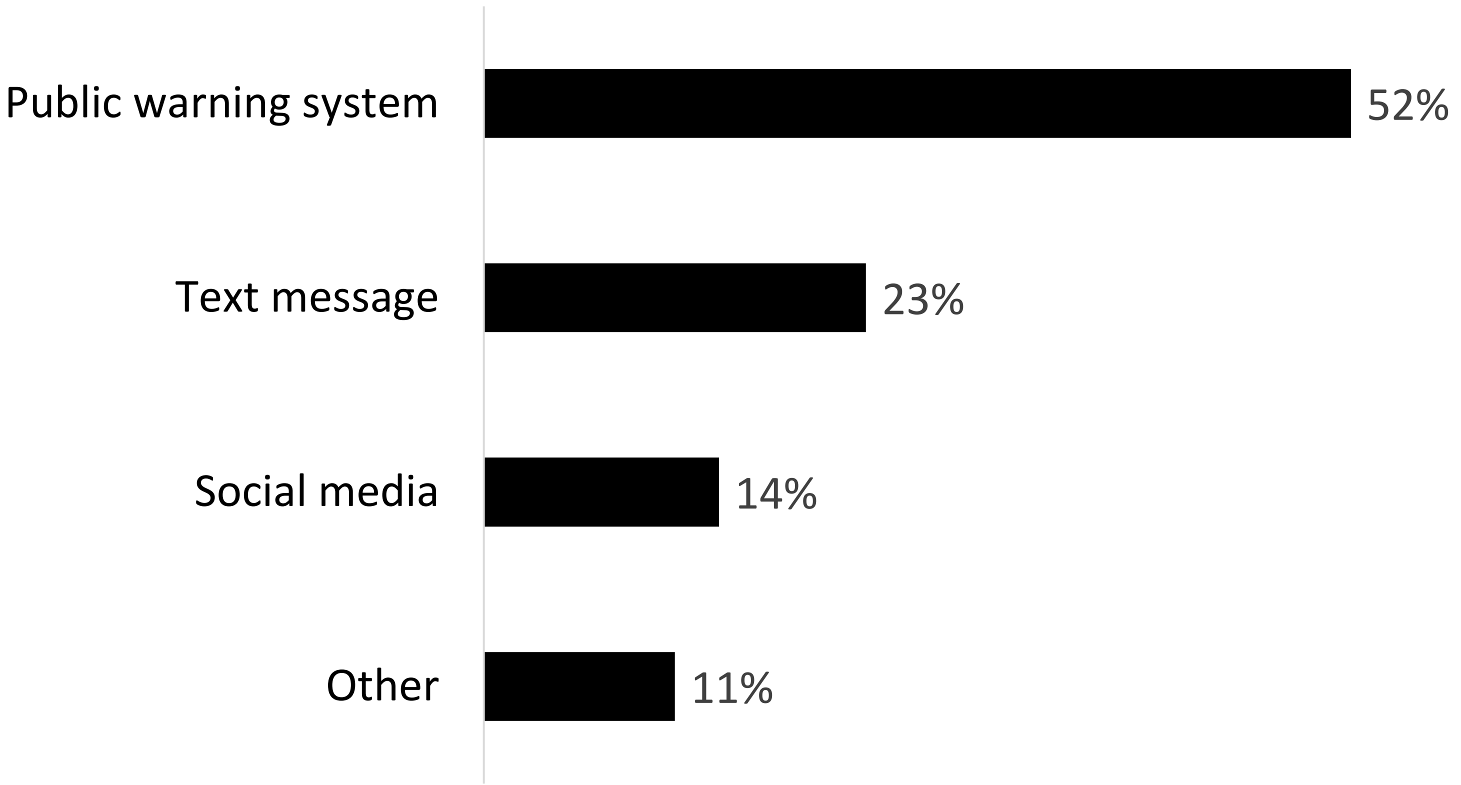
Q. If a mandatory evacuation order was issued, when would you most likely leave to your destination after the order was issued? (N=112)



