Infrastructure Town Hall

Shahram Pezeshk, Ph.D., P.E., F.ASCE
Department of Civil Engineering
The University of Memphis

April 14, 2023

The Intend of this Town Hall

- To stimulate discussion and help determine a **strategic direction for the college**.
- To Identify areas with the greatest **potential for interdisciplinary collaboration**.

Agenda

- **Background**
- Shahram Pezeshk, Civil Engineering
- Stephanie Ivey, Civil Engineering
- Alexander Headley, Mechanical Engineering
- Sabya Mishra and Mihalis Golias, Civil Engineering
- Mohd Hasan Ali, Electrical and Computer Engineering
- Discussion

Infrastructure

Air Ports

World's Largest Cargo Airport

Source: Phyllis J. Steckel


CN - Chicago
BNSF - West
CSX -NE
UP - West
NS - Atlanta
CN – New Orleans
Five Class 1 Railroads
• BNSF
• CSX
• UP
• NS
• CN

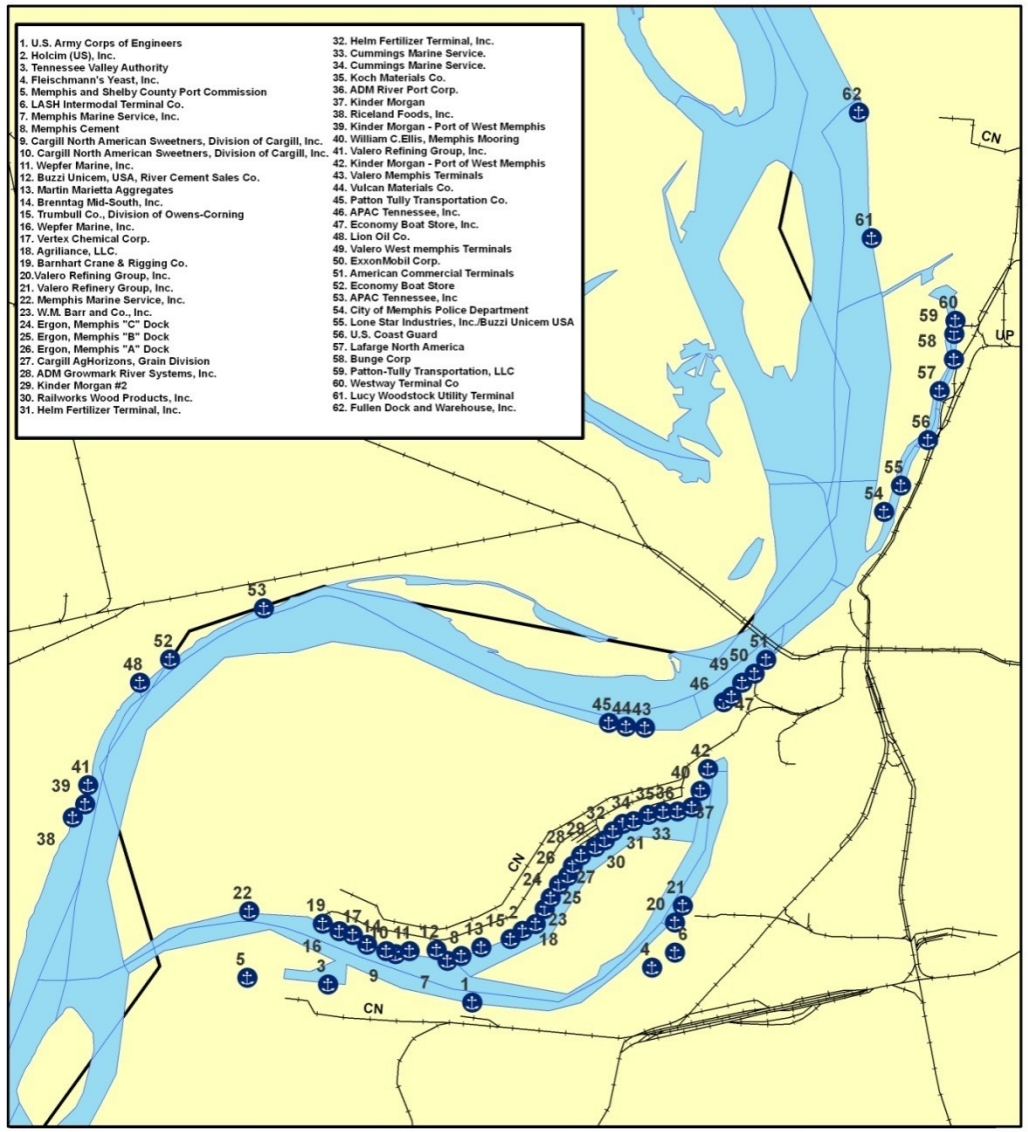
River Transportation – Memphis

- Second-largest port on the Mississippi
- First in foreign import tonnage
- 28% of all US waterborne commerce
- $6.7 billion economic impact
- 5,500+ direct and 9,900+ indirect jobs

Source: Phyllis J. Steckel

Source: Phyllis J. Steckel

Memphis Ports and Terminals Map



Memphis Area Chamber Infrastructure Study

CIFTS

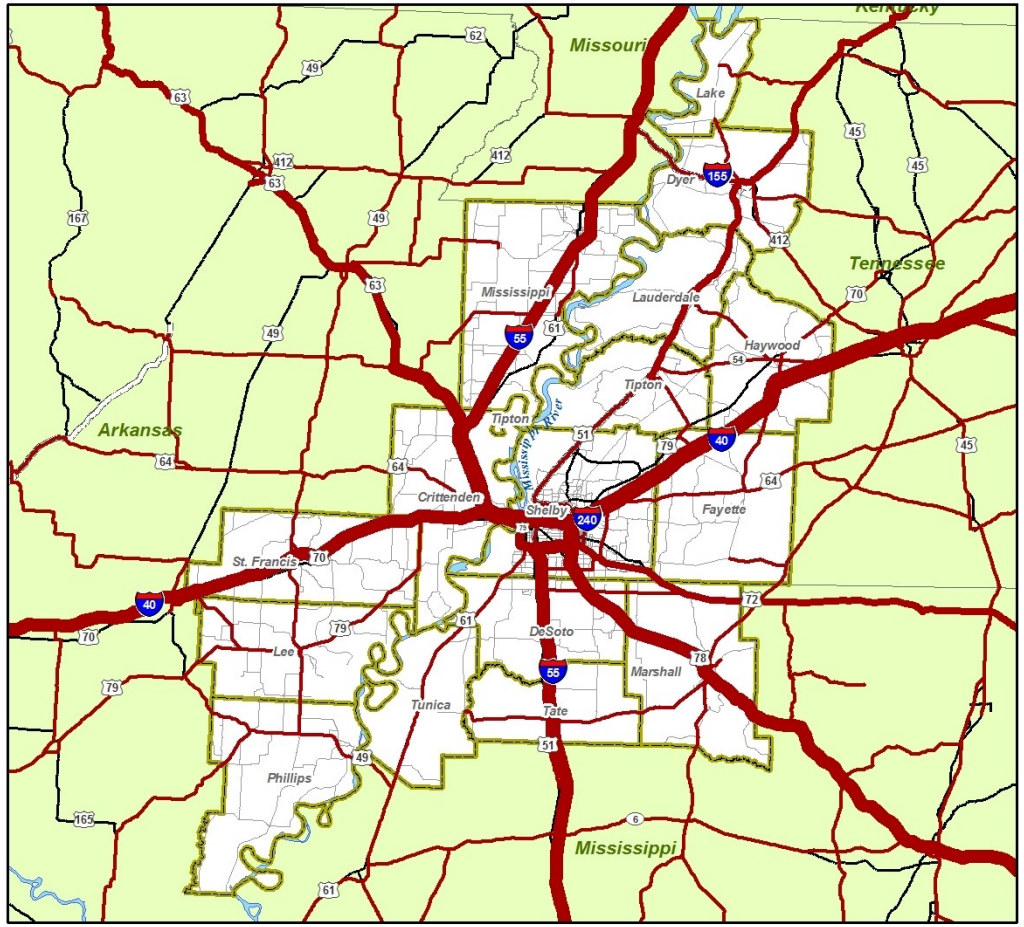
Source: US Army Corps of Engineers

Intermodal Terminals

Memphis Area Chamber Infrastructure Study CIFTS

Data source: Research and Innovation Technology Administration (RITA) & University of Memphis

Inbound Truck Tons (Year 2006) for Memphis Study Area



Legend

Inbound Truck Tons (2006):

- Less than 1 Million
- 1 - 2.5 Million
- 2.5 - 5 Million
- 5 - 10 Million
- More than 10 Million

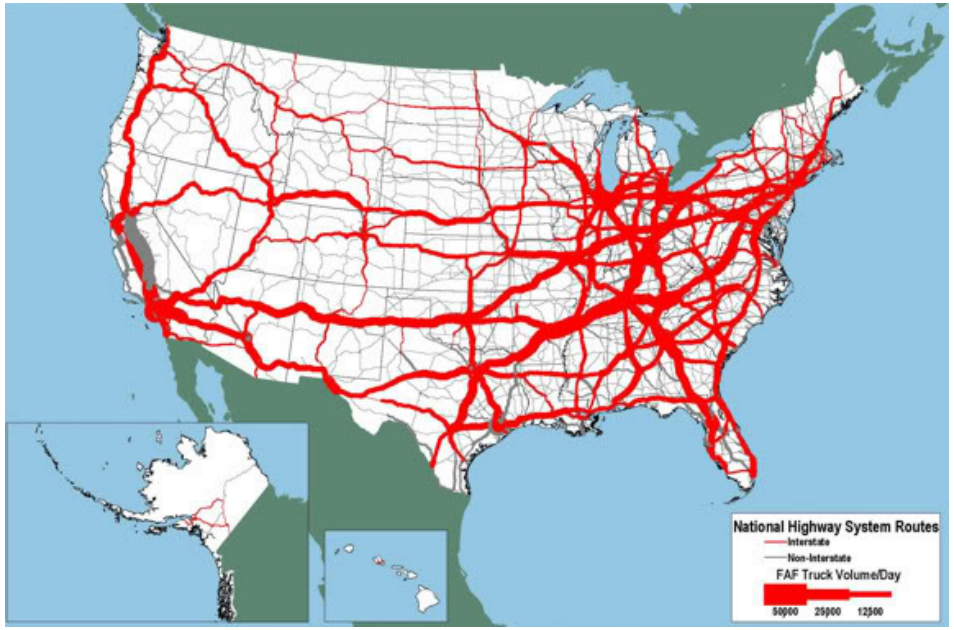
- Limited Access
- Highway
- Study Area Counties
- Water bodies (Lakes, Bays, ...)
- Study Area Counties

N W E S

Source: Global Insight, Transearch Data, 2006

Interstate Highways….

