Towards Resilient, Equitable & Sustainable Transportation (REST) Systems using Topological Credentials & Network Interdependencies

Transportation, Risk and Information CommonS Laboratory [TRICS Lab] @ OU

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Date: 10.17.2023

Pathway

Transportation, Risk and Information CommonS Laboratory [TRICS Lab] @ OU

Bangladesh University of Engineering and Technology

PURDUE UNIVERSITY

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

FIU

Pathway

Transportation, Risk and Information CommonS Laboratory [TRICS Lab] @ OU

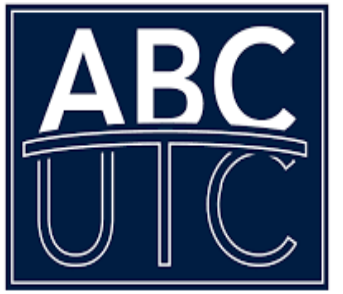
Formula: [Civil (Transportation) + Systems] Engineering * (Network + Data + Social) Science = TRICS

Pathway

Transportation, Risk and Information CommonS Laboratory [TRICS Lab] @ OU

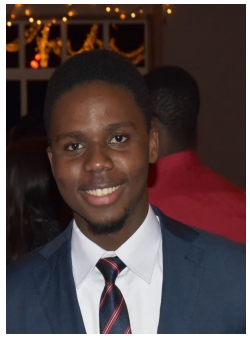
SOUTHERN PLAINS
TRANSPORTATION CENTER

OKLAHOMA
Transportation



ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

Team - Present



Menzi

Rabia

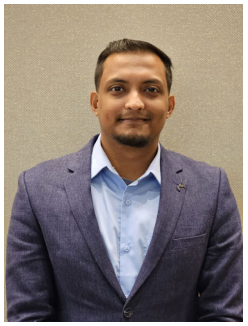
B.Sc.

Momin

Imran

Khalida

Ph.D.



Shadman

Vineela

Maisha

M.Sc.

Team - Alumni

James

Juan

Meleik

Mark

B.Sc.

Priyanka

Samir

Fariha

Rusho

M.Sc.

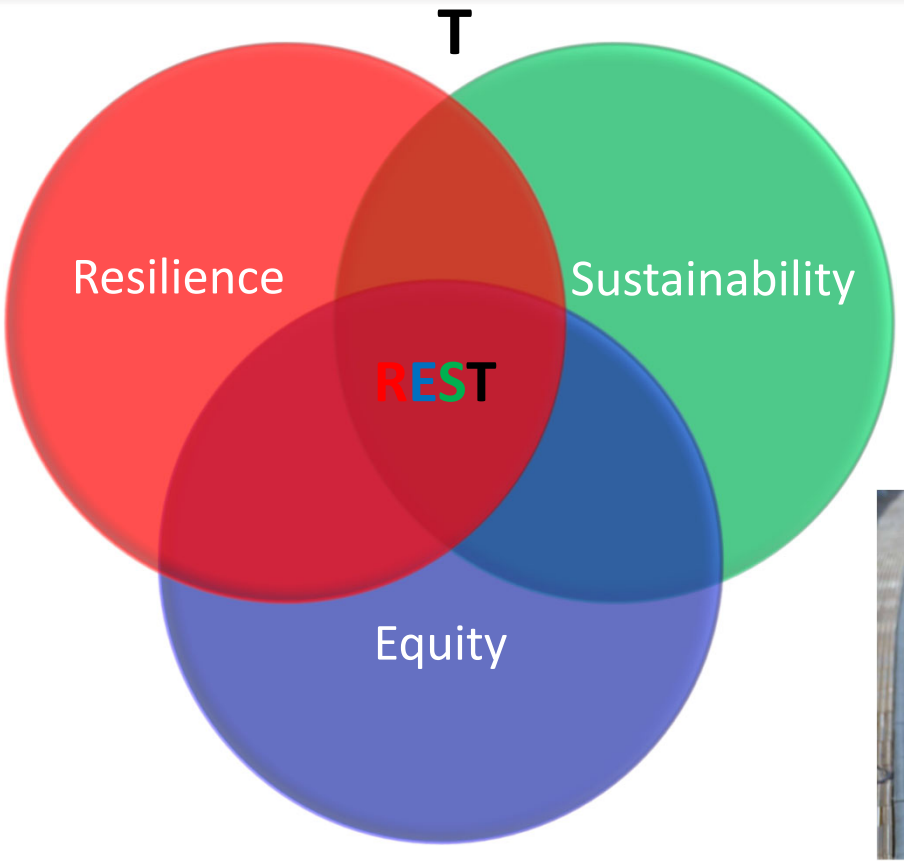
Ashraf

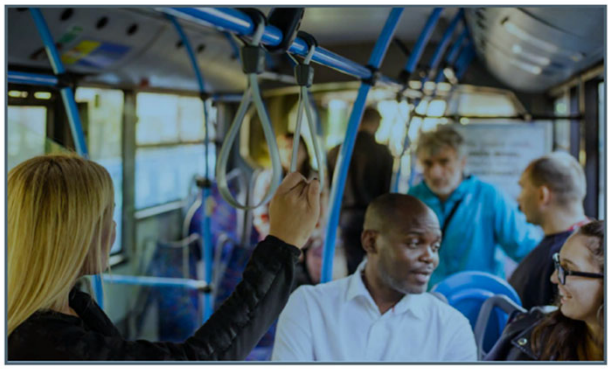
Nizamul

Rakib

Ph.D.

Resilient, Equitable & Sustainable Transportation (RESTT) Systems





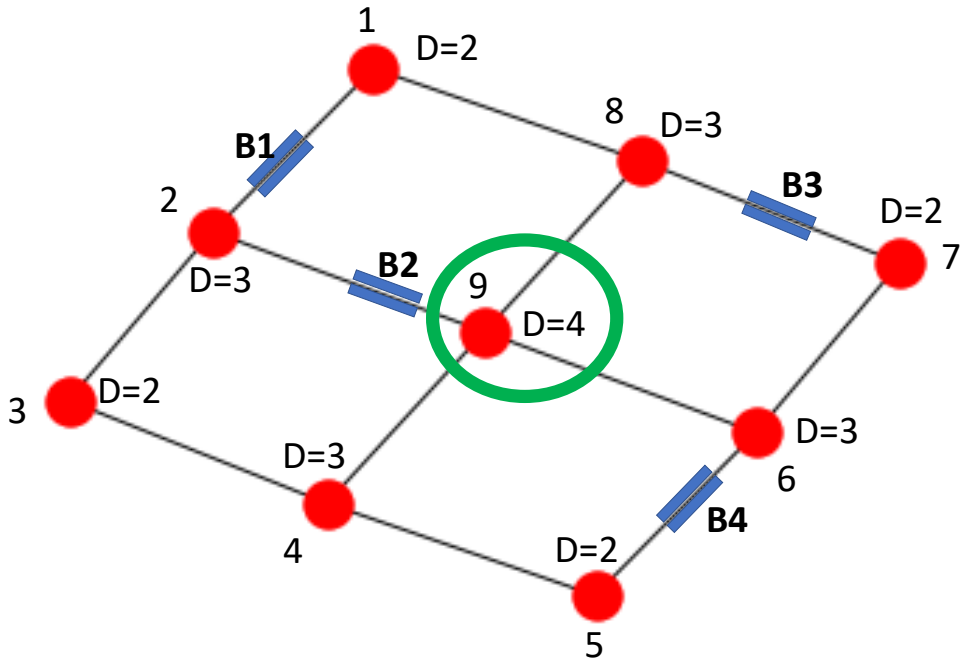
https://www.transportation.gov/dot-strategic-plan

https://www.news9.com/story/5e361f9c2f69d76f62044678/corps-of-engineers-photos-show-flooded-bridge-on-washita-river

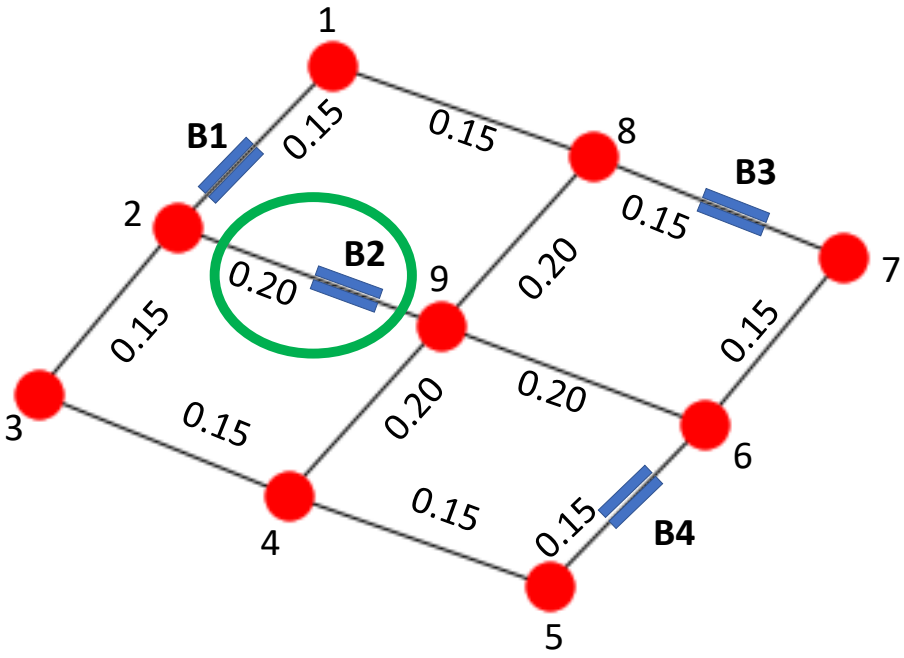
https://www.globalstewards.org/alternative-transportation.htm