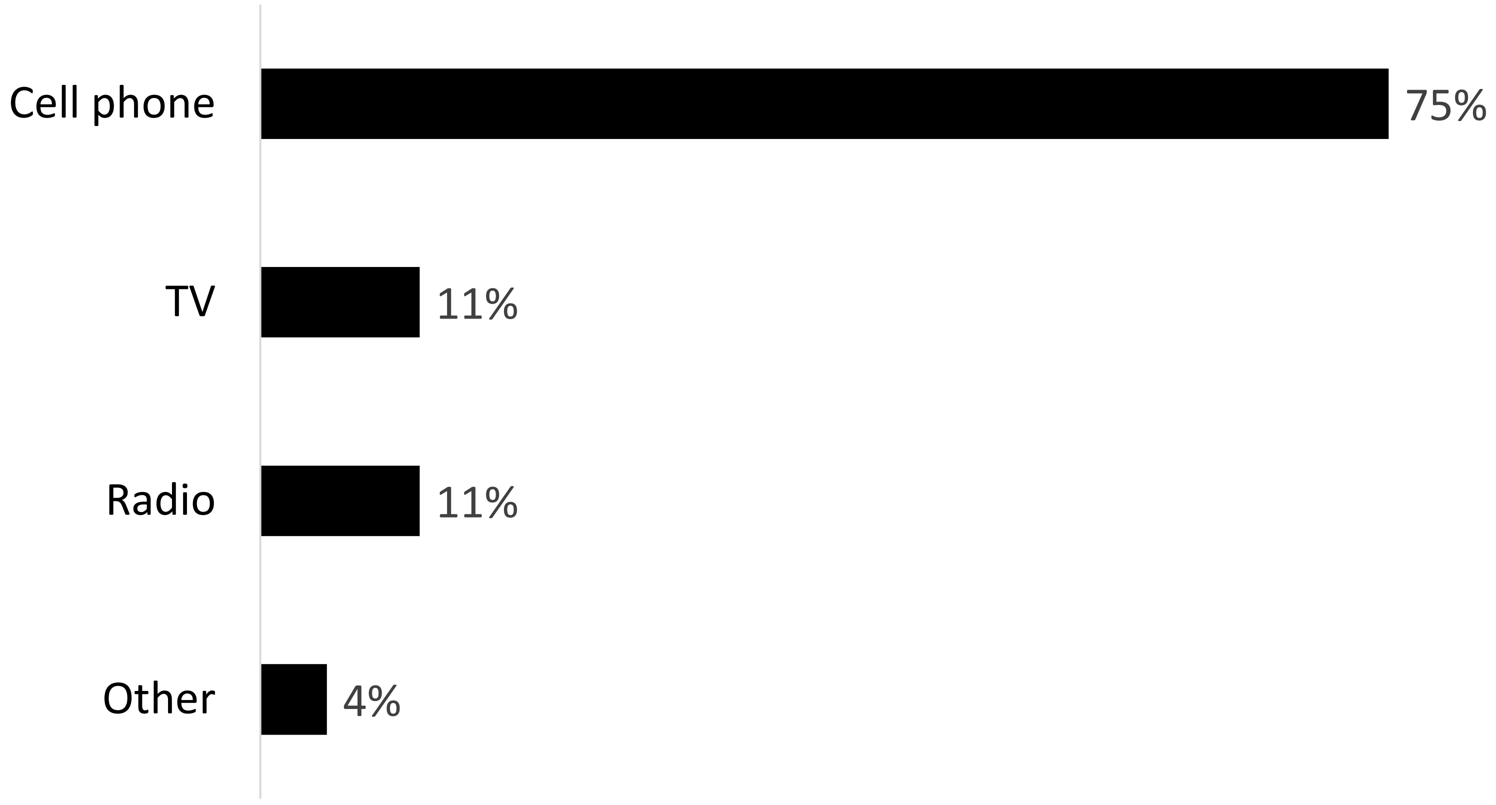
Q. Where would you go to? (N=114)



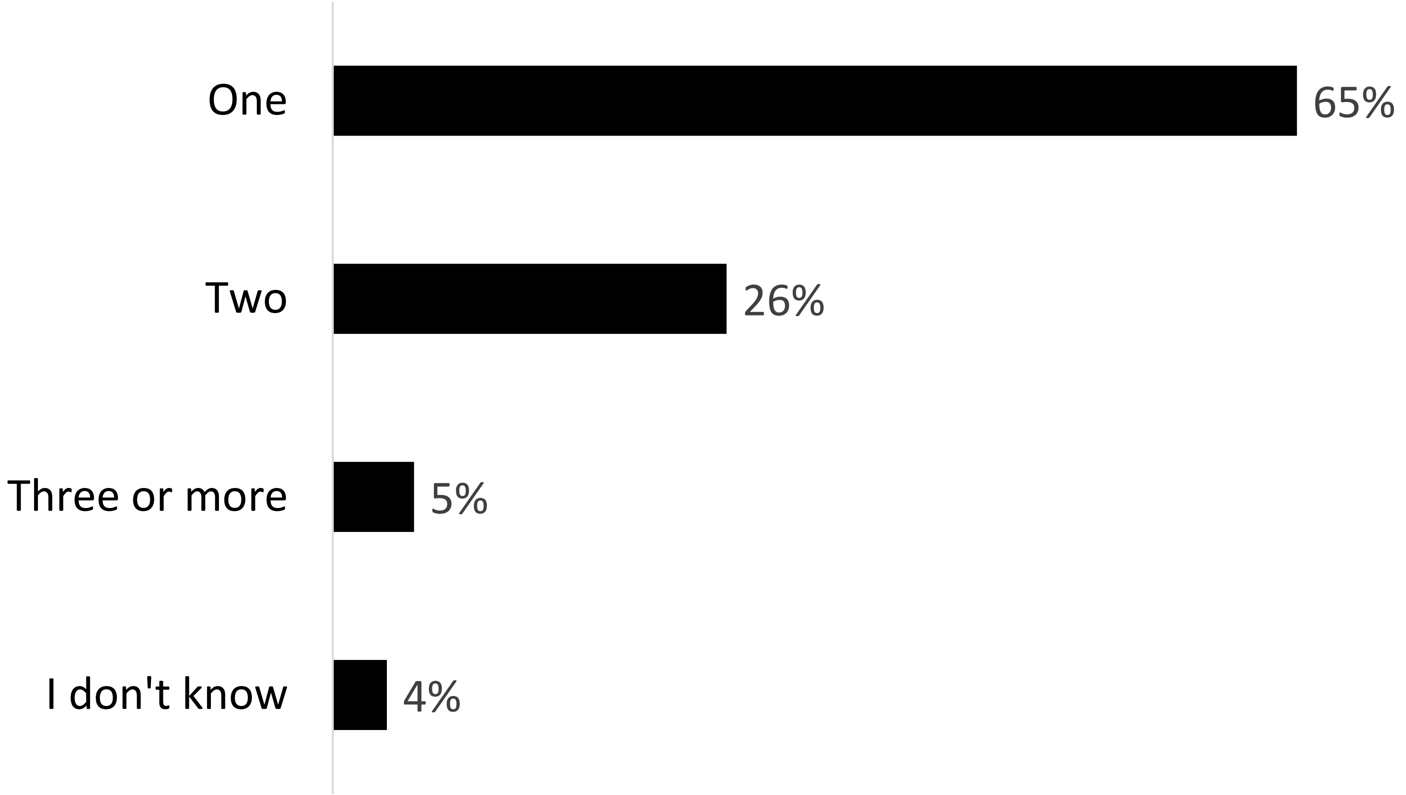
Q. From what sources do you expect to receive information related to evacuation? (N= 114)