- Interstate 40 – busiest trucking corridor in US
- Interstate 55
- 490 trucking terminals



Source: Phyllis J. Steckel

Infrastructure

Infrastructure Investment and Jobs Act

- The Senate's passage of the Infrastructure Investment and Jobs Act, the **largest long-term investment in our infrastructure** and competitiveness in nearly a century.
- **Tennessee** would expect to receive **$5.8 billion for federal-aid highway** apportioned programs and **$302 million for bridge replacement and repairs**.
- **Tennessee** can also compete for the **$12.5 billion Bridge Investment Program for economically significant bridges** and nearly **$16 billion of national funding in the bill dedicated to major projects that will deliver substantial economic benefits to communities**.

Infrastructure

- Tennessee would expect to receive **$630 million over five years** under the Infrastructure Investment and Jobs Act **to improve public transportation** options across the state.
- Under the Infrastructure Investment and Jobs Act, Tennessee would expect to receive **$88 million** over five years to support the **expansion of an EV charging network in the state. Tennessee** will also **have the opportunity to apply for the $2.5 billion in grant funding dedicated to EV charging in the bill**
- Tennesseans will also benefit from the bill's historic **$3.5 billion** national investment in weatherization which will **reduce energy costs** for families.
- Under the Infrastructure Investment and Jobs Act, based on the traditional state revolving fund formula, **Tennessee** will expect to receive **$697 million** over five years to **improve water infrastructure** across the state and ensure that clean, safe drinking water is a right in all communities.

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- Stephanie Ivey, Civil Engineering
- Alexander Headley, Mechanical Engineering
- Sabya Mishra, Civil Engineering
- Mohd Hasan Ali, Electrical and Computer Engineering

Shahram Pezeshk Expertise Highlight Transportation and Resilient Infrastructure

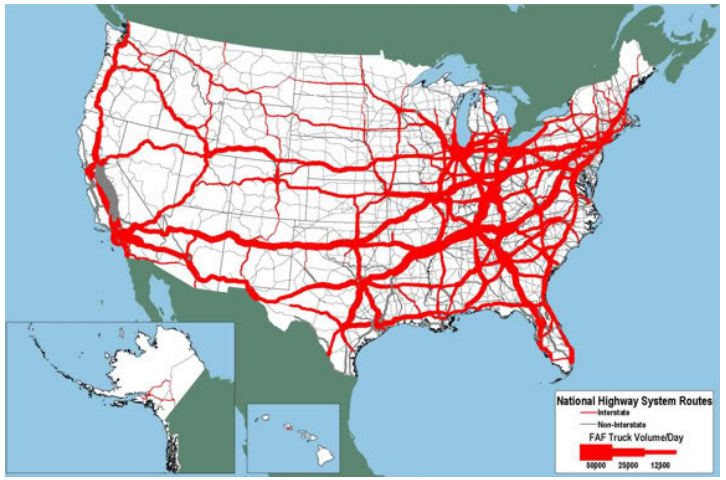
- **Transportation**
  - Bridges;
  - Transportation safety,
  - Passenger and freight rail;
  - Highway and pedestrian safety;
  - Airports;
  - Power and grid reliability and resiliency;
  - Resiliency;
  - Electric vehicle charging;
  - Big data;
  - Multimodal and freight transportation
  - The potential societal benefits of improving the efficiency of traffic systems
  - How to replace the gas tax revenues due to the increase in electric vehicles
  - Workforce

- **Resilient Infrastructure**
  - Resiliency with recovery from natural hazards such as **floods**, tornados, ice storms, and **earthquake**
  - Resilience educational programs
  - Water and sewer system
  - Structural system
  - Multi-hazard resiliency
  - Community resiliency and infrastructure recovery following extreme events
  - Resilient cities
  - Utility systems
  - Performance-based design and construction

Pezeshk's Experience

- Seismic Hazard
- Earthquake Engineering and Geophysical Field Testing
- Machine Learning and Optimization
- Engineering Seismology
- Transportation Related Research and Bridges

$12.5 billion Bridge Investment Program for economically significant bridges



Alternative Mississippi River Crossings

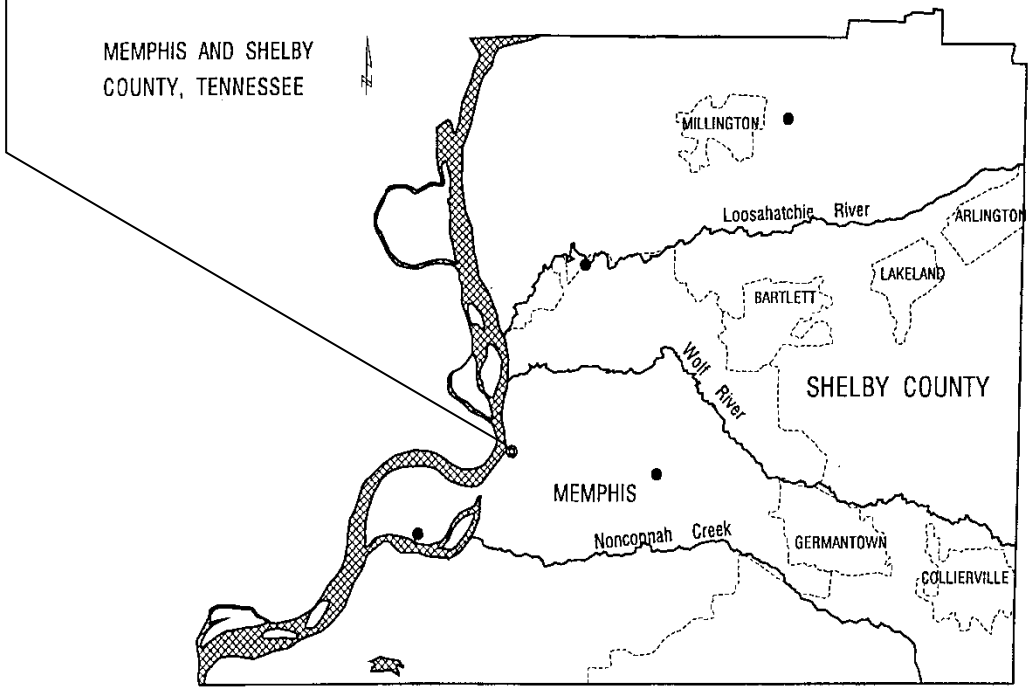
- I-40 Bridge
  - Constructed in 1960's
  - East-west Interstate
  - Major Route for Truck Traffic (35 to 40 percent)
- I-55 Bridge
  - Constructed in 1940's
  - North-south Interstate

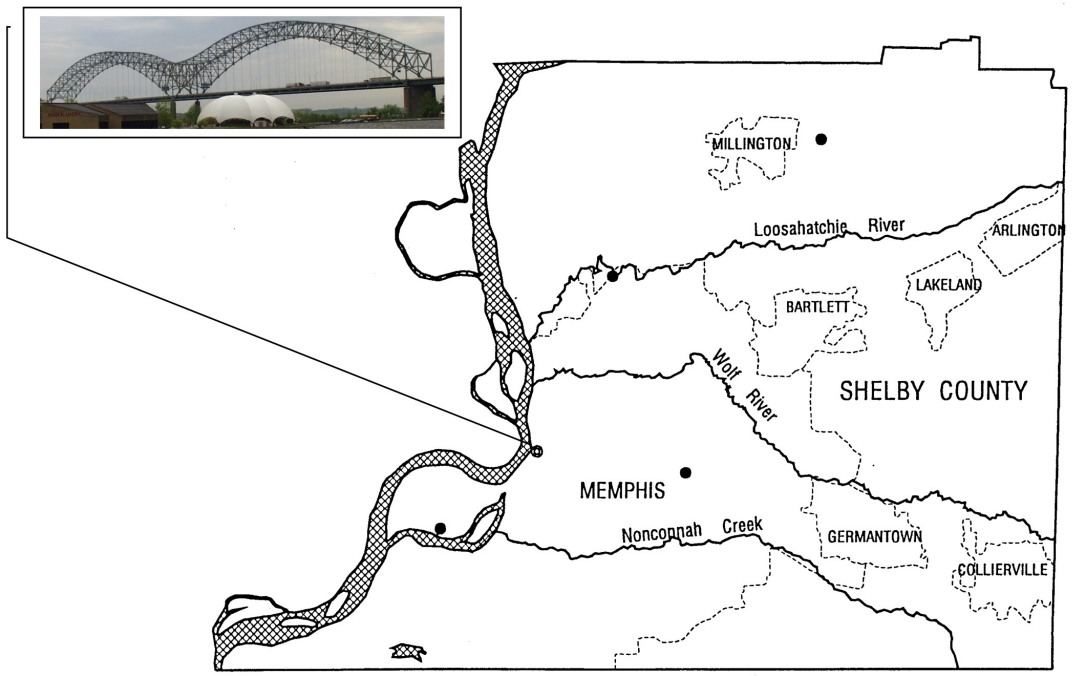
Interstate 40 – busiest trucking corridor in US

