



MIT **Mobility Initiative**

Jinhua Zhao

Professor of Cities and Transportation

mmi.mit.edu

We have progressed so far...



Ever since the first hominids left Africa, human beings have been on the move. The canoe was invented in 8,000 B.C. and the first form of public transportation was a stagecoach operated in Paris in 1662. Fast forward to today's self-driving car

prototype, and it's clear just how far we've come.
Source: The Atlantic, https://www.theatlantic.com/video/index/397865/animated-history-transportation/?utm_source=fbb



Morning traffic on the Southeast Expressway in Dorchester. (David L. Ryan/Globe Staff)



Beijing 1982



What is success?

Has the progress in transportation technology translated into the betterment of our mobility system? No!

Four Technology Themes in Mobility

1

Mobility Decarbonization

To reduce carbon emission by transitioning from fossil fuel to sustainable alternatives:

- Electric vehicles
- EV charging
- Battery technology
- Fuel Cells
- Hydrogen

2

Autonomous Driving

To enable vehicles to operate without or with minimal human intervention, aiming to replace or assist human drivers, including:

- Sensors & processors
- Localization & Mapping
- Perception software
- Full-stack players

3

Connected Vehicle Tech

To enable real-time data exchange with other vehicles, infrastructure, and external systems.

4

Next-Gen Aviation & Space Tech

Sustainable aviation fuel; autonomous flights; eVTOL; hydrogen aircraft;

SpaceX, BlueOrigin; launch, satellite, manufacturing, in-space services

MIT Mobility Venture Fall 2023

For each theme, we will cover the following content:

- A** The Opportunity
- B** Investment Activities
- C** Trends
- D** Market Landscape
- E** Highlight Startups

Different framings of transportation

As a congestion problem

As a sustainability problem

As a social justice problem

As a personal identity problem

As an urban creativity problem

As a public health problem

Changes in Transportation

Technology

- Automation
- Electrification
- 5G/Connected
- Shared economy
- ...

Data

- Ubiquitous sensing
- AI / computing
- Cybersecurity
- ...

Value

- Climate change
- Future of work
- Public health
- Social justice
- Urban livability
- ...

What defines the future of mobility?

Behavior + Computation

Behavioral thinking

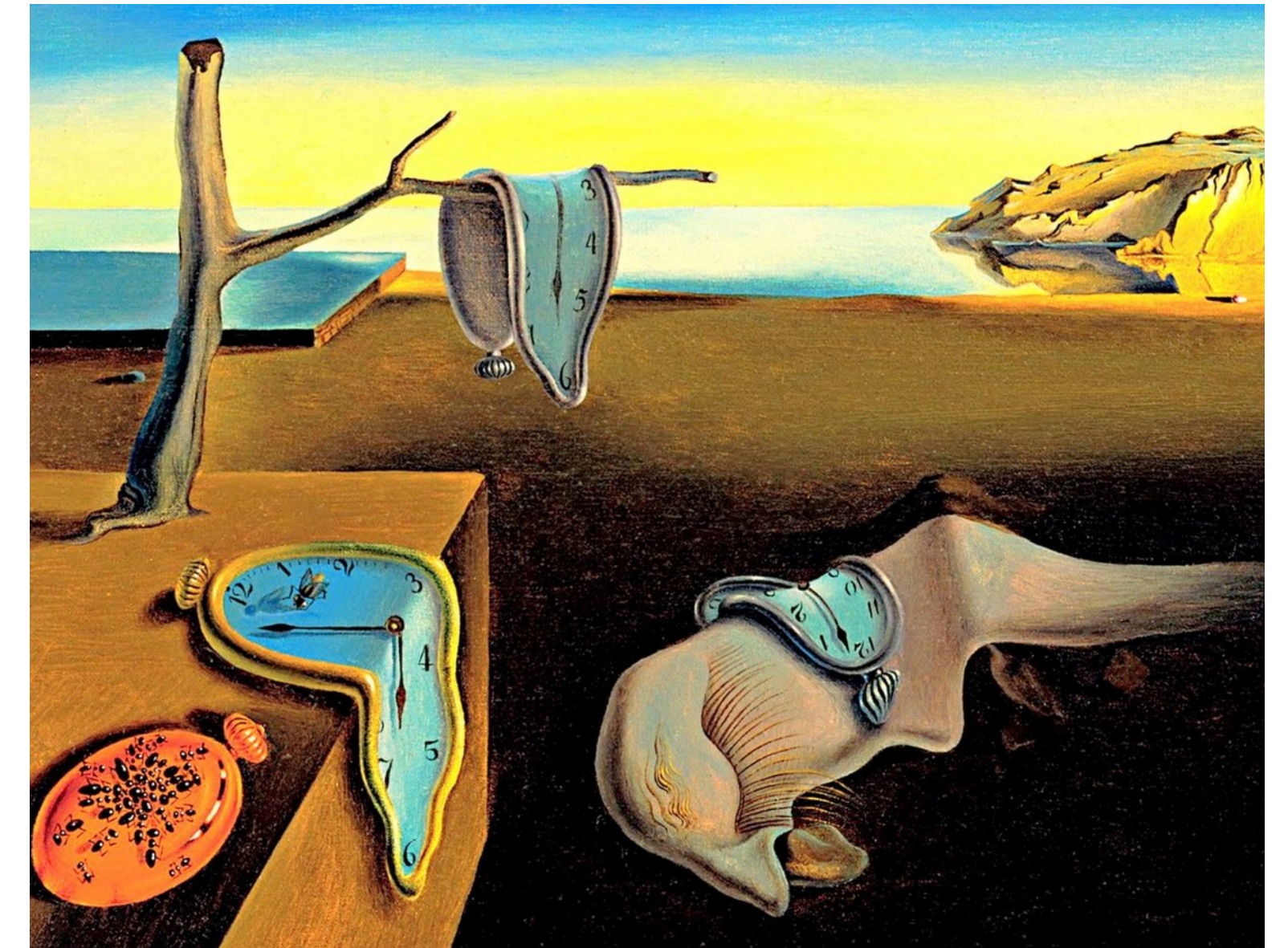
is travel social?