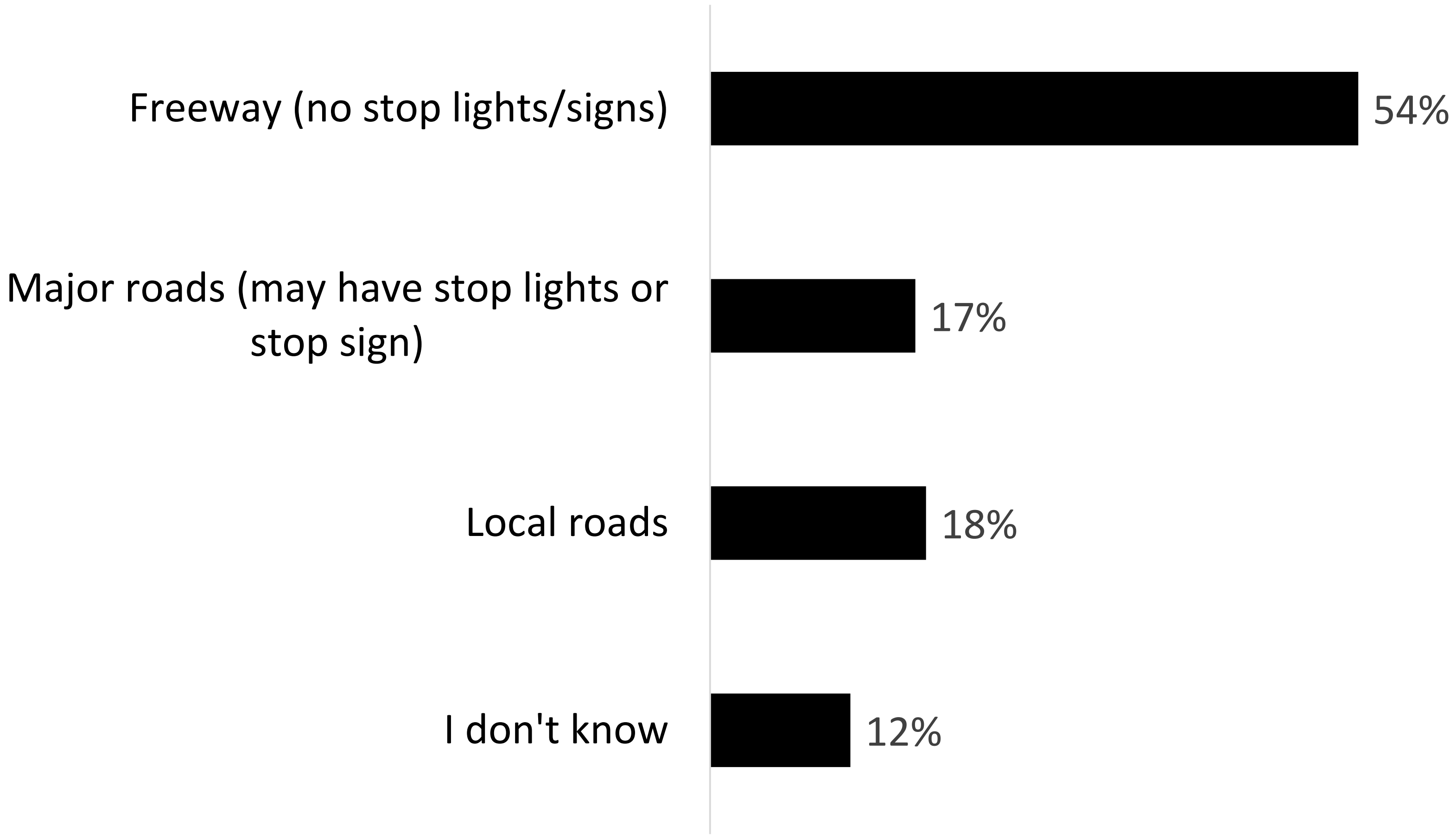
Q. From what devices do you expect to receive information related to evacuation? (N= 114)