Alternate I-55 Crossing

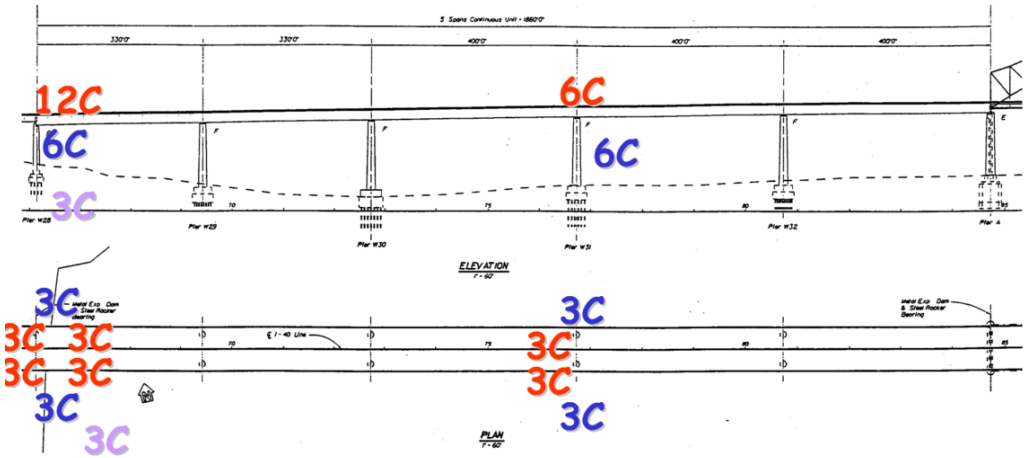
I-55 Masonry Pier

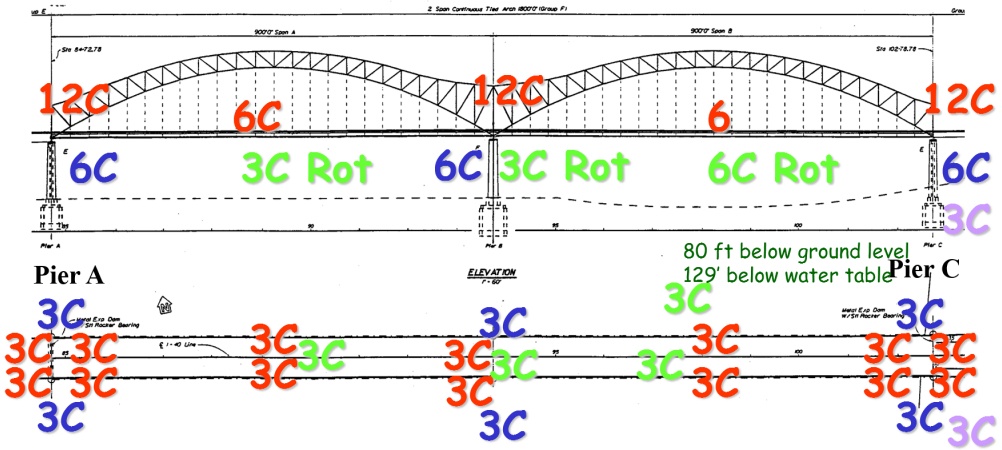
Location of the I – 40 Bridge





Seismic Instrumentation Project of Dr. Pezeshk



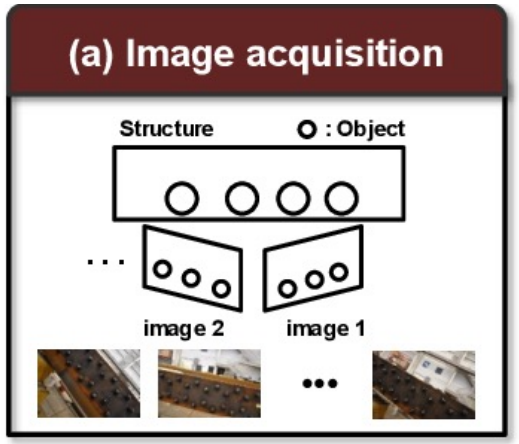


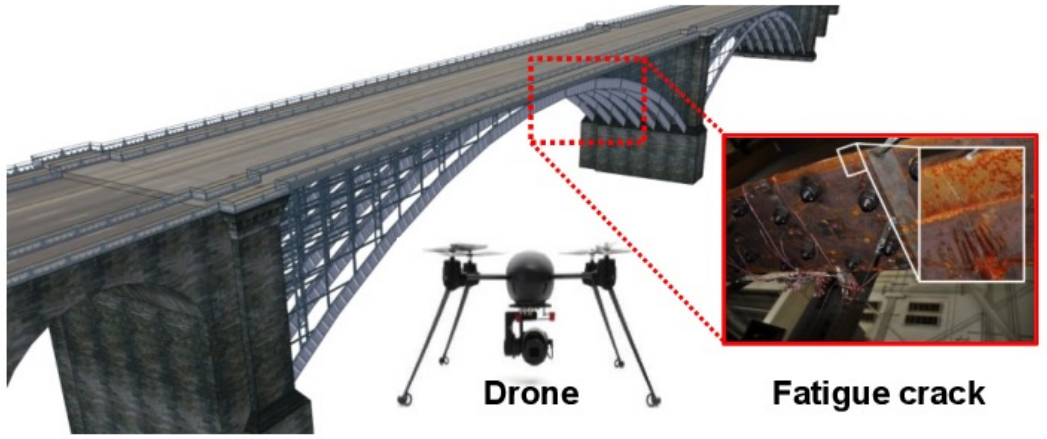
3C = 3 Components

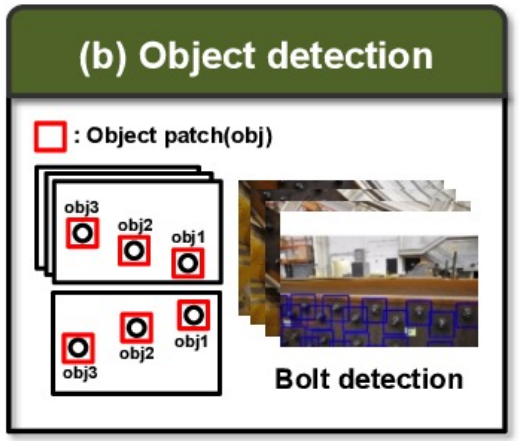
Future work

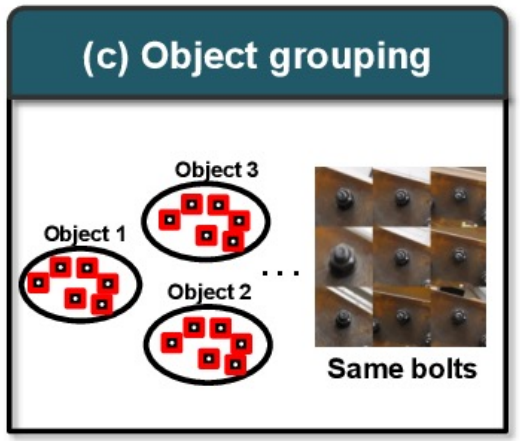
[Center for Innovative Research in Bridge Engineering]

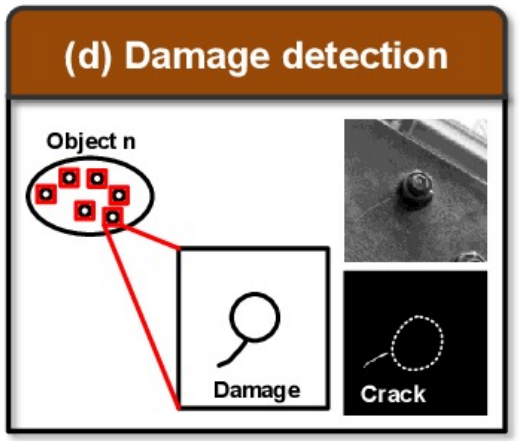
https://www.memphis.edu/cirbe/











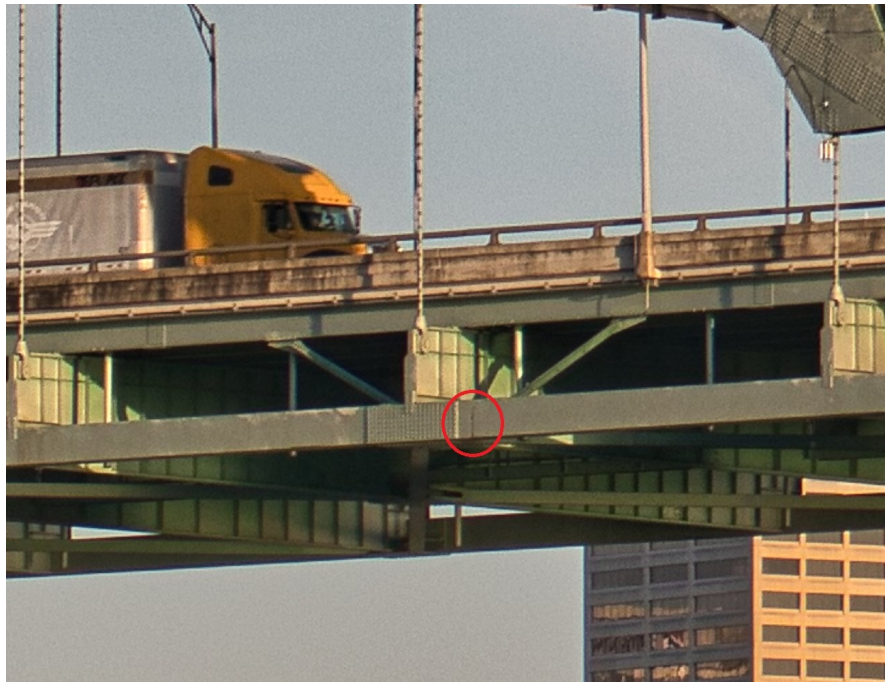
Big Data

- Time of crack detection – I-40 Bridge

Data Analyses from Seismic Instrumentation Installed on the I-40 Bridge

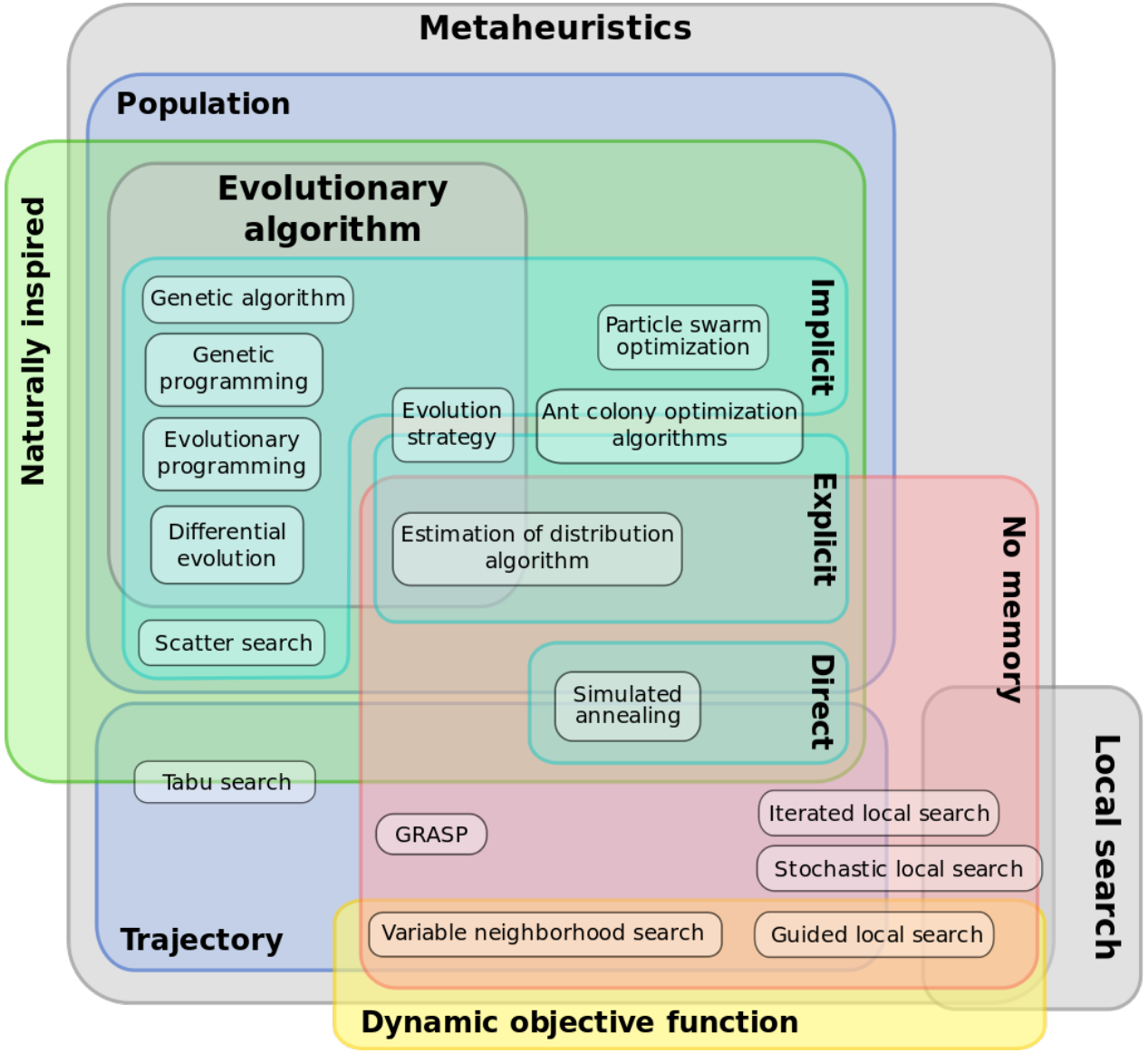
Determination of When Crack Occurred on the Hernando de Soto I-40 Bridge