Topological Credentials

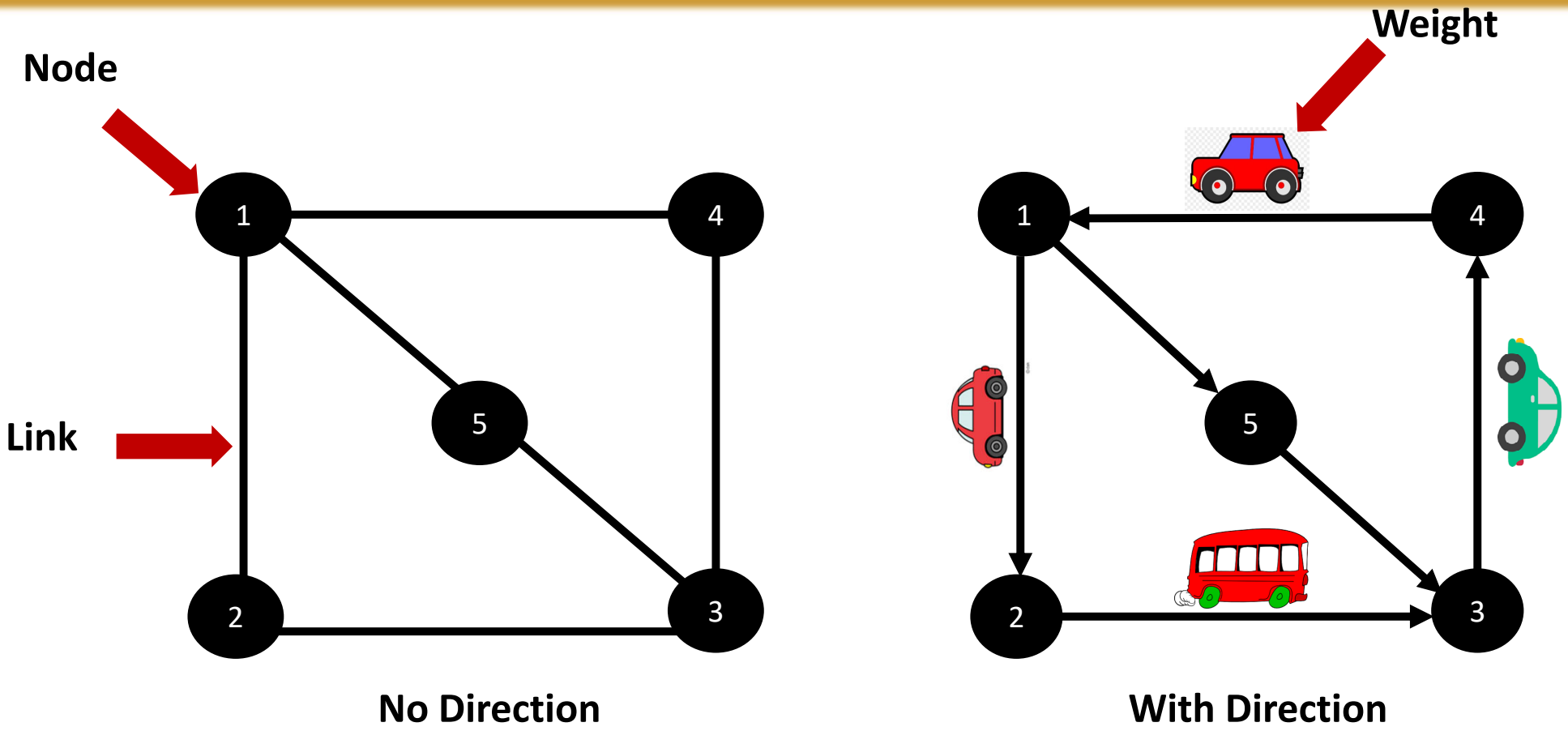
Node Properties



Link Properties

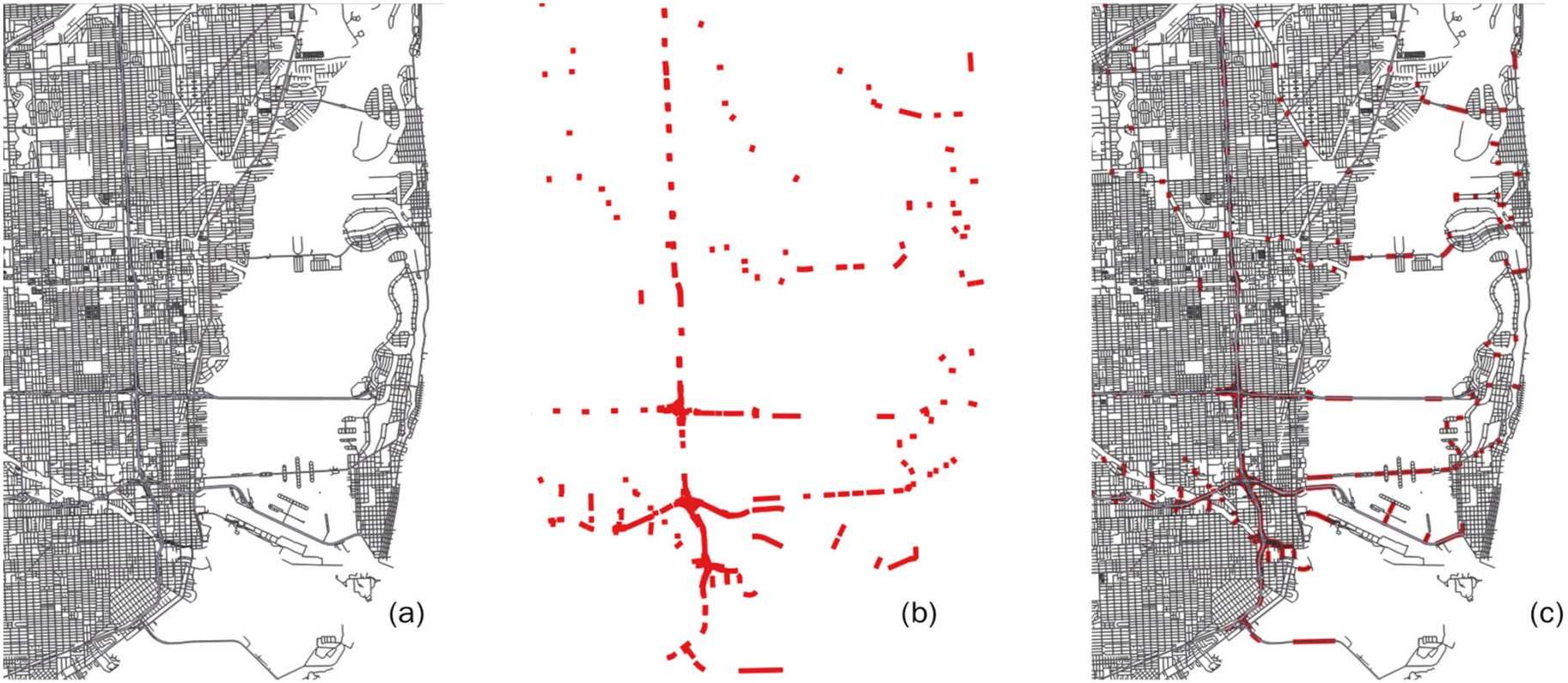


Topological Credentials

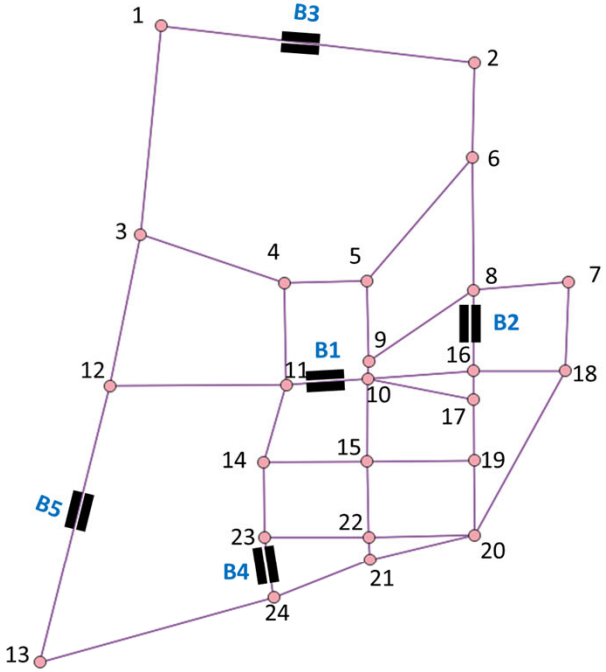


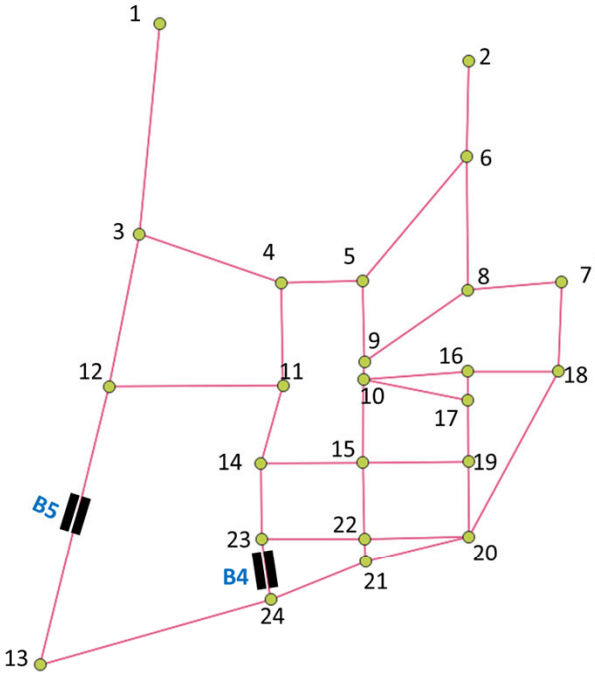
Topological Credentials: Accelerated Bridge Construction