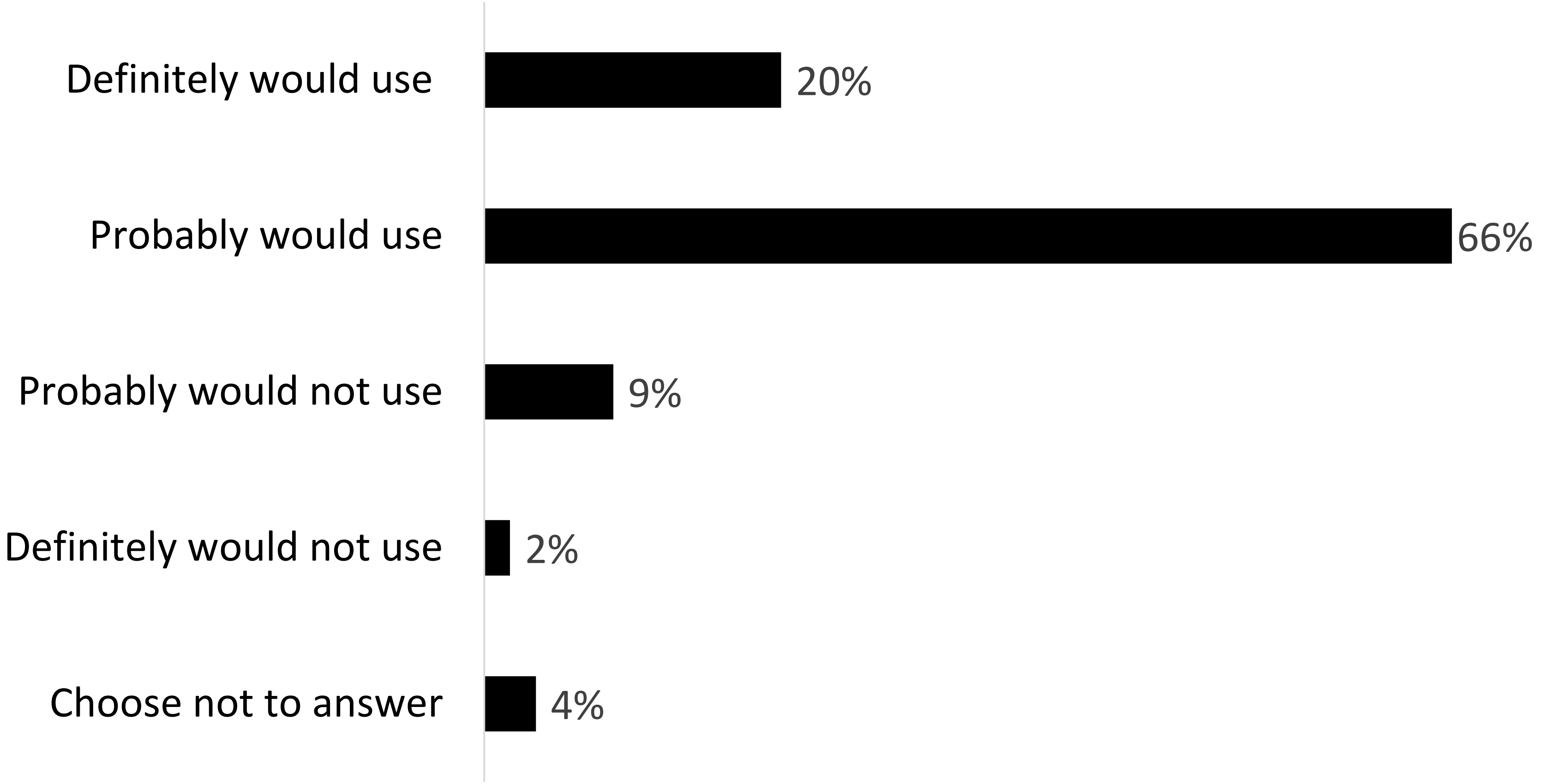
Q. How many vehicles would you use to evacuate? (N=110)