Research Final Report from the University of Memphis | Shahram Pezeshk, Charles Camp, Ali Kashani, and Mohsen Akhani| October 31, 2021



Meta-heuristic optimization algorithms

- Camp and Pezeshk



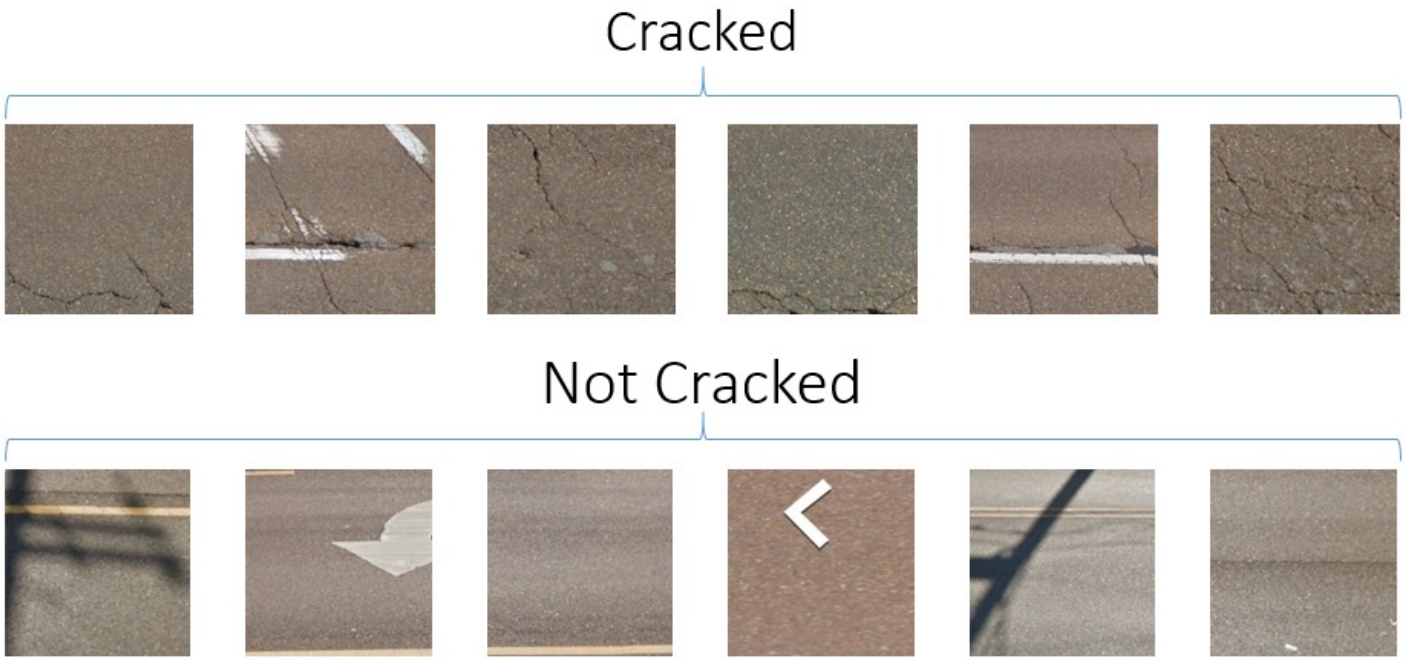
Computer Vision & Machine Learning

Delineating cracks in concrete

Computer vision & machine learning

Delineating cracks in asphalt pavements

Google Street View



Computer vision & machine learning

Delineating cracks in asphalt pavements

Major roads are updated on a regular basis.

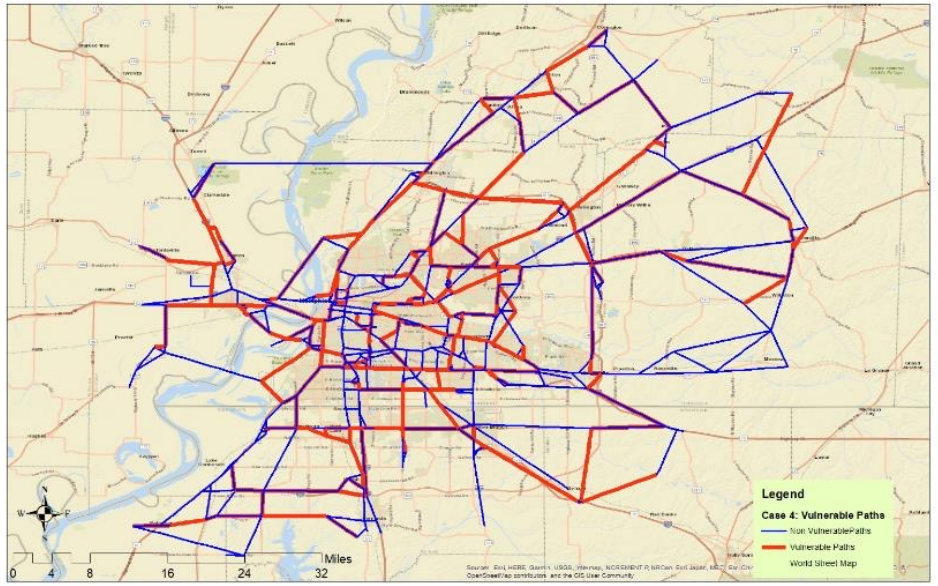
Computer vision & machine learning

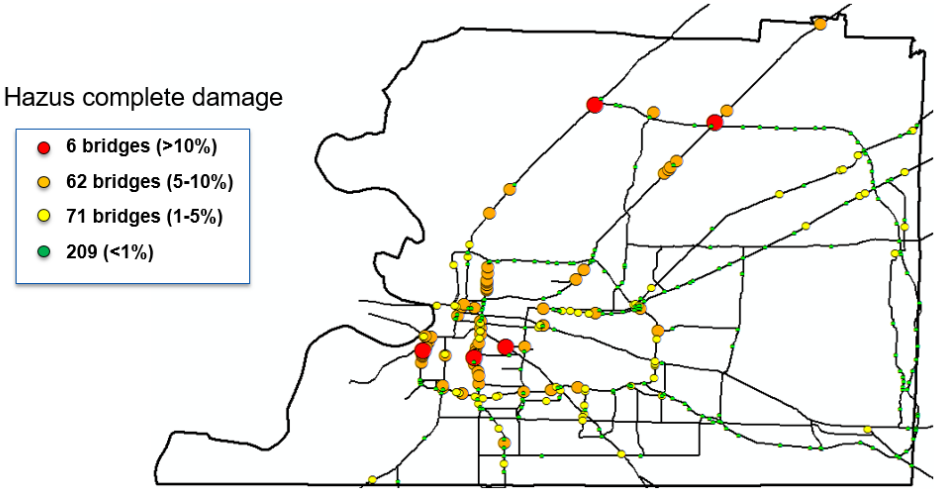
Delineating cracks in asphalt pavements

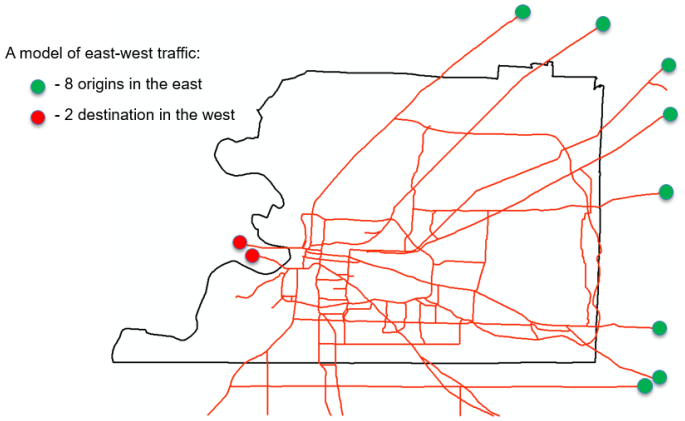
Final GSV Results

Improving resilience of networks in West Tennessee

- The effect of muti-hazard
  - earthquake,
  - hurricane,
  - flood and man-made hazard
  - improve network vulnerability and resilience