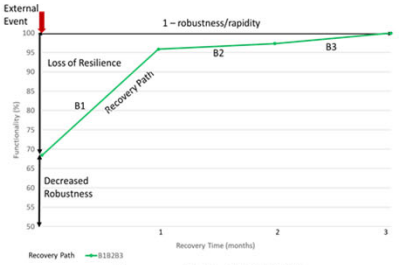
- ***Complex Networks Perspectives*** *towards* ***Accelerated Bridge Construction (ABC)***



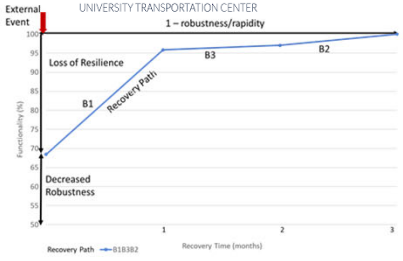
Topological Credentials: Bridge Recovery Schemes



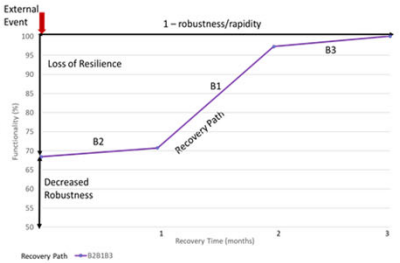




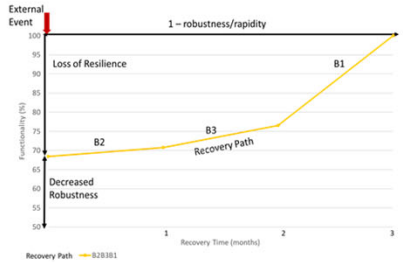
Recovery Path: B1-B2-B3



Recovery Path: B1-B3-B2



Recovery Path: B2-B1-B3



Recovery Path: B2-B3-B1

Recovery Path: B3-B1-B2

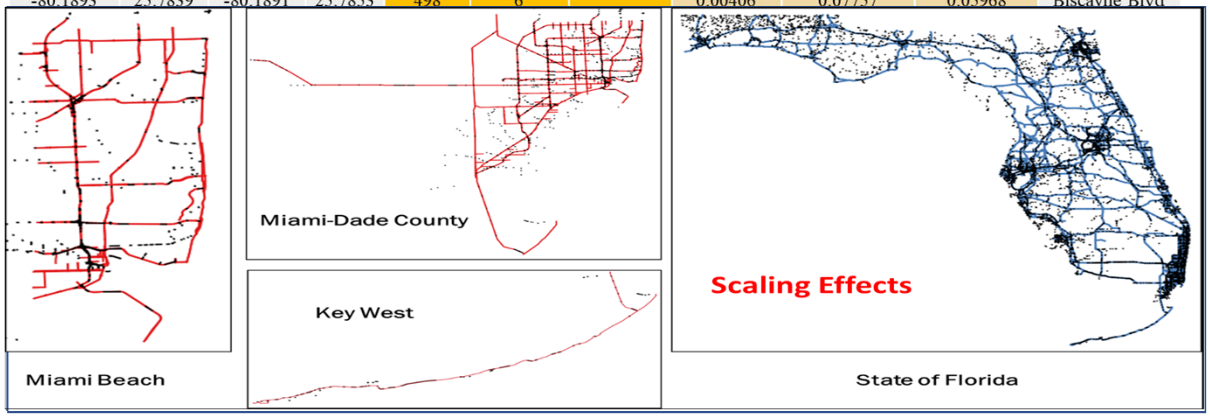
Recovery Path: B3-B2-B1

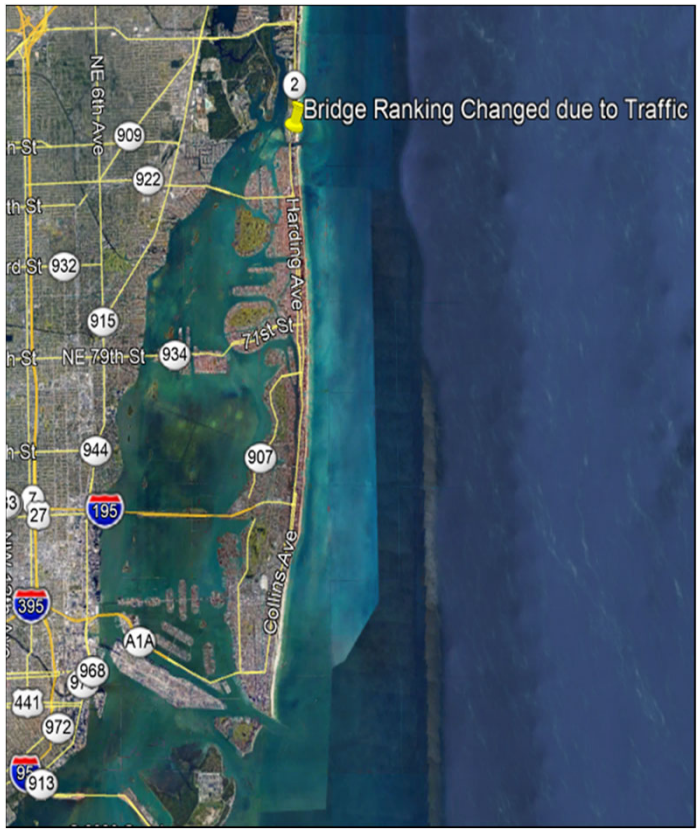
Ahmed, M. A., **Sadri, A. M.,** Mehrabi, A., & Azizinamini, A. (2022). Identifying topological credentials of physical infrastructure components to enhance transportation network resilience: case of Florida bridges. *Journal of transportation engineering, Part A: Systems*, *148*(9), 04022055.

Topological Credentials: Network Scaling Effects

- ***Complex Networks Perspectives*** *towards* ***Accelerated Bridge Construction (ABC)***

Link Coordinates				Bridge Rank			Edge Betweenness Centrality			
Start Long.	Start Lat.	End Long.	End Lat.	Florida	Miami-Dade	Miami Beach	Florida	Miami-Dade	Miami Beach	Roads/Bridges
-80.1220	25.9299	-80.1219	25.9304	258	10	1	0.01022	0.07515	0.08365	Collins Ave
-80.1227	25.8871	-80.1220	25.9299	355	20	2	0.00747	0.07327	0.07132	Collins Ave
-80.1840	25.8327	-80.1841	25.8333	494	19	3	0.00412	0.07330	0.06068	Biscayne Blvd
-80.1841	25.8334	-80.1846	25.8478	491	22	4	0.00418	0.07242	0.06039	Biscayne Blvd
-80.1841	25.8333	-80.1841	25.8334	493	21	5	0.00414	0.07261	0.06026	Biscayne Blvd
-80.1893	25.8124	-80.1891	25.8134	502	18	6	0.00400	0.07403	0.06015	Biscayne Blvd
-80.1891	25.8134	-80.1869	25.8255	503	17	7	0.00400	0.07404	0.06009	Biscayne Blvd
-80.1893	25.7820	-80.1893	25.7839	497	7	8	0.00406	0.07757	0.05974	Biscayne Blvd
-80.1893	25.7839	-80.1891	25.7853	498	6	9	0.00406	0.07757	0.05968	Biscayne Blvd





Topological Credentials

- ***Complex Networks Perspectives*** *towards* ***Accelerated Bridge Construction (ABC)***


US011501236B2

(12) **United States Patent**
Sadri et al.

(10) **Patent No.: US 11,501,236 B2**
(45) **Date of Patent: Nov. 15, 2022**

(54) **SYSTEMS AND METHODS FOR ANALYZING A PHYSICAL INFRASTRUCTURE**

(71) Applicants: **Arif Mohaimin Sadri**, Miami, FL (US); **Md Ashraf Ahmed**, Miami, FL (US)

(72) Inventors: **Arif Mohaimin Sadri**, Miami, FL (US); **Md Ashraf Ahmed**, Miami, FL (US)