Q. Which type of road would you mostly travel on? (N=112)

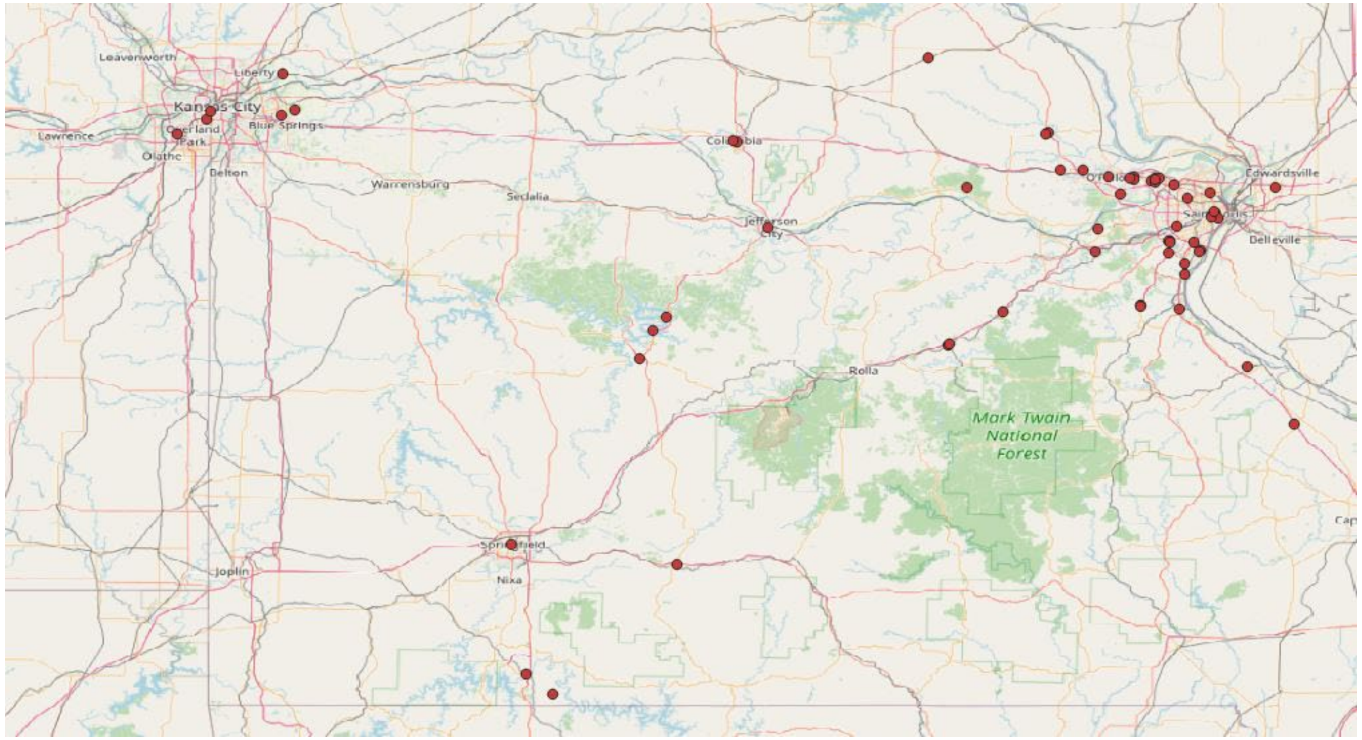


Q. If government officials recommended using a particular evacuation route, would you use that route? (N=114)



Q. What route would you take to get to your destination? (N=105)

Q. Where would you go? Please enter city name (N=82)



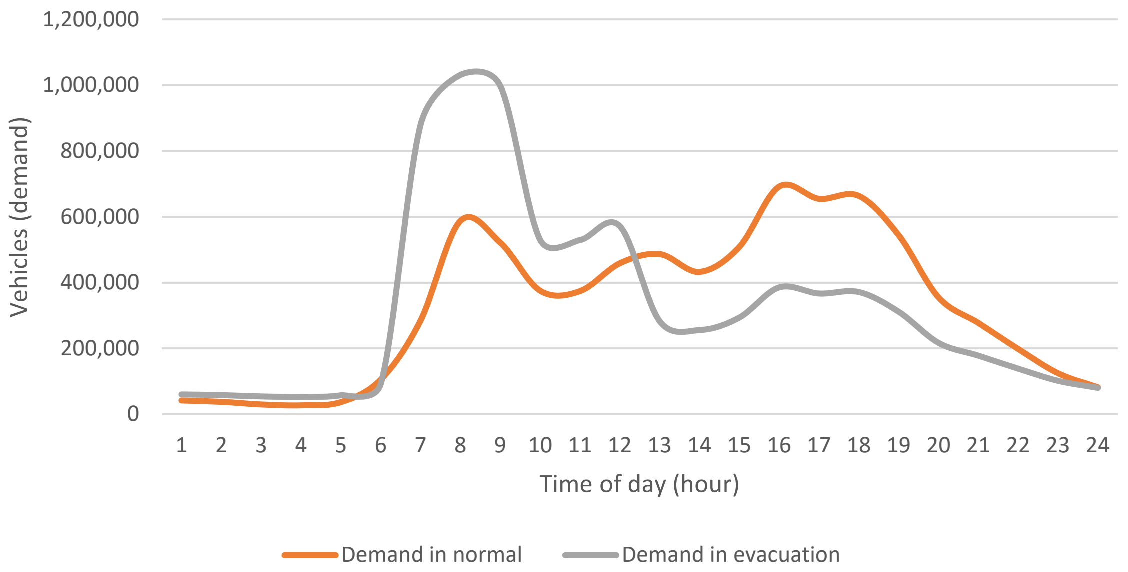
Red dots show destinations that respondents provided

Evacuation modeling

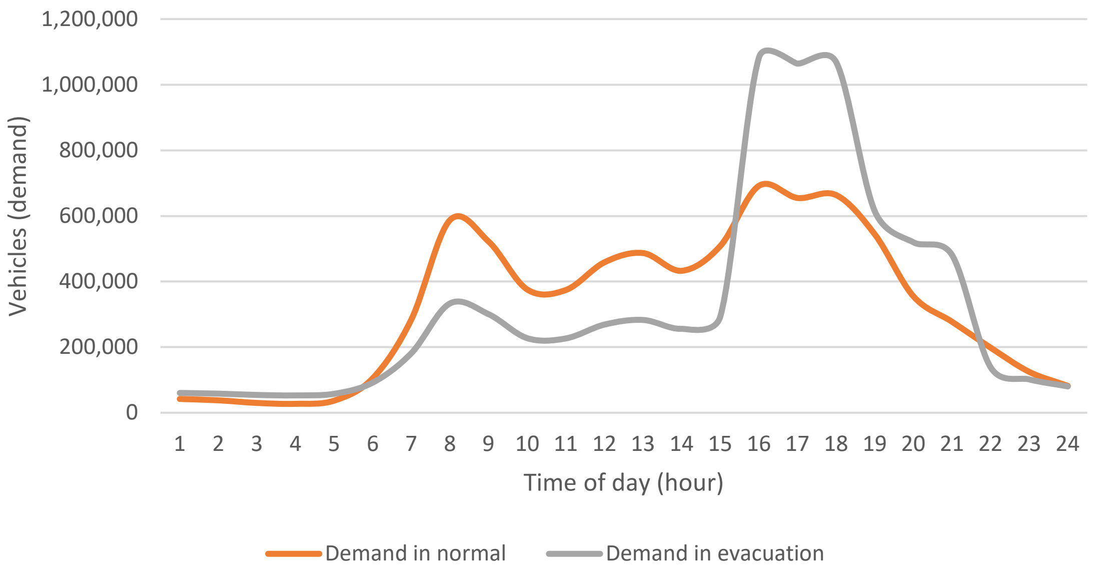
Demand Creation

- St. Louis evacuation survey was used to generate evacuation demand
  - 56% of demand was assigned within 3 hours of earthquake occurrence
  - 26% of demand was assigned within 3 to 6 hours
  - Remaining 18% equally distributed from 6 to 24 hours

Demand Curves – how traffic is loaded onto the network



Earthquake Occurrence at 7 A.M.