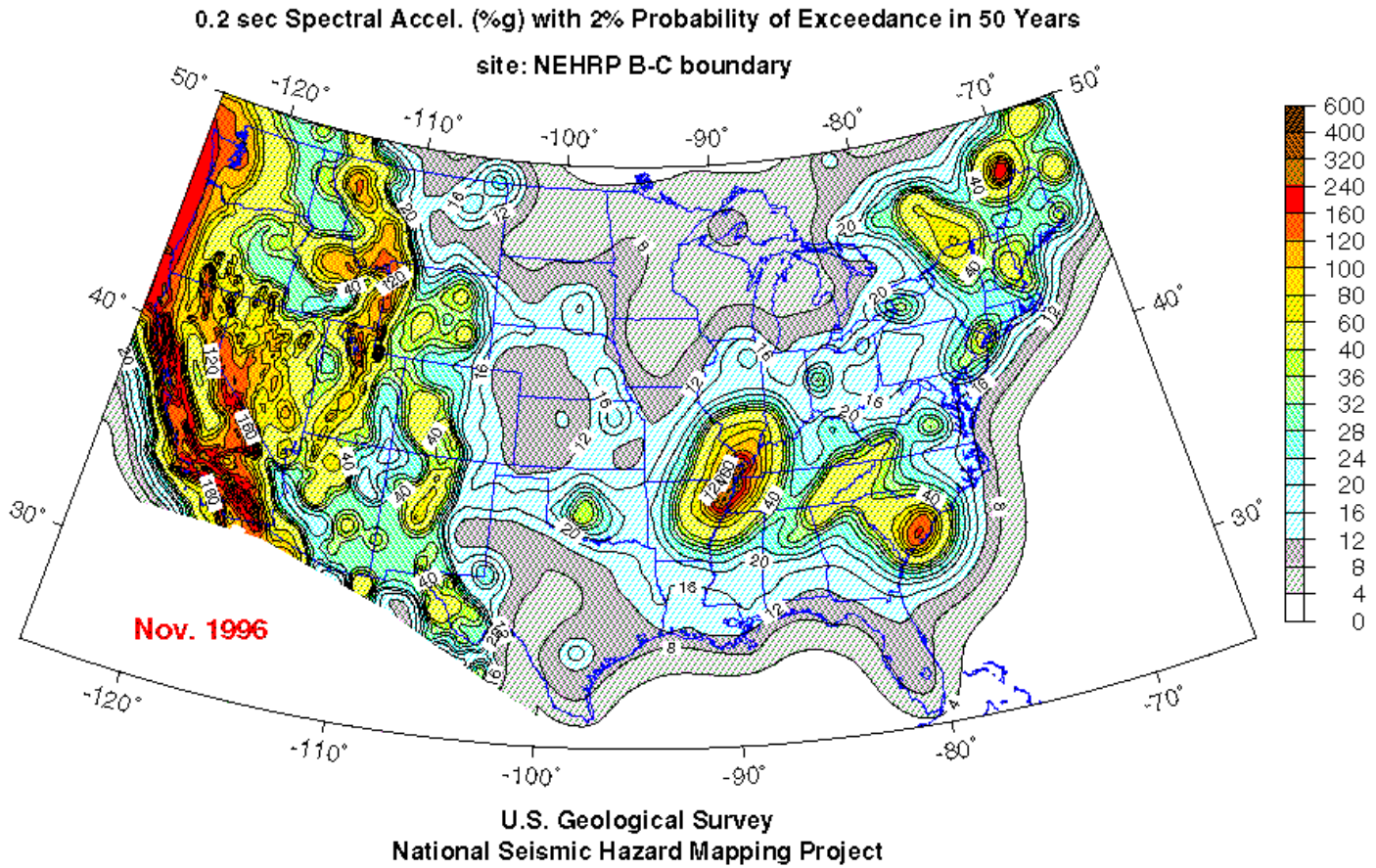




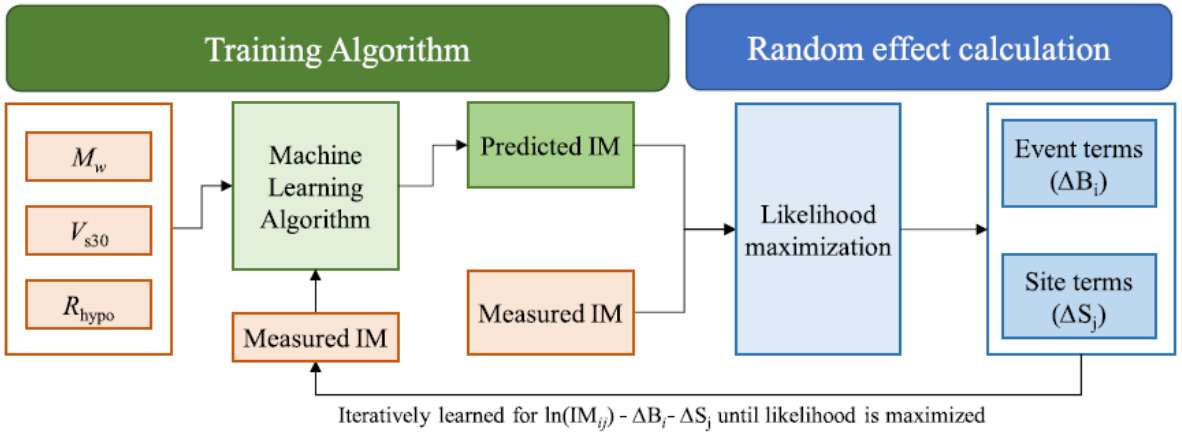


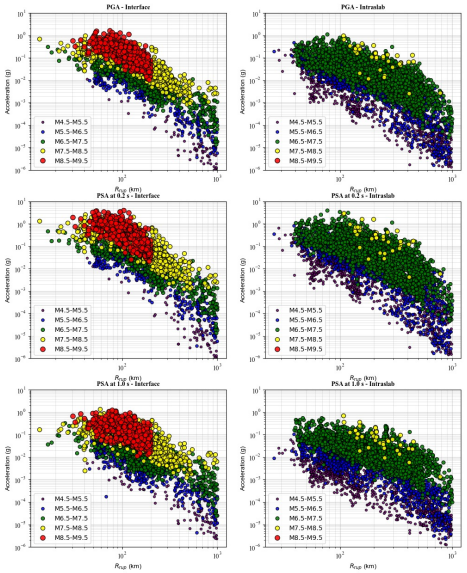
Seismic Hazard

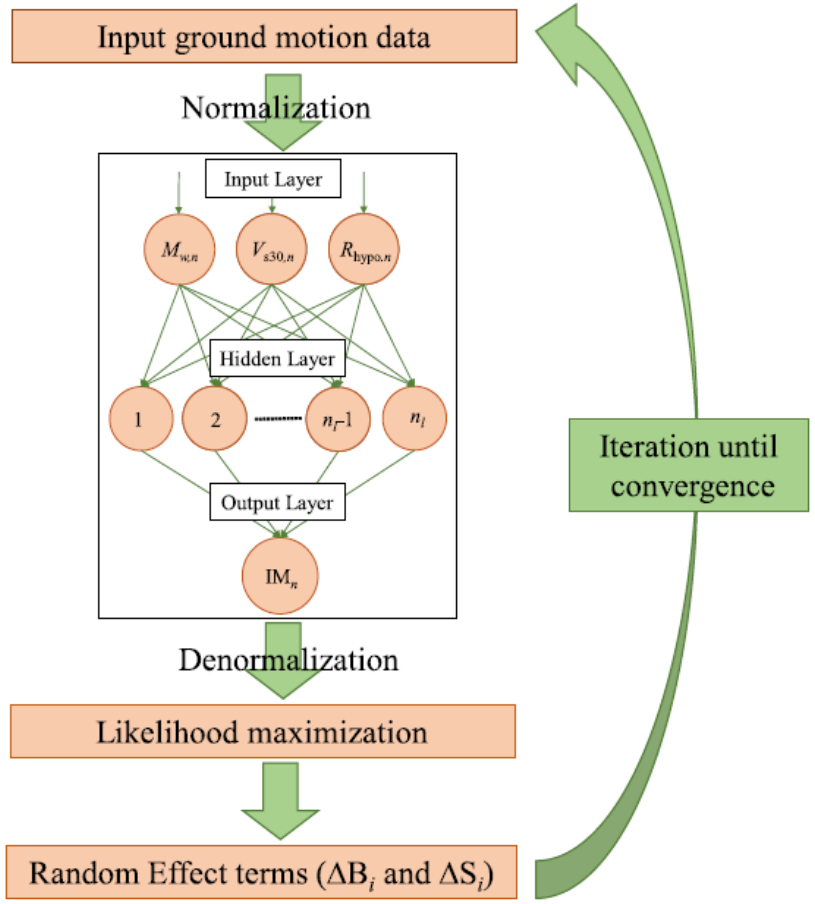
Seismic Hazard



Machine learning in ground motion prediction







Center for Disaster Recovery and Resiliency

- The Center for Disaster Recovery and Resiliency is a **multidisciplinary** center promoting **infrastructure resiliency** and **recovery from natural hazards such as floods, tornados, ice storms, and earthquakes**.
- The CDRR builds collaboration among city and town managers, disaster managers, local EMS agencies, **university researchers**, and city planners to develop strategies to **recover from natural hazards and build more resilient infrastructure**

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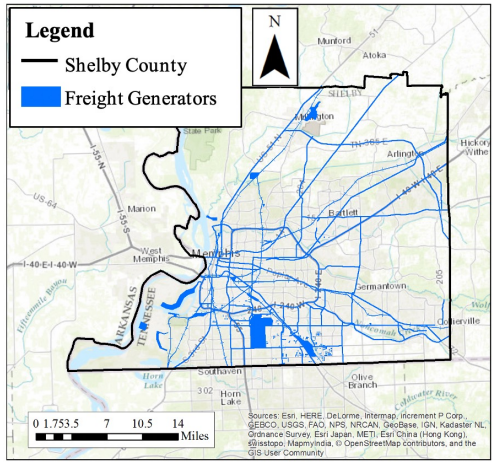
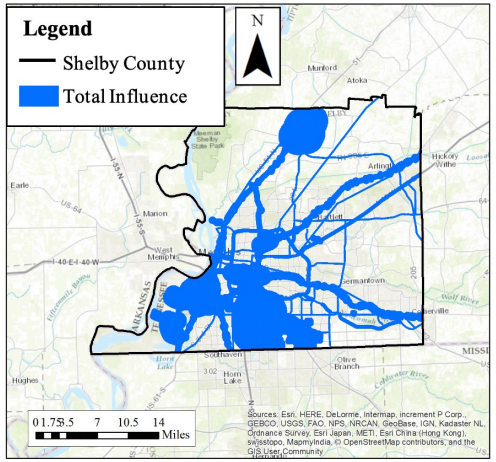
Transportation Planning and Policy

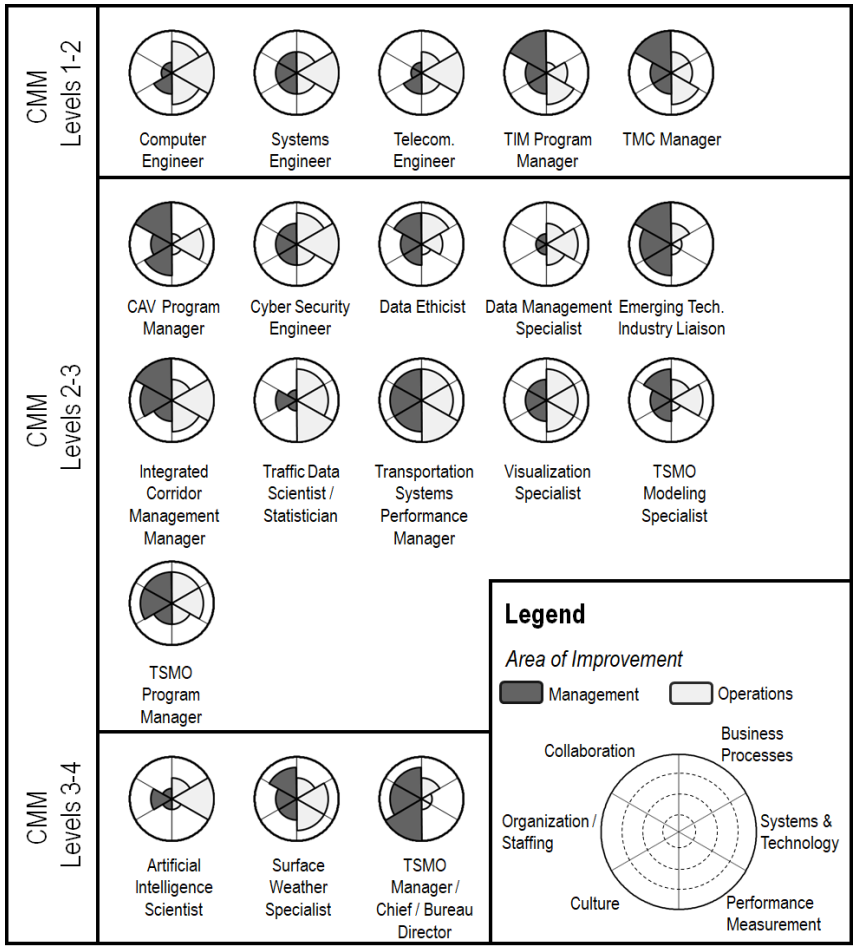
- Community livability
- Complete Streets Capability Maturity Model
- Infrastructure equity assessments
- Fleet electrification