(56) **References Cited**

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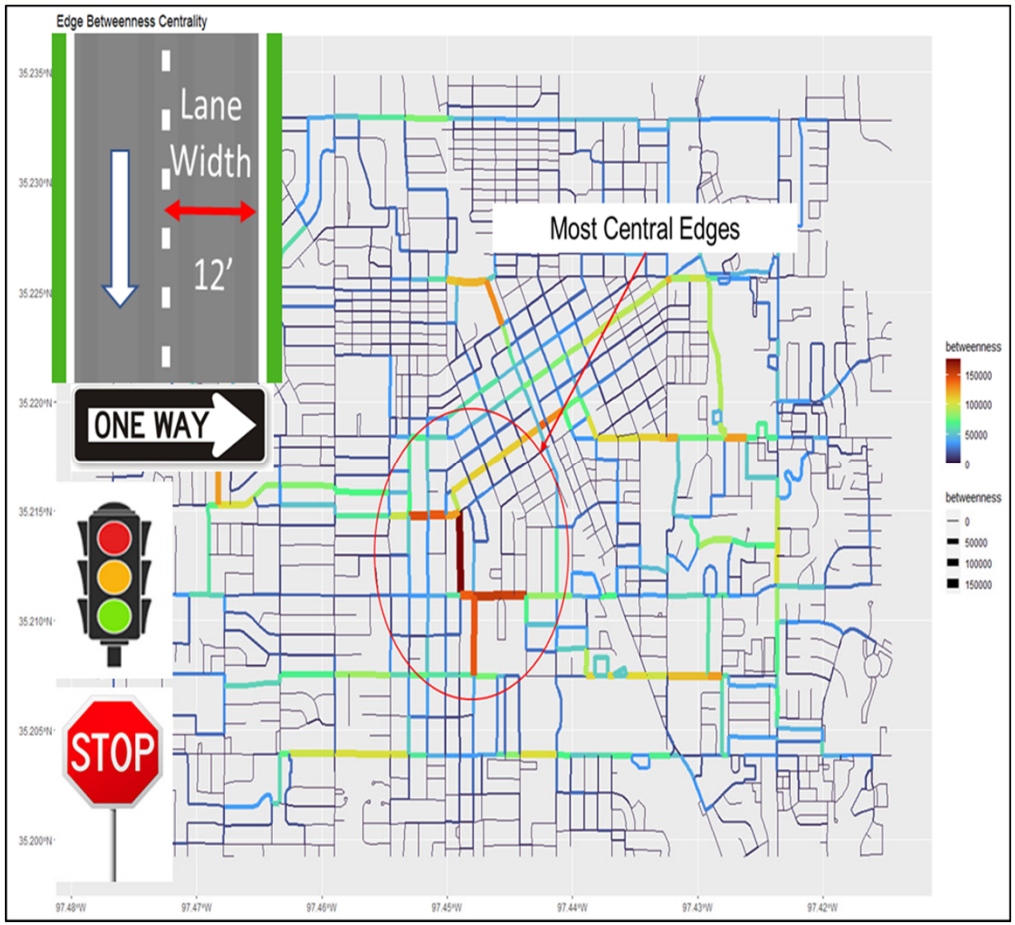
2013/0269125	A1*	10/2013	Grace	E01D 19/125 14/73
2017/0122909	A1*	5/2017	Goroshevskiy	G01N 33/20

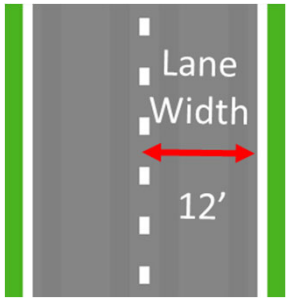
FOREIGN PATENT DOCUMENTS

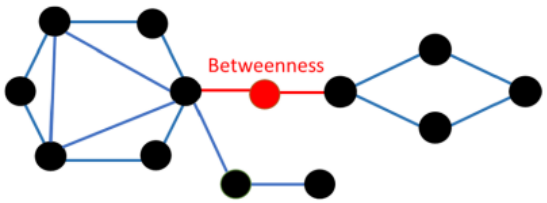
CN	107247826 A	*	10/2017

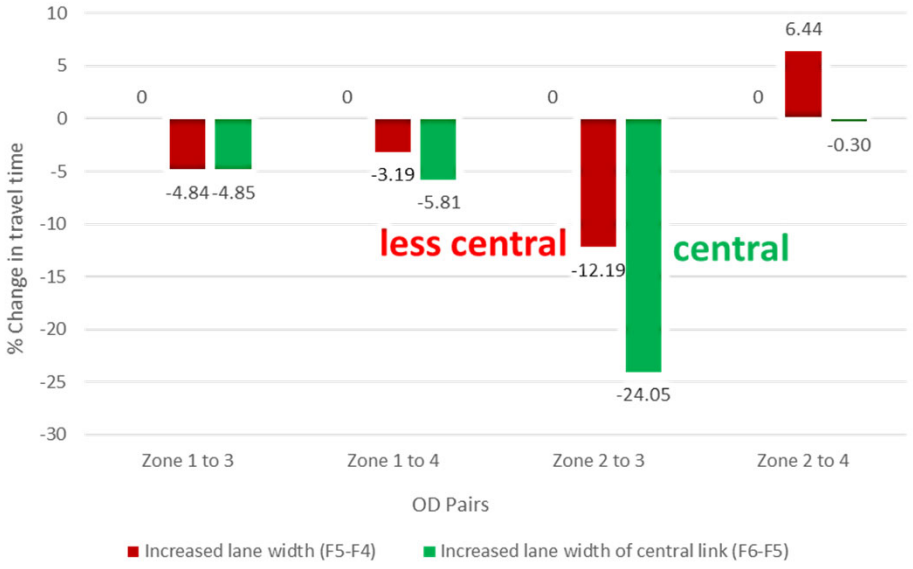
Topological Credentials: Network Interventions

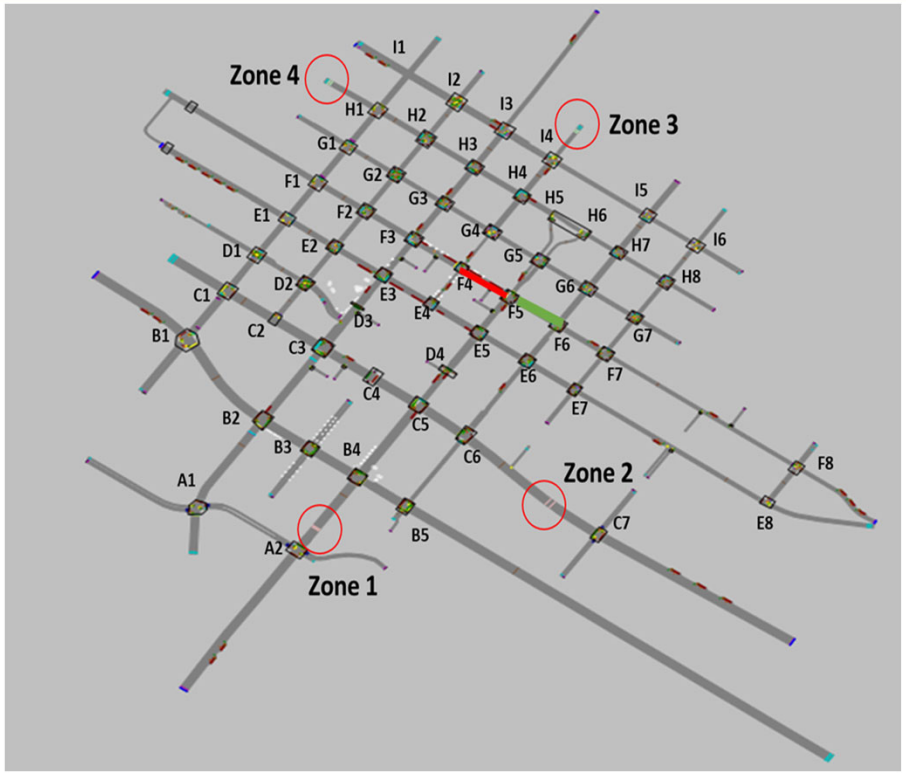


Topology Based Design Interventions









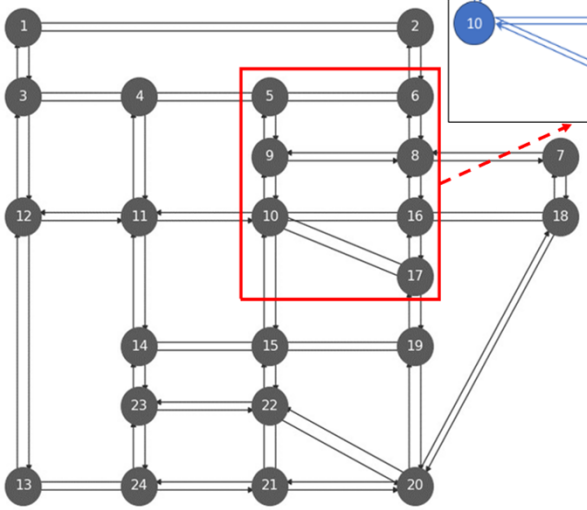
Ahmed, M.A., Kays, H.M.I. & **Sadri, A.M.** *Centrality-based lane interventions in road networks for improved level of service: the case of downtown Boise, Idaho*. Appl Netw Sci 8, 2 (2023). https://doi.org/10.1007/s41109-023-00532-z

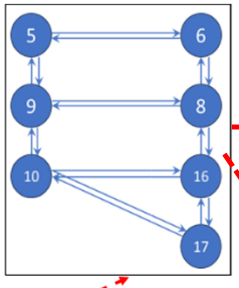
Topology Based Directionality Interventions

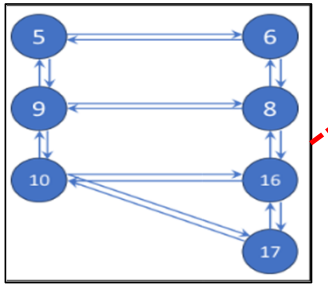
Kays, H.M.I., Momin, K.A., Muraleetharan, K. K. "Muralee" & **Sadri, A.M.** *A Data-driven Resilience Framework of Directionality Configuration based on Topological Credentials in Road Networks*. 2024 TRB Annual Meeting (Paper No. TRBAM-24-04838)