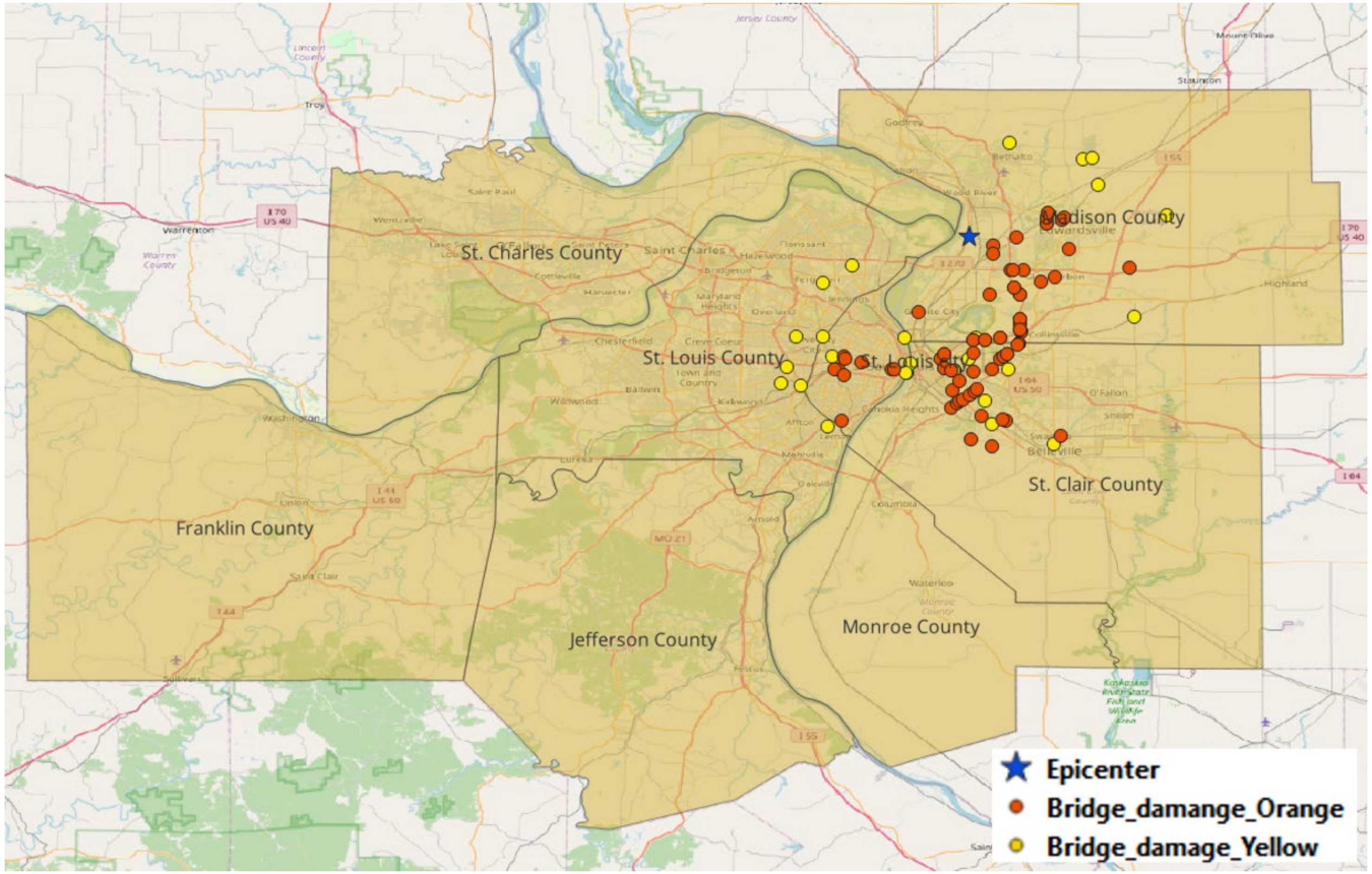


Earthquake Occurrence at 4 P.M.

Network treatment

- To reflect roadway damage during the earthquakes, bridge condition data was used.
- The United States Geological Survey (USGS) ShakeCast model provided impact of earthquake on infrastructure.
- ShakeCast simulated a 6.7 magnitude earthquake - 78 bridges (moderate-high level damage) and 27 bridges (moderate level damage).
- Traffic simulation models for base case (no network damage) and damaged case

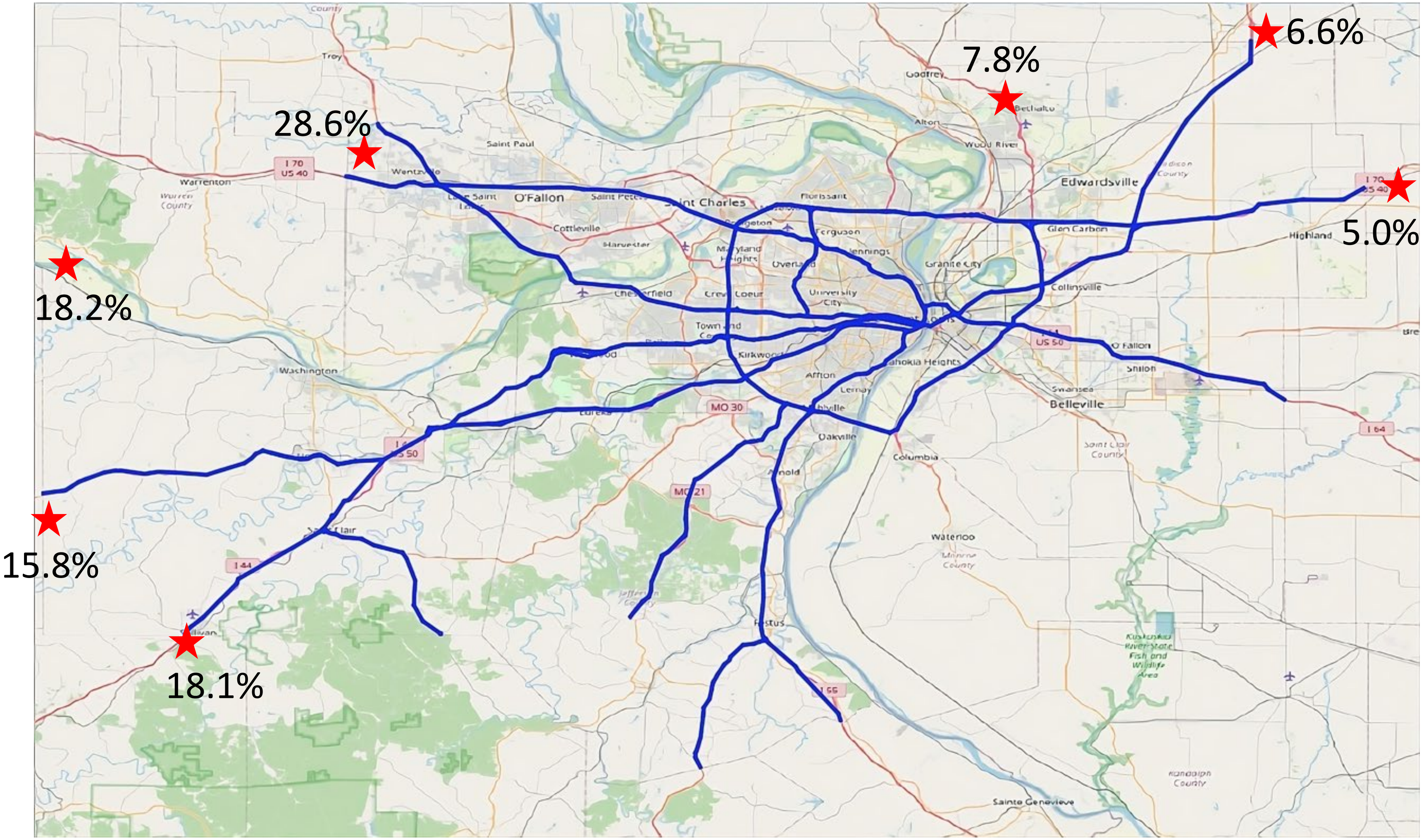
Network treatment- Locations of bridge damage