Transportation-Workforce

- Gender Equity
- Knowledge Management
- ITS Professional Capacity Building
- ‘New Mobility’ workforce
- TSMO Workforce



CAESER DTL and SETWC

- caeser.memphis.edu

- memphis.edu/setwc

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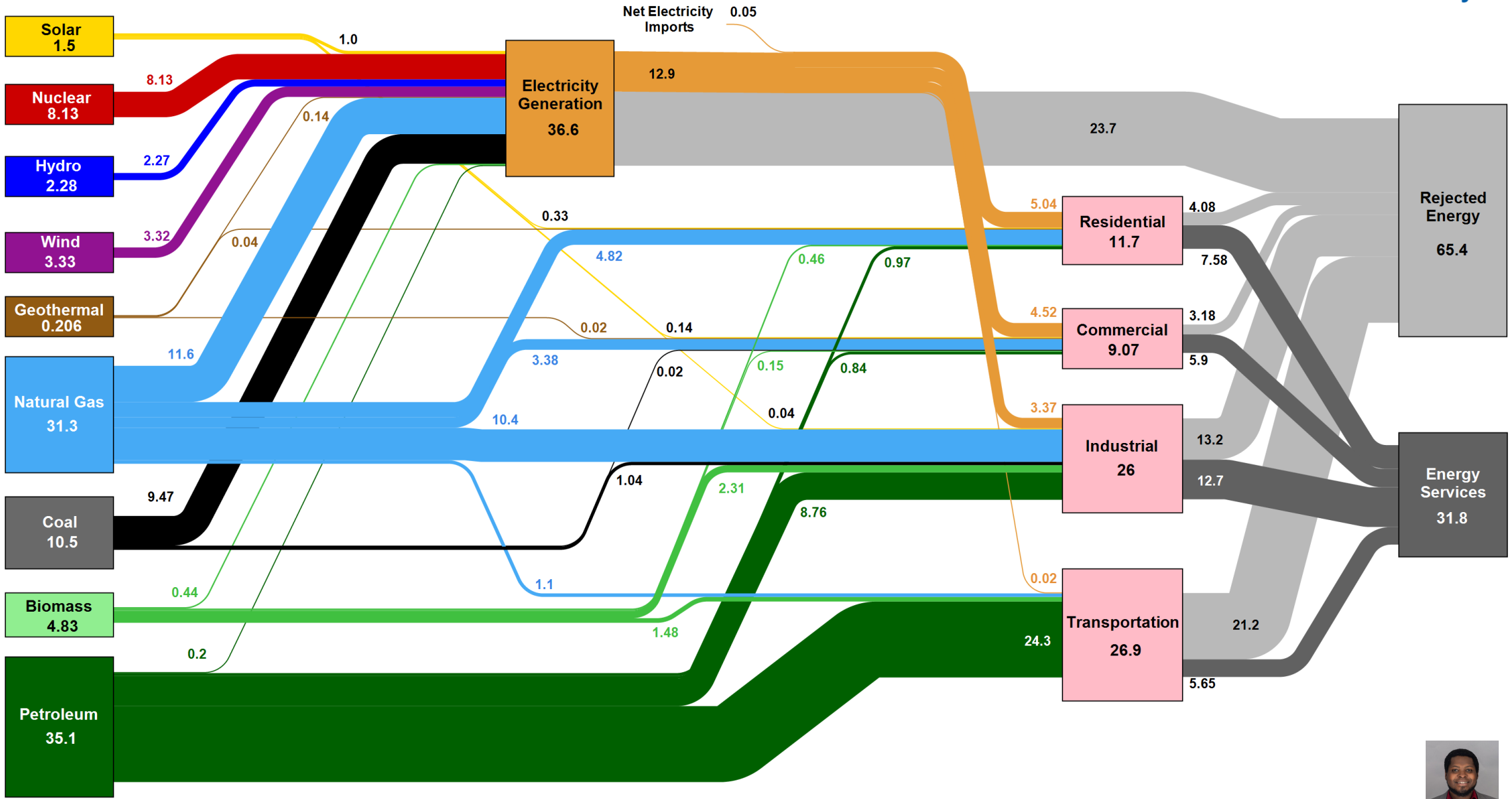
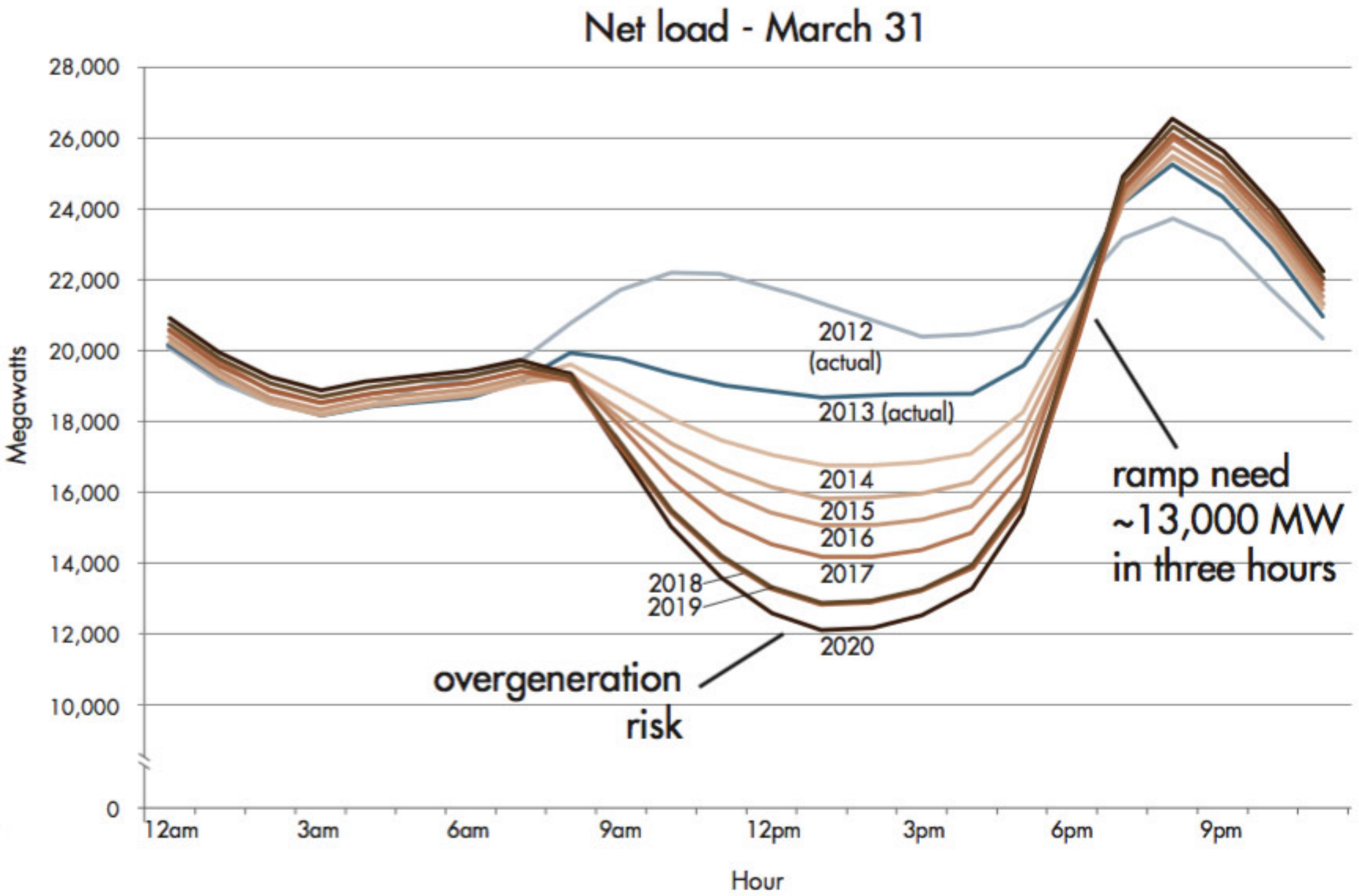
Estimated U.S. Energy Consumption in 2021: 97.3 Quads

Lawrence Livermore National Laboratory



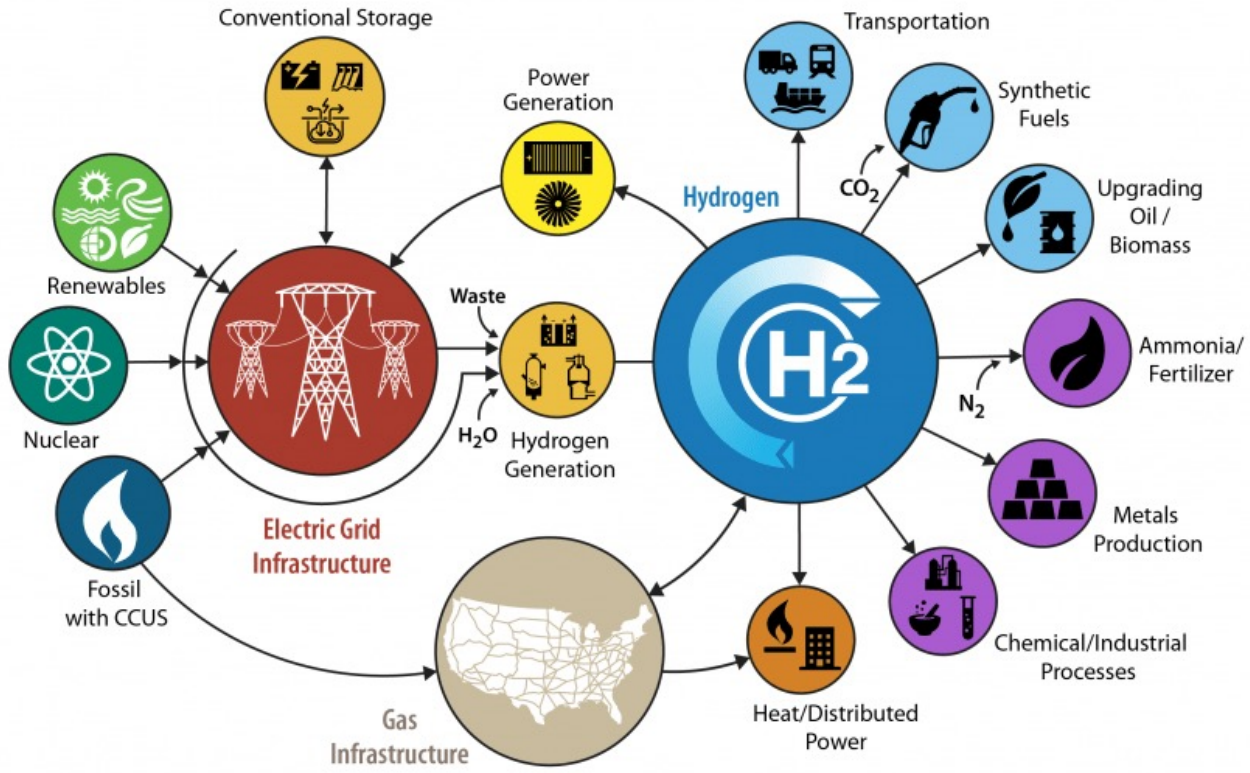
Source: LLNL March, 2022. Data is based on DOE/EIA MER (2021). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Too much of a good thing?