A Sample Network

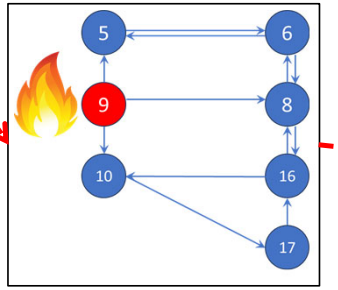
All-to-All TAZ road network



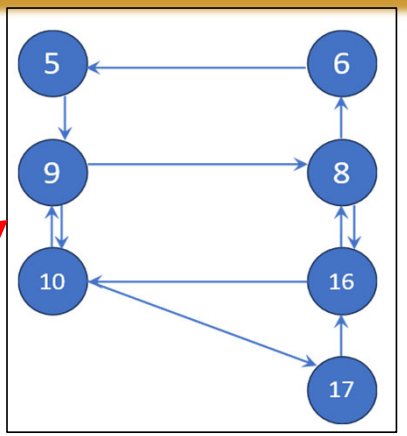




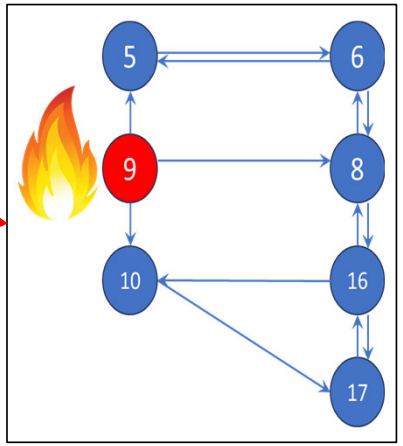
Daily Traffic



Evacuation Traffic



Optimal Configuration for **Daily Traffic**

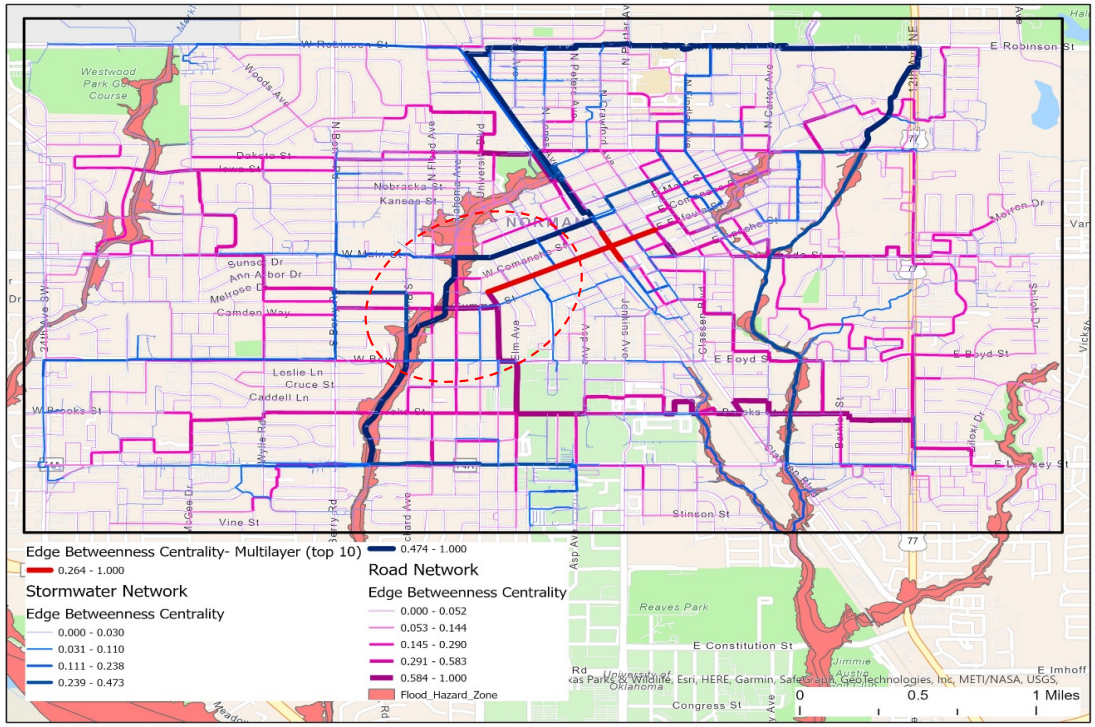


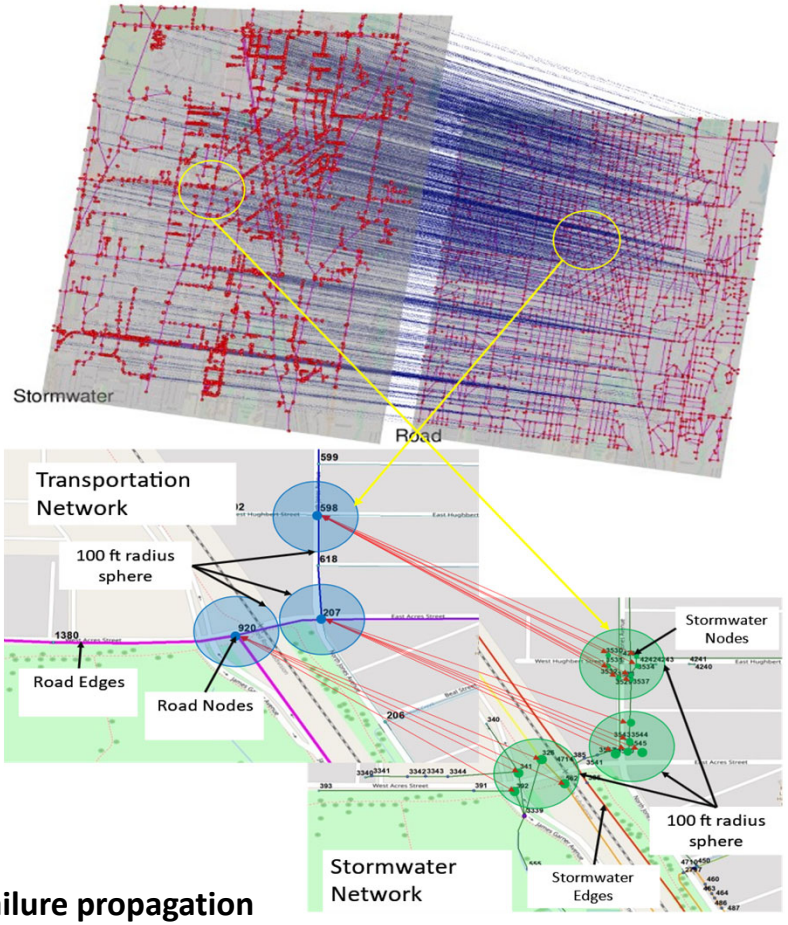
Optimal Configuration for **Evacuation Traffic**

Systematic Directionality Intervention: 16% travel time improvement during major ***Evacuation Scenario***

Network Interdependencies

Kays, H. M. I., **Sadri, A. M.,** Muraleetharan, K. K. "Muralee", Harvey, P. S., & Miller, G. A. (2023). Exploring the Interdependencies Between Transportation and Stormwater Networks: The Case of Norman, Oklahoma. Transp Research Record, 0(0). https://doi.org/10.1177/03611981231189747

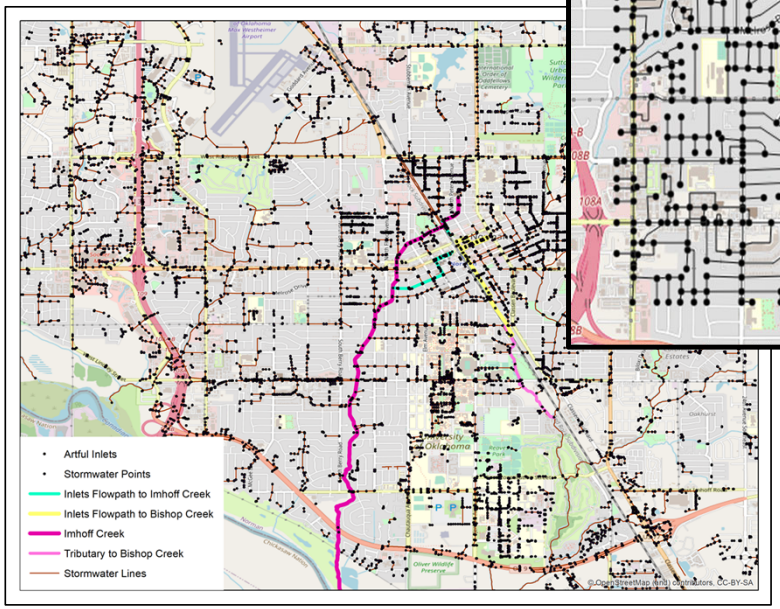


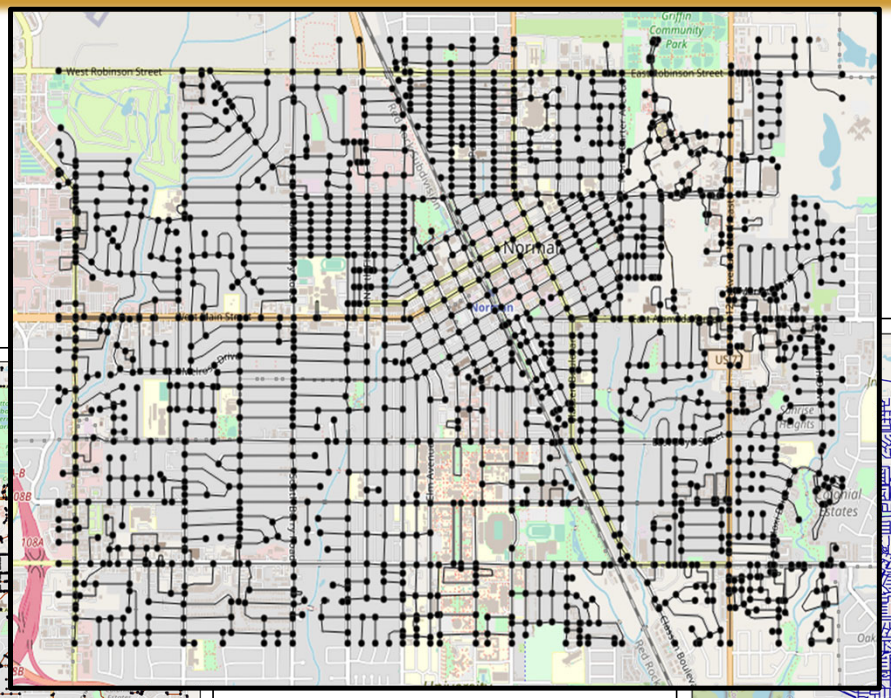


Developing a **GIS**-based **multi-layered network interface** to identify the **thresholds** of **failure propagation**