Scenario Generation

- Evacuation scenarios: created by varying evacuation demand, road network, and time of earthquake occurrence.
- Residents assumed to evacuate to one of the super zones outside the St. Louis metro region (4 located in Missouri, 3 in Illinois) - see next slide
- Two different occurrence times for earthquake (EQ): 7 am and 4 pm
- Residents in Missouri, would evacuate to super zones in the west.
- Residents in Illinois, would evacuate to super zones in the north.
- Demand is generated for 3,003 zones and are distributed to the super zones based on proximity, using the Gravity Model.

Distribution of Demand to Super Zones



List of Scenarios

- Scenario 0: Base network, normal daily demand
- Scenario 1: Base network, 100% demand (EQ occurs at 7 am)
- Scenario 2: Base network, 50% demand (EQ occurs at 7 am)
- Scenario 3: Base network, 30% demand (EQ occurs at 7 am)
- Scenario 4: Base network, 100% demand (EQ occurs at 4 pm)
- Scenario 5: Base network, 50% demand (EQ occurs at 4 pm)
- Scenario 6: Base network, 30% demand (EQ occurs at 4 pm)

List of Scenarios (continued)

- Scenario 7: Damaged network, 100% demand (EQ occurs at 7 am)
- Scenario 8: Damaged network, 50% demand (EQ occurs at 7 am)
- Scenario 9: Damaged network, 30% demand (EQ occurs at 7 am)
- Scenario 10: Damaged network, 100% demand (EQ occurs at 4 pm)
- Scenario 11: Damaged network, 50% demand (EQ occurs at 4 pm)
- Scenario 12: Damaged network, 30% demand (EQ occurs at 4 pm)

- Six baseline scenarios and six damaged network scenarios

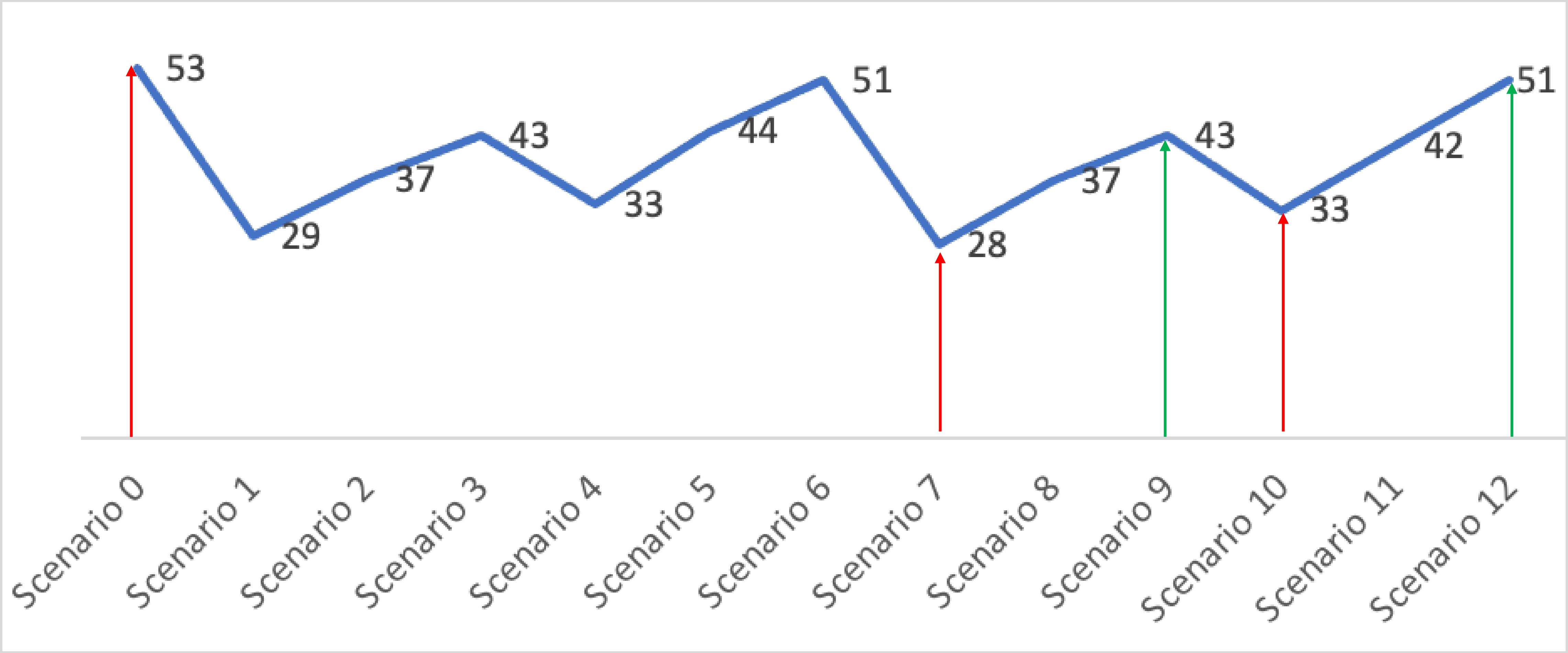
- 2 networks x 3 demands x 2 EQ times = 12 scenarios (plus one baseline)