Trends in NSF/DOE Focus

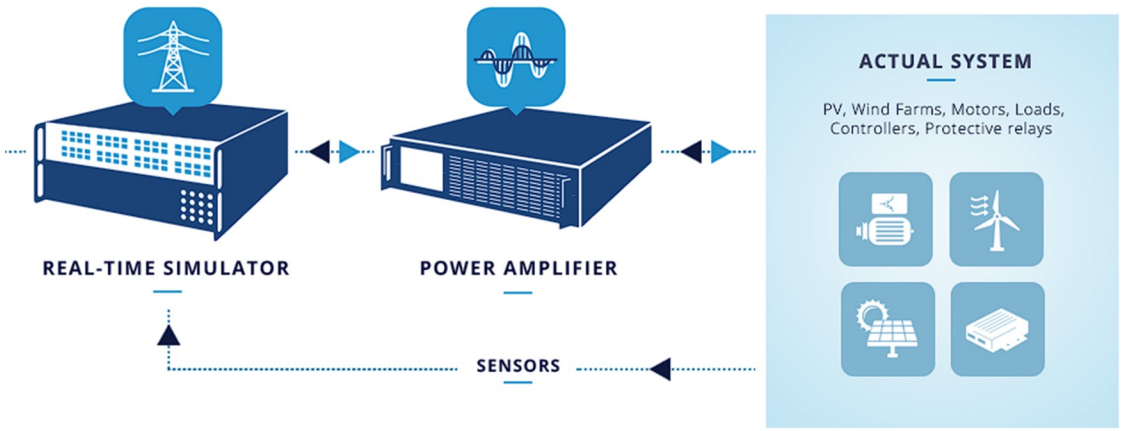
- LARGE investments in major demonstrations
  - $8B for hydrogen hubs
- Increased focus on installations and implementation
  - Not just looking at basic research, but also pathways widespread use
- **Energy Equity**
  - How do you transition the energy infrastructure without leaving some people behind?
  - Justice 40
- Interdisciplinary focus
  - Technical and social science interconnections
- Workforce development



Energy System Optimization Lab (E-SOL)

Research Areas:

- Thermofluid / Electrochemical System Modeling
- Optimization and Control
- Battery Safety Analysis
- Hydrogen Integration



Research Applications:

- Electric Grid Modernization
  - System planning and control
  - Technoeconomic analysis
- Fire Safety
- Alternative Fuel Production and Use

Research Sponsors:

- **Sandia National Laboratories**
  - BattCav: Modeling heat transfer in grid scale energy storage from Li-ion battery thermal runaway
- **US Department of Energy (Co-PI)**
  - Building partnerships for development of sustainable energy systems with atmospheric measurements
  - SMART Second-life Battery Project
- **USDA**
  - MidSouth Energy Efficiency and Clean Energy Audit Program

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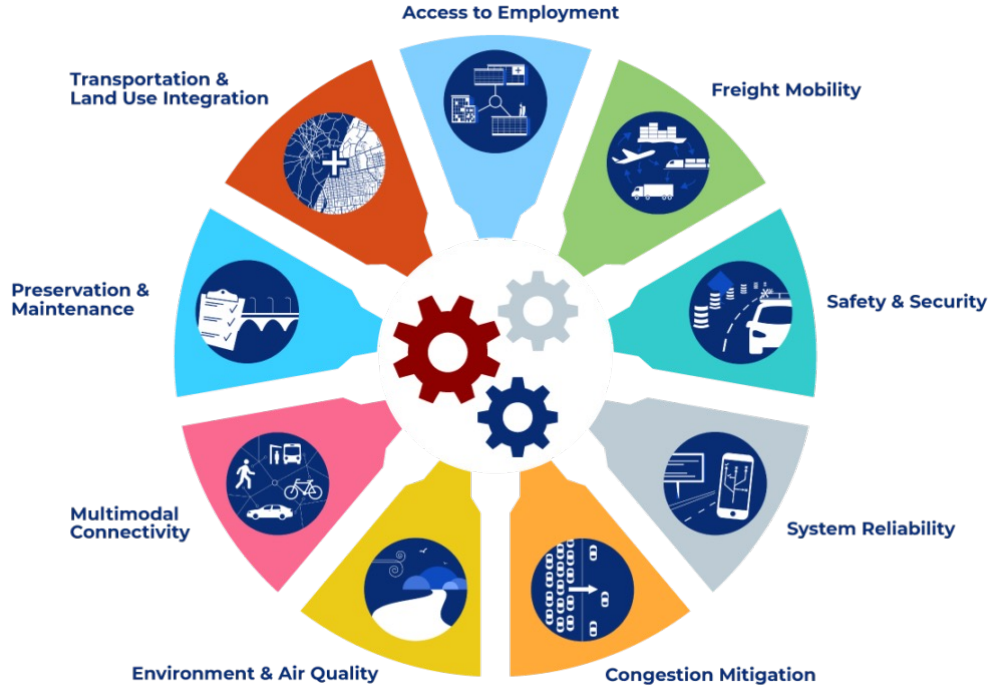
Transportation planning and traffic operations



Transportation Infrastructure

Public transportation and micro mobility

Freight Transportation, Supply Chains, Logistics

Connected, automated, and emerging vehicle technologies, Electric vehicles, and alternative energy

Roadway, and work zone safety

Last mile deliveries

Traffic Simulation & Human factor studies

Example Projects / Center Statistics

- Building human-technology safety partnerships in roadside work zones (NSF)
- Quantitative Evaluation of Truck Caravanning (US DOT)
- Modeling household e-commerce delivery rates and freight travel impacts (US DOT)
- Informed Safety, Mobility, & Driver Comfort (FedEx and TDOT)
- Optimal refueling gas station locations in post-evacuation conditions (US DOT)
- Evaluating the adoption and impacts of autonomous delivery modern technologies (US DOT)
- Accelerating Innovative Mobility (FTA and MATA)
- Center for Electrified and Autonomous Transportation (NSF)
- Assessing Commercial Motor Vehicles' Situation Awareness after Transition from Automated to Manual Driving (US DOT)

Center for Transportation Innovations in Education and Research

C-TIER

Website: https://www.memphis.edu/ctier/

For more information please contact:
Prof. Sabya Mishra
Director, C-TIER
Email: smishra3@memphis.edu

Prof. Mihalis Golias
Co-Director, C-TIER
Email: mgkolias@memphis.edu

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Dr. Hasan Ali

Associate Professor

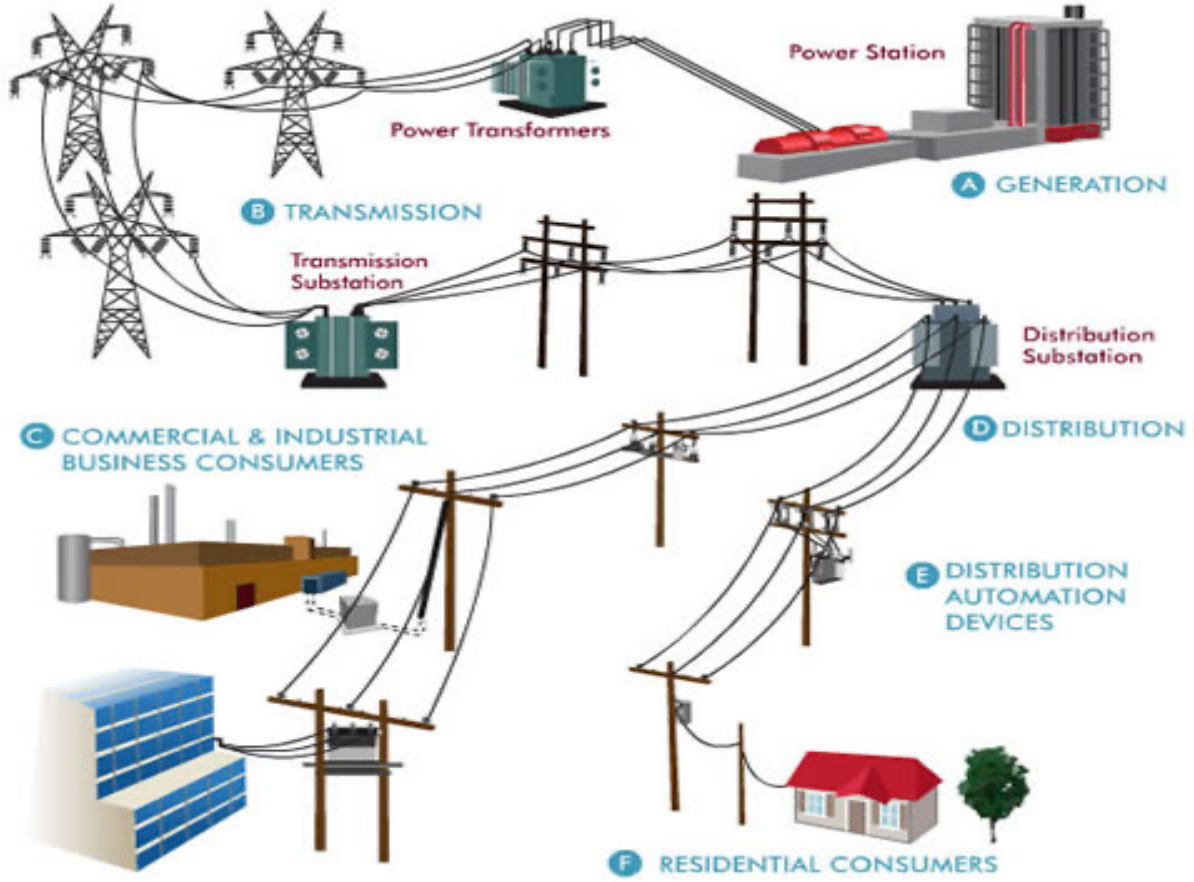
Department of Electrical and Computer Engineering

The University of Memphis

April 14, 2023

Electric Power and Energy

Power Generation (11KV/13.8 KV) → Power Transmission 132 KV/Higher → Power Distribution (33 KV/11 KV) → Consumers (110 V/220 V)



Current Research Interests

- Cybersecurity issues and solutions to modern power grids
- Electric vehicle charging station and system
- Smart grid/microgrid controls
- Renewable/Alternative energy systems (mainly wind and solar) and Fuel cell system
- Energy storage systems
- Load forecasting in smart building systems

Collaborators:

1) Dr. Dipankar Dasgupta (Computer Science)
2) Dr. Myounggyu Won (Computer Science)
3) Dr. Sabyasachee Mishra (Civil Engg)
4) Dr. Mihalis Golias (Civil Engg)
5) Dr. Alexander Headley (Mechanical Engg)
6) Dr. Sanjay Mishra (Physics & Material Science)

Current Funded Research

[1] Mohd Hasan Ali (PI), Cyber Resilient 5G-Enabled Electric Vehicle Charging Infrastructure, National Security Agency (NSA), Amount: $498,083, [September 16, 2022 to September 16, 2024].