Network Interdependencies

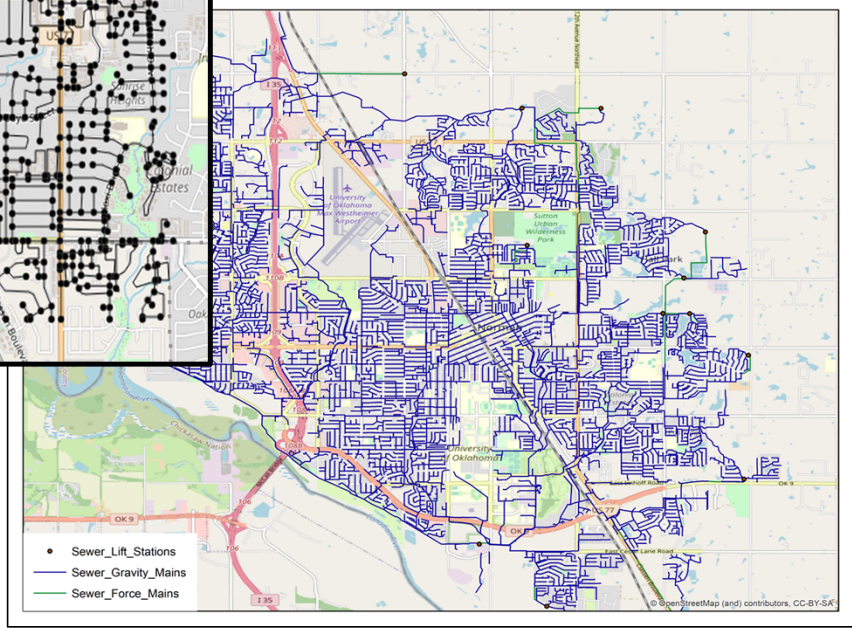
Storm water Network





Road Network

Sewer Network



Social-Physical Coupling

INPUT

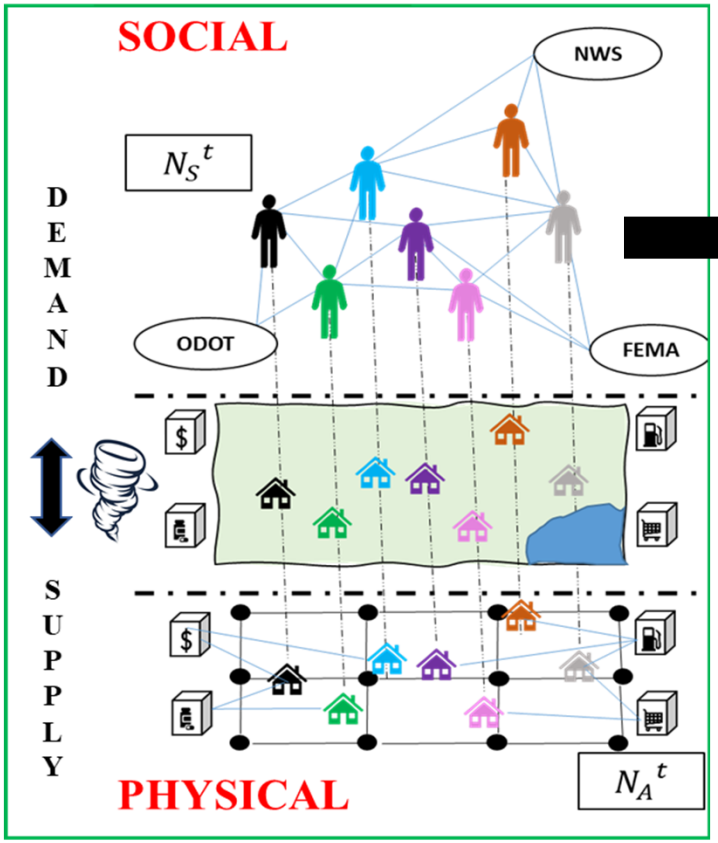
Demand: Human Factors

Supply: Infrastructure

Weather **D**ynamics

Community **F**actors

Stakeholder **P**riorities



OUTPUT

Network **I**nterventions

System **I**mpact **A**ssessments

Tradeoffs: **A**ir vs. **S**urface

Tradeoffs: **D**emand vs. **S**upply

Resilience **M**etrics

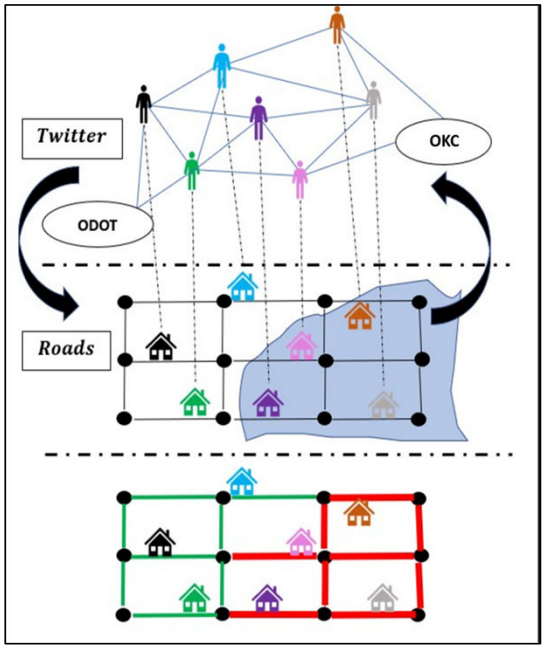
Equity **M**etrics

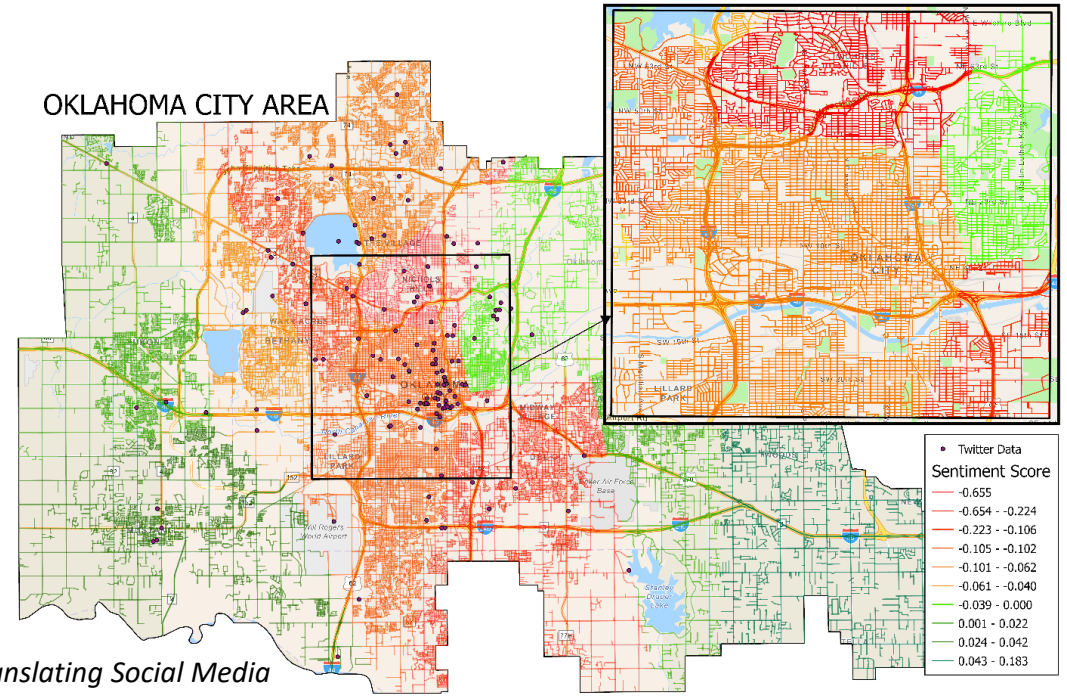
Model: **D**ata-driven **S**ocial-**P**hysical **N**etwork **I**nterdependencies

Social-Physical Coupling

Relevant Tweets Generated from Oklahoma (Oct 25-30, 2020)