is travel emotional?

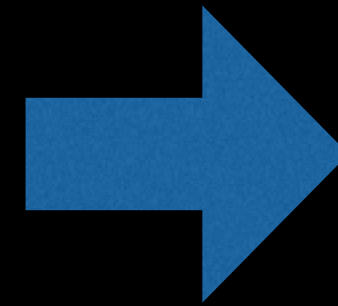


is time absolute?



Business Decision

- EV range anxiety
- Ridesharing Pricing
- AV adoption
- Congestion charge
- Ownership vs access
- Car profit margin
- ...



Behavioral Thinking

- Emotional—> rational
- Preference of sharing
- Risk preference
- Price salience
- Option value
- Car pride
- ...

Behavioral Science

- Emotional
- Social
- Perceptual



Transportation Technology

- Electrification
- Automation
- Connectivity
- Sharing

Computational Foundation

















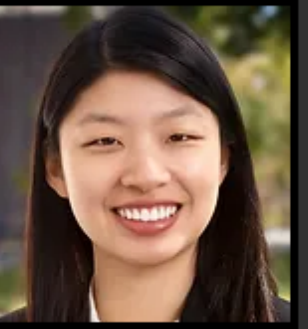






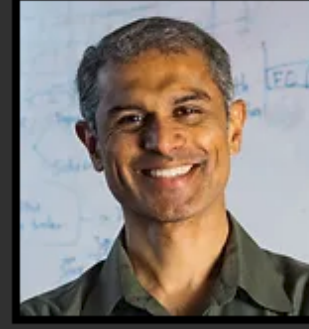








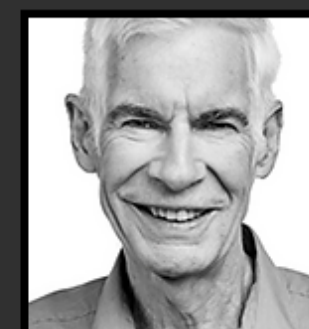
- Representation
- Explanation
- Prediction
- Control
- Creation

How is MIT contributing?

Transportation Faculty and Researchers (Sample)