[2] Mohd Hasan Ali (PI), DHS/FEMA-CTG-22: Zero Trust: Identity & Access Management, Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA), Amount: $450,000, [September 2022 to August 2025].

[3] Mohd Hasan Ali (PI), DHS/FEMA-CTG-21: Cybersecurity Impact Analysis for End Users and End-User Security and Privacy (ESP), Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA), Amount: $599,997, [September 2021 to August 2024].

[4] Mohd Hasan Ali (PI), Inductive Coupling and Mobile Energy Disseminator-Based Dynamic Wireless Charging of Electric Vehicles, Undergraduate Design Project Grant, Electric Power Research Institute (EPRI) , Amount: $5,000 [January 2023 to December 2023].

[5] Mohd Hasan Ali (Co-PI), Cybersecurity Education for Critical Infrastructure Protection (in Community Development) Through Regional Coalition, National Security Agency (NSA), Amount: $1,999,737, [August 2021 to July 2023].

[6] Mohd Hasan Ali (Co-PI), IUCRC Planning Grant The University of Memphis: Center for Electrified and Autonomous Transportation in Agile Freight Supply-Chains (CEATAFS), National Science Foundation (NSF), Amount: $20,000 [August 2022 to July 2023].

[7] Mohd Hasan Ali (Co-PI), 502 Project: Promoting Cybersecurity Awareness in Greater Memphis Area, National Security Agency (NSA), Amount: $14,993 [February 2023 to October 2023].

5G-Enabled EVCS Cyber-Physical Architecture

PV specs
•1.065 kW capacity
•MPP: 36.75 V, 29 A
•Irradiance: 1000 W/m^2 , 25 °C

BES specs
- 48V nominal voltage
- 100 Ah rated capacity

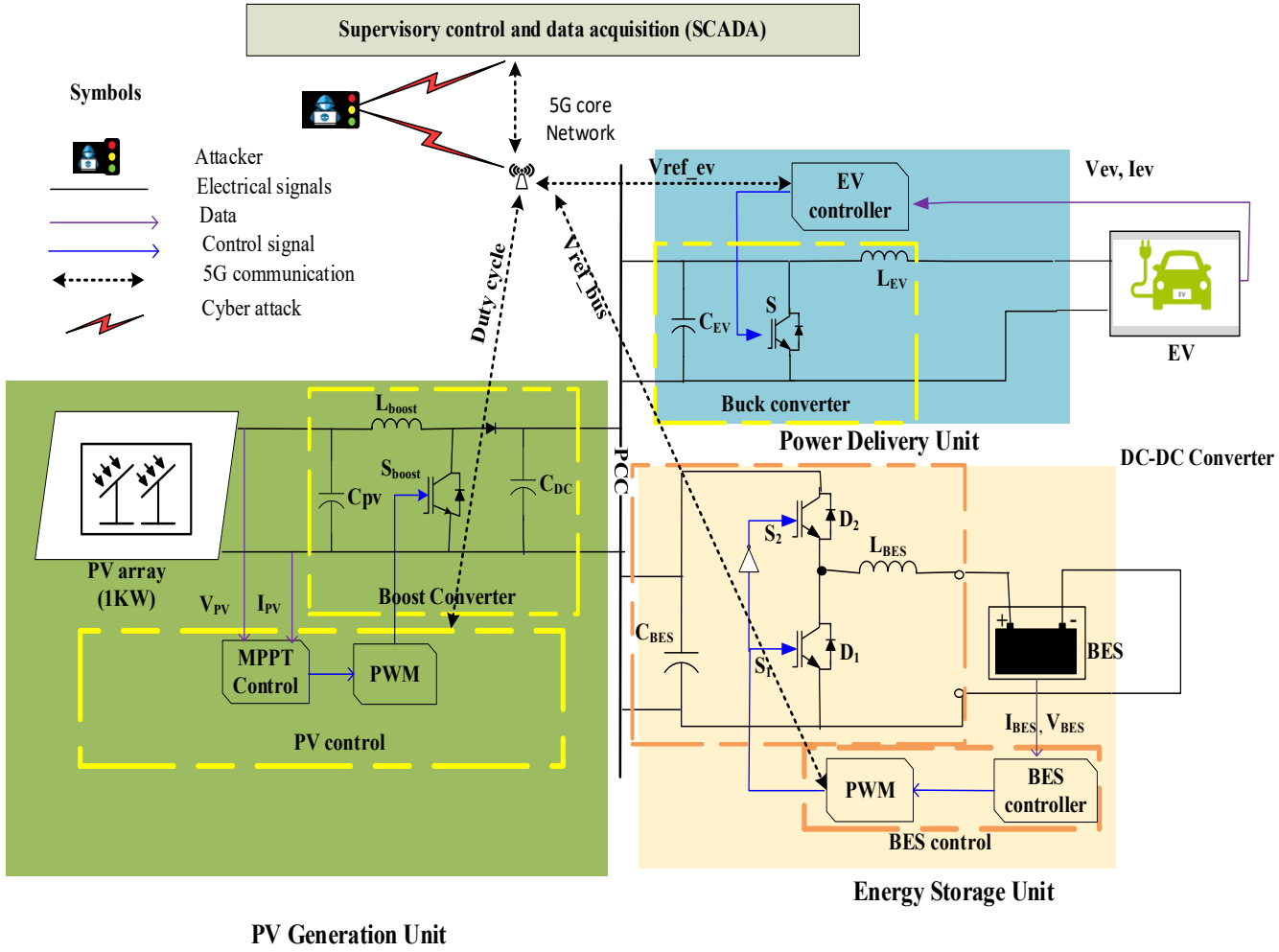


Fig. 1. EVCS Prototype.

Dynamic Wireless Charging of Electric Vehicles

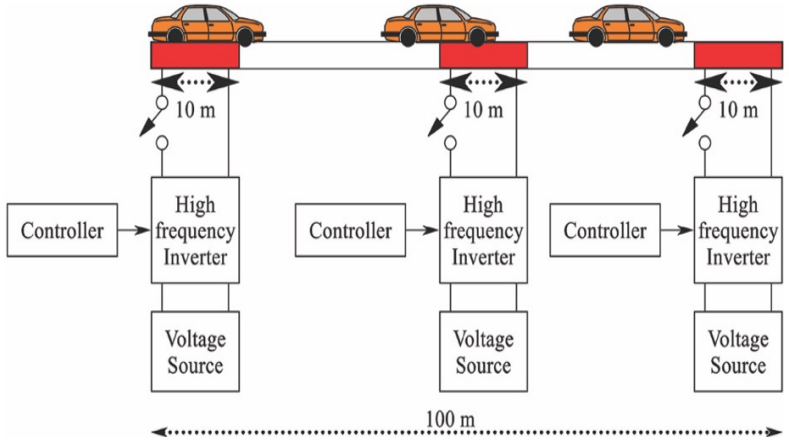


Fig. 2. Detailed block diagram of segmented primary charging pad.

Benefits of DWC

- Energy transfer by contactless manner.
- Eliminates heavy charging chords and connectors.
- Insulation and worn conductor issues will be solved, weather resistant.
- High operational flexibility with power supply.
- Vehicles can be charged up anytime.
- Short range problems will be solved.
- Long charging time can be replaced by DWC.

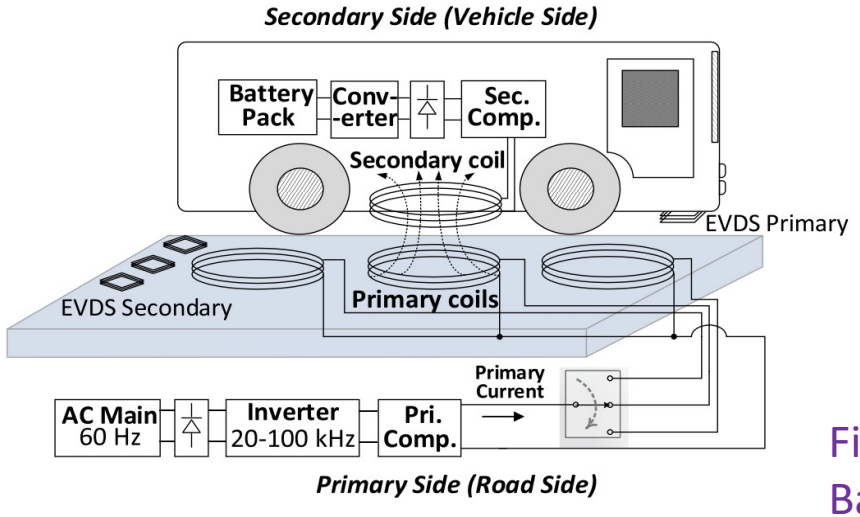


Fig. 3. Diagram of a DWPT System.

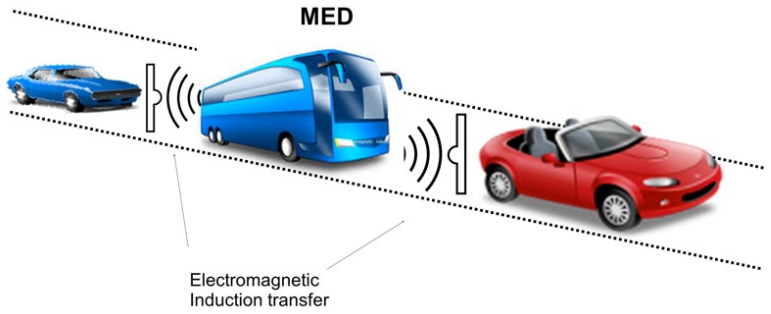


Fig. 4. Mobile Energy Disseminator (MED) Based DWC for ETs.

Anticipated Areas for Expansion/Growth

- Grid Modernization
- Grid Resiliency
- Electric Vehicle Charging Station and System

Key Inter/Multidisciplinary Opportunities

- Cybersecurity Issues and Solutions to Modern Power Grids
- Electric Vehicle Charging Station and System
- Energy Storage Systems (Battery, Supercapacitor, Fuel Cell)

Agenda

- Background
- Shahram Pezeshk, Civil Engineering
- Stephanie Ivey, Civil Engineering
- Alexander Headley, Mechanical Engineering
- Sabya Mishra and Mihalis Golias Civil Engineering
- Hasan Ali, Electrical and Computer Engineering
- **Discussion**