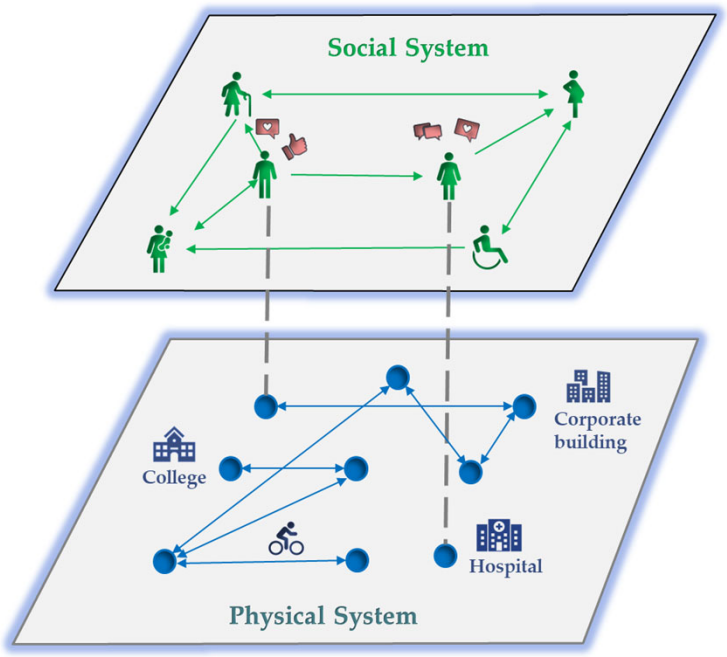
blocked due to fallen power cables in cleveland on i44 eb between sw 89th stexit 113 and sw 74th stexit 114 okctraffic → (Sentiment score: -0.56)

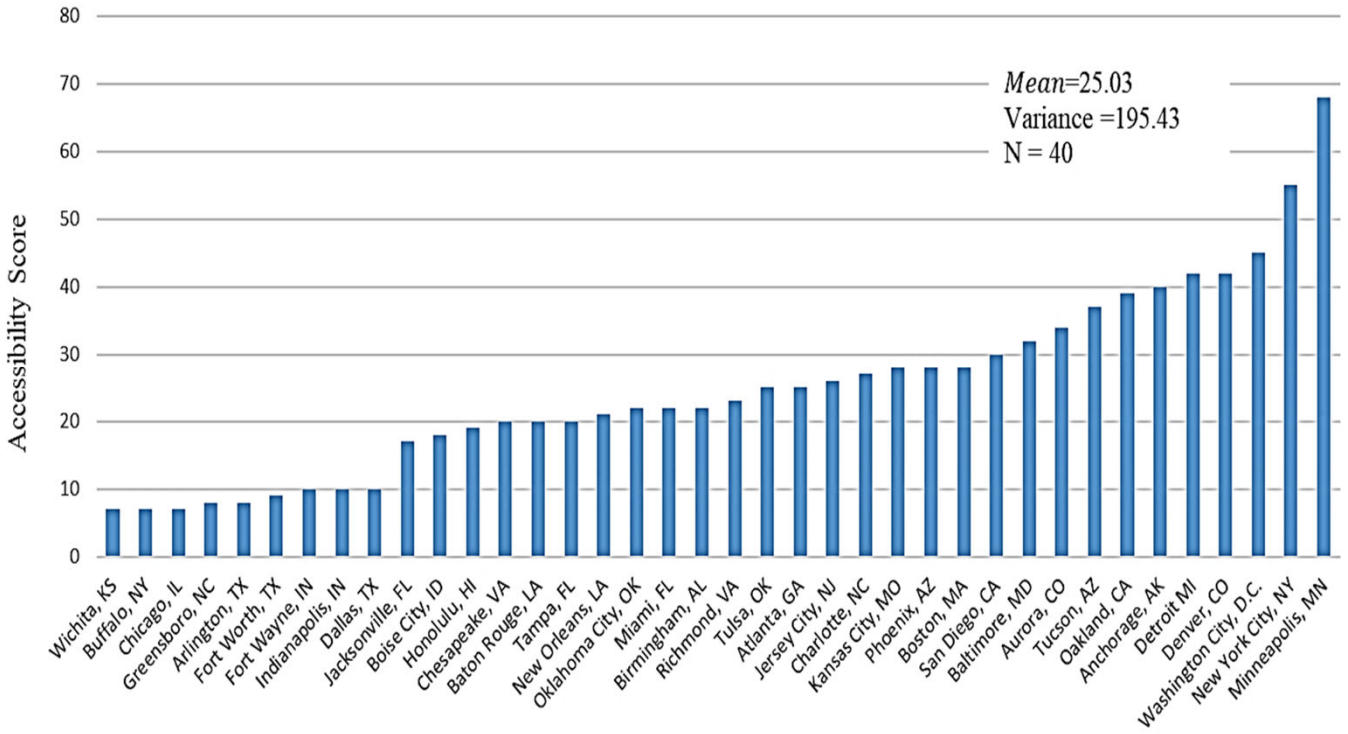




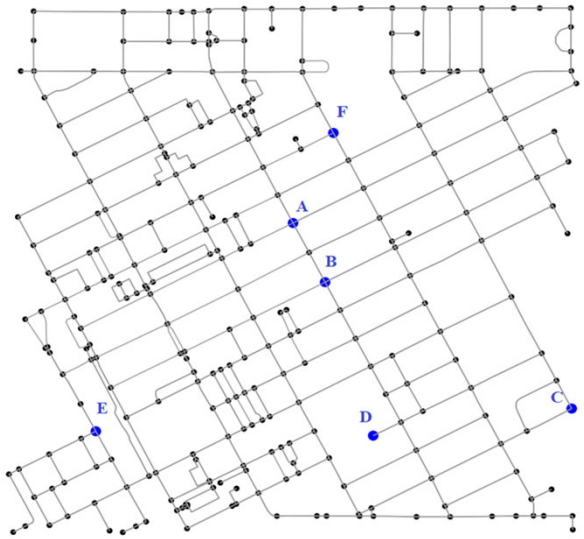
Kays, H.M.I., Momin, K.A., Muraleetharan, K. K. "Muralee" & **Sadri, A.M.** *Translating Social Media Crisis Narratives into Road Network Utilization Metrics: The Case of COVID-19 and 2020 Oklahoma Ice Storm*. 2024 TRB Annual Meeting (Paper No. TRBAM-24-03452)

Social-Physical Coupling: Bike Networks

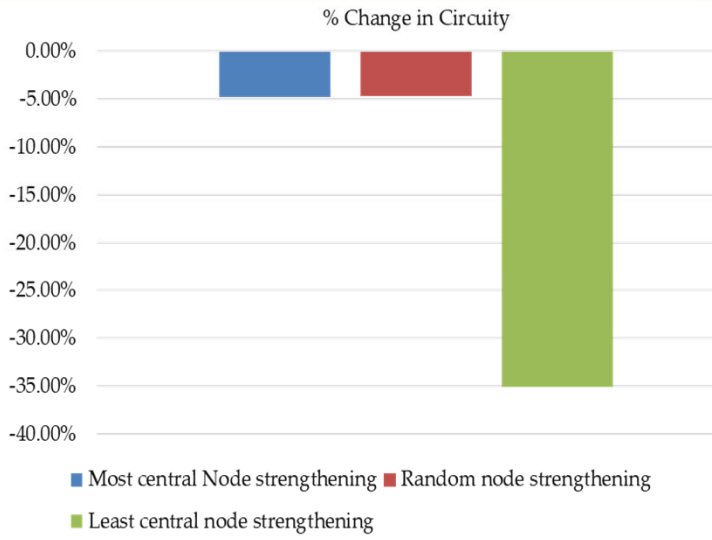


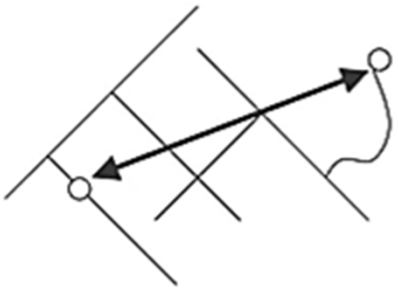


Social-Physical Coupling: Bike Networks



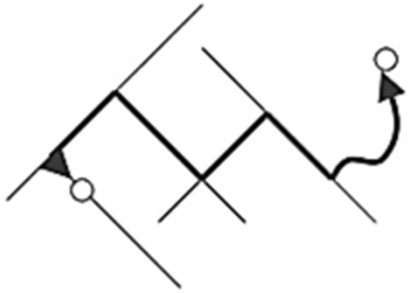
Case	Label	Betweenness Centrality
Most Central Nodes	A	0.28562265
	B	0.274671533
Least Central Nodes	C	0
	D	0
Random Nodes	E	0.052196417
	F	0.034304357