- Scenario 1,4,7,10 (Worst cases) investigated congestion more specifically (mesoscopic)

Simulation Results – Average Speeds (mph)

Scenario	AM	MidDay	PM	NightTime	24-hour Average
Scenario 0	51.66	54.39	50.40	54.99	52.86
Scenario 1	24.17	26.28	30.84	34.17	28.87
Scenario 2	32.01	35.19	38.67	42.81	37.17
Scenario 3	38.84	41.90	44.35	47.91	43.25
Scenario 4	37.30	39.51	24.63	32.21	33.41
Scenario 5	45.49	46.79	42.86	40.58	43.93
Scenario 6	53.11	53.71	46.93	50.90	51.16
Scenario 7	22.42	24.89	30.31	33.60	27.81
Scenario 8	31.63	34.58	38.62	42.86	36.92
Scenario 9	38.41	41.95	44.50	48.17	43.26
Scenario 10	37.02	39.28	22.70	31.67	32.67
Scenario 11	44.58	41.63	42.84	38.62	41.92
Scenario 12	53.44	54.03	46.68	51.26	51.35

Average Speed across Network (mph)



AM Scenarios Comparison – Speed Maps

Baseline

Scenario 7 (100% demand)

Scenario 8 (50% demand)

Scenario 9 (30% demand)

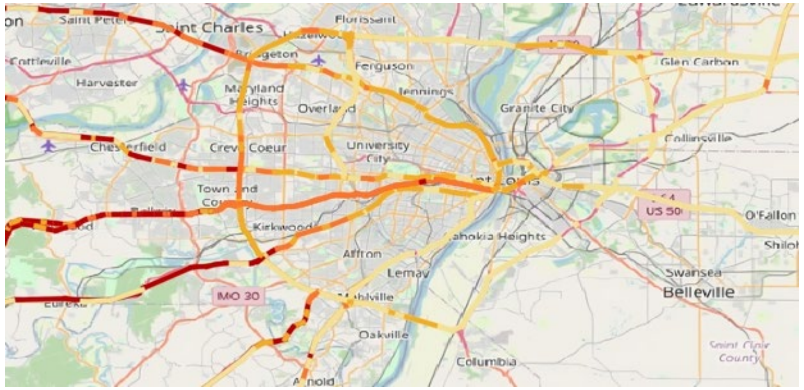
- 60-80 mph
- 40-60 mph
- 20-40 mph
- 0 - 20 mph

PM Scenarios Comparison – Speed Maps

Baseline

Scenario 10 (100% demand)

Scenario 11 (50% demand)



Scenario 12 (30% demand)

- 60-80 mph
- 40-60 mph
- 20-40 mph
- 0 - 20 mph

Tabletop exercise

Purpose

To help establish processes for predicting the traffic impacts of an earthquake in the St. Louis region under various assumptions and scenarios.

Overview

The discussion-based tabletop exercise was conducted at MoDOT's St. Louis Traffic Management Center on September 21, 2023. Participants included MoDOT staff from St. Louis and Central Office, Illinois DOT, Florissant Valley Fire Department, St. Louis County, St. Louis County Fire Department, State Emergency Management Agency, Missouri Department of Natural Resources, St. Louis City Fire Department, and Mercy Hospital.

Tabletop exercise

Discussion

- There is a need to ingress support resources, at least as crucial as evacuation.
- Evacuation destinations are also critical, as well as support to get people to those destinations (i.e., food, water, medical).
- Communications systems are critical to all elements of the response. Agencies are highly dependent on telecommunications. Systems are needed for internal agency communications at various levels, interoperability, communications to and from field devices, and public information.
- Accurate information to the public is critical to convey the evolving traffic situation, recommended actions, and public expectations.
- Supply chain and just-in-time deliveries are a big concern, particularly in the medical community.
- Significant infrastructure damage and utility issues (including pipelines) are still a concern.
- Resource management is critical for all agencies.

Conclusion

- **Understanding evacuation behavior**

From the survey responses, various types of data were explored, including socio-demographic factors and evacuation-related factors such as the perception and expectation of evacuees concerning emergency evacuation during earthquakes.

- **Evacuation model development**

Macroscopic and mesoscopic traffic simulation models were created to predict traffic flow patterns under various earthquake scenarios and varying demand levels. These models offer valuable insights for evacuation planning and traffic management during earthquakes (and other disasters).

Conclusion

- **Analyze traffic impacts**

The simulations revealed significant regional traffic congestion, particularly on major highways. Several bottlenecks on: US 100 and I-44 in St. Louis City and St. Louis County, and I-70 and US 67 in St. Louis County

- **Importance of communication and collaboration**

The tabletop exercise highlighted the critical role of communication and collaboration between MoDOT, emergency responders, and other stakeholders in ensuring a coordinated and efficient response to an earthquake event.

Questions

Contacts:

Chris Engelbrecht – christopher.engelbrecht@modot.mo.gov

Rick Bennett – richard.e.bennett@wsp.com