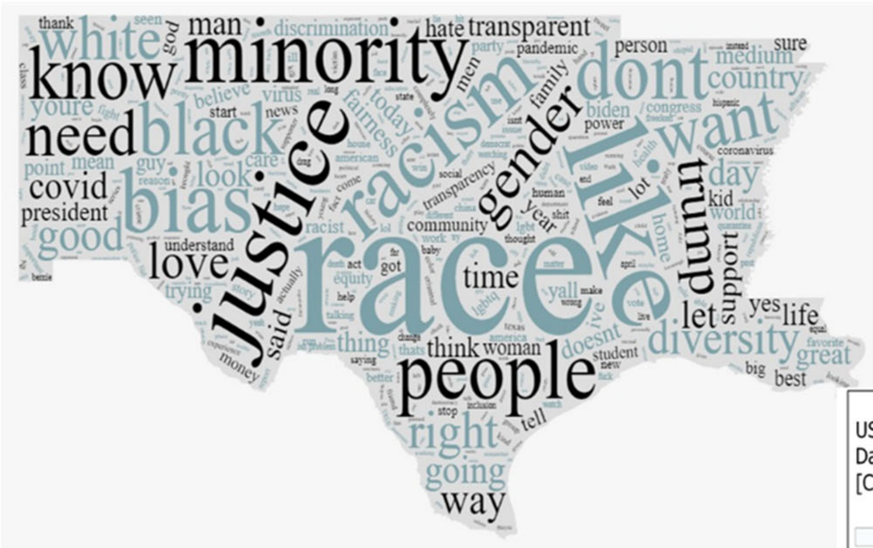
Euclidean Distance

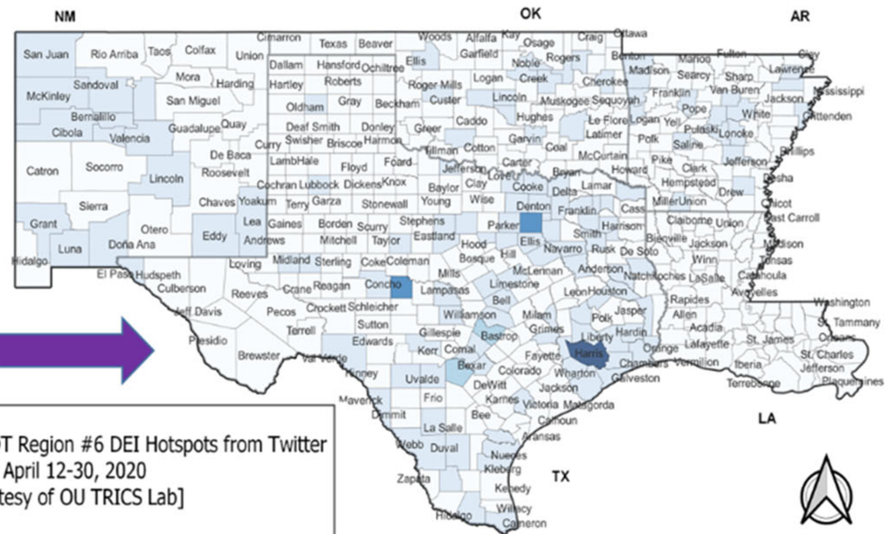
- **Circuity ↓ Accessibility ↑**
- **Income ↑ Accessibility ↑**
- **Bike Users ↑ Accessibility ↑**



Actual Distance

DEIA Hotspots in USDOT Region 6 on Twitter

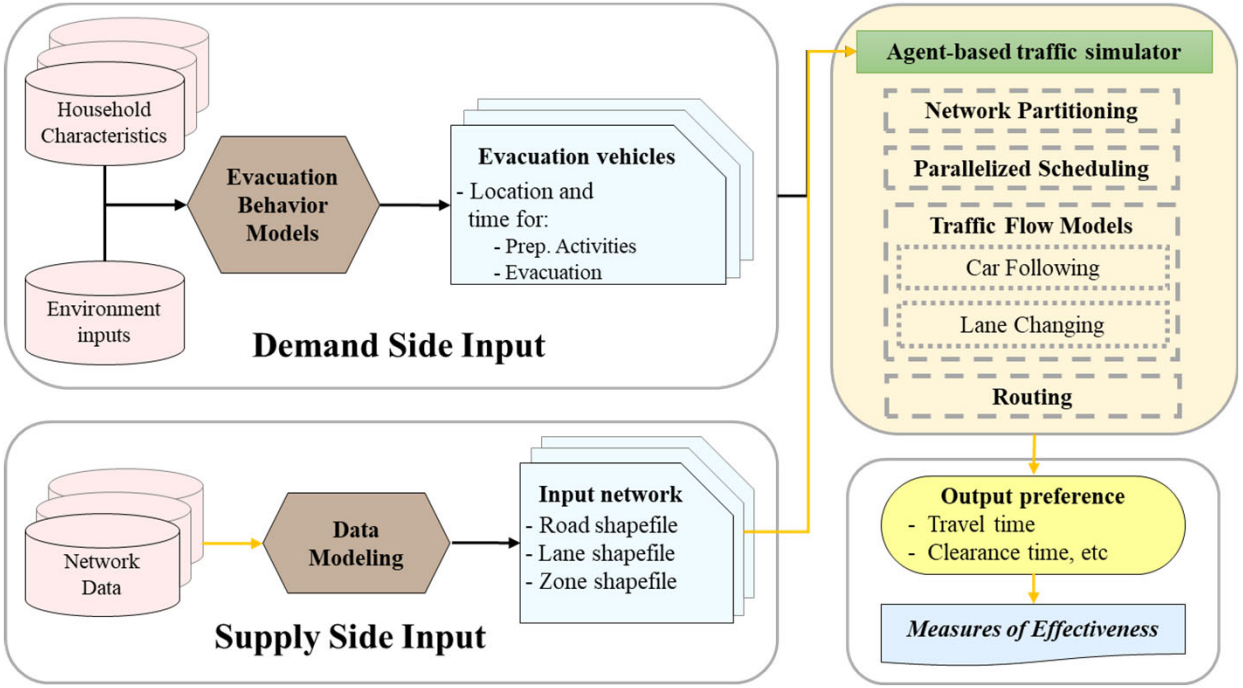


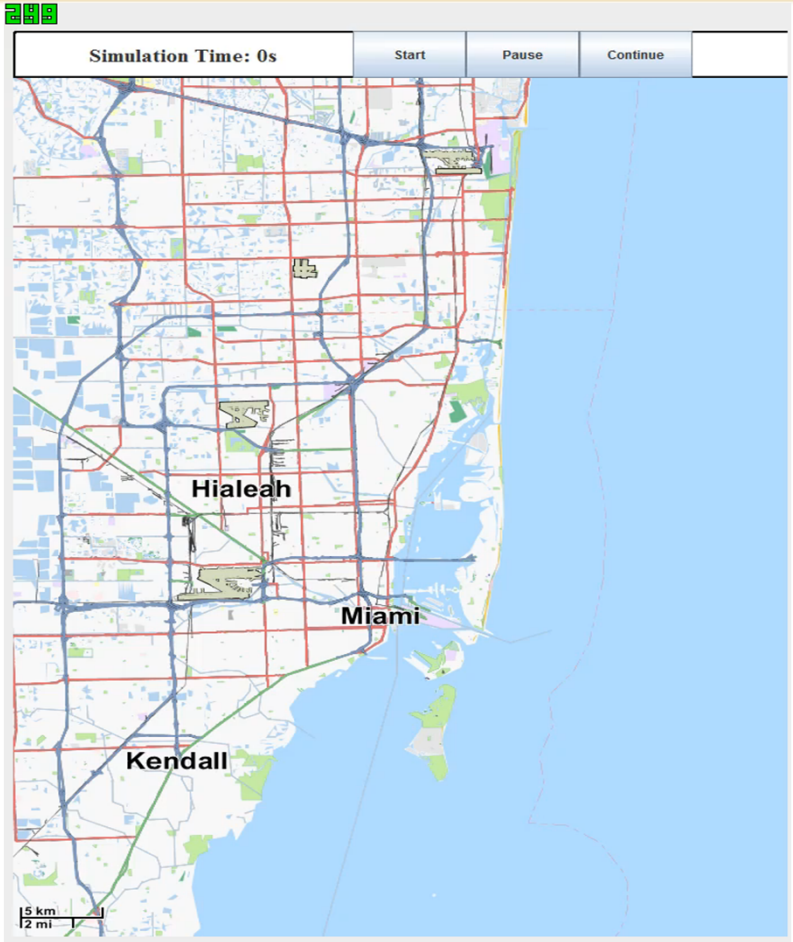


USDOT Region #6 DEI Hotspots from Twitter
Date: April 12-30, 2020
[Courtesy of OU TRICS Lab]

- 0 - 0
- 0 - 189
- 189 - 283
- 283 - 377
- 377 - 472
- 472 - 566

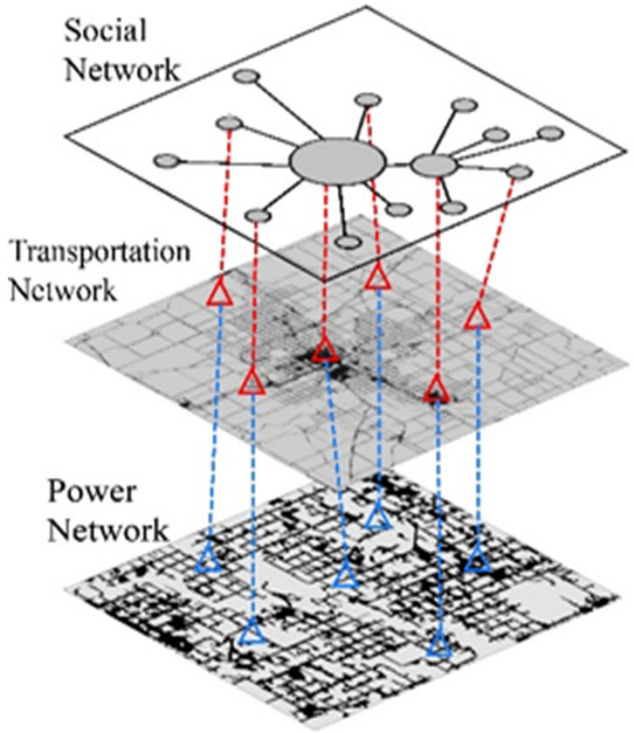
System-wide Impact Assessments: Agent-based Modeling





Conclusions and Next Steps

Resilient, Equitable & Sustainable Transportation (REST) Systems



Topological Credentials

System Interdependencies

Social-Physical Coupling

System-wide Impacts

TRICS Lab @ OU

Thank you!

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