Mobility Initiative

 <p>Jim Aloisi Lecturer of Transportation Policy and Planning</p> <p>Research Interests: Urban Transportation, Equity, Public Realm Design, Public Transportation Funding and Service Delivery</p>	 <p>Saurabh Amin Robert N. Noyce Career Development Associate Professor</p> <p>Research Interests: Control of Infrastructure Networks, Security of Cyber-Physical Systems, Applied Game Theory and Information Economics</p>	 <p>Steven Barrett Director, Laboratory for Aviation and the Environment</p> <p>Research Interests: Climate Impacts of Aviation, Aircraft Emissions, Biofuels, Electric Aircraft Design, Low Emission and Noise Aircraft Propulsion</p>	 <p>Charlie Fine Chrysler Leaders for Global Operations Professor of Management</p> <p>Research Interests: Operations Strategy, Supply Chain Management, Value Chain Roadmapping, Outsourcing Dynamics</p>	 <p>Daniel Freund Assistant Professor of Operations Management</p> <p>Research Interests: Analytics, Combinatorial Optimization, Management Science, Operations Management, Sharing Economy</p>	 <p>Jason Jackson Ford Career Development Assistant Professor of Political Economy</p> <p>Research Interests: Community Development, Economic Development, Law and Policy, Machine Learning, Transportation and Mobility</p>	 <p>John Leonard Samuel C. Collins Professor of Mechanical and Ocean Engineering</p> <p>Research Interests: AI & Machine Learning, Graphics & Vision, Robotics, Big Data and Transportation</p>	 <p>Elisabeth Reynolds Lecturer, MIT Department of Urban Studies and Planning</p> <p>Research Interests: National and Regional Systems of Innovation, Competitiveness, Manufacturing Ecosystems</p>	 <p>Cathy Wu Gilbert W. Winslow (1937) Career Development Assistant Professor</p> <p>Research Interests: Machine Learning, Control Theory, Multi-agent Systems, Implications of AI & Automation</p>	 <p>Jessika Trancik Associate Professor of Energy Studies</p> <p>Research Interests: Storage Technologies, Environmental Analysis, Energy Technologies</p>	 <p>Chris Zegras Professor of Transportation and Urban Planning</p> <p>Research Interests: Environmental Planning and Management, Healthy Communities and Active Living, Transportation and Mobility, Urban Economics</p>
 <p>Bill Aulet Professor, Sloan School; Managing Director, Martin Trust Center, MIT</p> <p>Research Interests: Entrepreneurship Education, Economics & Business</p>	 <p>Dimitris Bertsimas Professor of Management and Operations Research, Associate Dean of Business Analytics</p> <p>Research Interests: Optimization, Stochastic Systems, Machine Learning, Robust Optimization, Transportation and Finance</p>	 <p>Alexandre Jacquillat Assistant Professor, Operations Research and Statistics</p> <p>Research Interests: Stochastic optimization, data-driven decision-making, analytics, vehicle routing, transportation scheduling</p>	 <p>Fábio Duarte Principal Research Scientist and Lecturer of Transportation Policy and Planning</p> <p>Research Interests: Urban Technologies, Transportation and Planning, Social Construction of Technologies</p>	 <p>John Attanucci Lecturer, Research Associate and Manager of the MIT Transit Research Program</p> <p>Research Interests: Transportation Planning, Transit Management and Operations, Transit Information and Decision Support Systems</p>	 <p>Jing Li William Barton Rogers Career Development Professor of Energy Economics</p> <p>Research Interests: Industrial Organization, Environmental & Energy Economics</p>	 <p>David Mindell Dibner Professor of the History of Engineering and Manufacturing, Professor of Aeronautics and Astronautics</p> <p>Research Interests: Autonomy in Human Environments; Precision Navigation; Ultra-Wideband for Urban Transit</p>	 <p>Don Sadoway John F. Elliott Professor of Materials Chemistry</p> <p>Research Interests: Electrochemistry, Electrochemical extraction & sensors, recycling of metals, lithium solid-polymer-electrolyte batteries</p>	 <p>Fred Salvucci Senior Lecturer and Senior Research Associate</p> <p>Research Interests: Infrastructure, Urban Transportation, Public Transportation, Institutional Development in Decision-Making</p>	 <p>Matthias Winkenbach Director of the MIT Megacity Logistics Lab; Director of the MIT CAVE Lab</p> <p>Research Interests: Multi-tier Distribution Network Design, Urban Logistics, Last-Mile Delivery, Urban Freight Policy, Data Analytics and Visualization</p>	 <p>Sanjay Sarma Vice President for Open Learning (2013-2022) and Professor of Mechanical Engineering</p> <p>Research Interests: Automotive Technologies, Batteries, Digital Learning, Design, Manufacturing</p>
 <p>Hamsa Balakrishnan Professor of Aeronautics and Astronautics</p> <p>Research Interests: Design, Analysis, and Implementation of Control and Optimization Algorithms for Large-Scale Cyber-Physical Infrastructures</p>	 <p>Hari Balakrishnan Fujitsu Chair Professor in the EECS Department</p> <p>Research Interests: Networking, Data Management, Sensing, Mobile and Sensor Computing, Wireless Networks, Overlay and P2P Networks</p>	 <p>Sertac Karaman Associate Professor of Aeronautics and Astronautics</p> <p>Research Interests: Robotics, Autonomous Vehicles, Foundations of Mobility</p>	 <p>Bill Green Hoyt C. Hottel Professor in Chemical Engineering</p> <p>Research Interests: Fuel Chemistry, Evaluation of Alternative Fuels & Engines</p>	 <p>Jinhua Zhao Associate Professor of Transportation and City Planning, Director of MIT Mobility Initiative</p> <p>Research Interests: Urban Transportation, Travel Behavior, Shared and Automated Mobility Planning, Public Transit</p>	 <p>Andres Sevtsuk Charles and Ann Spaulding Career Development Associate Professor of Urban Science and Planning</p> <p>Research Interests: Spatial Analysis, Walkability, Public Transport, Business Location Patterns, Urban Design</p>	 <p>Daniela Rus Andrew (1956) and Erna Viterbi Professor of Electrical Engineering and Computer Science</p> <p>Research Interests: Robotics, Artificial Intelligence, and Data Science</p>	 <p>Anson Stewart Research Scientist</p> <p>Research Interests: Spatial Analysis, Urban Transportation, Public Transportation</p>	 <p>Sarah Williams Associate Professor of Technology and Urban Planning</p> <p>Research Interests: Semi-formal Transportation, Urban Information, Technology, Media Design, Data Action, Urban Design, Data Visualization and Privacy</p>	 <p>Sandy Pentland Toshiba Professor of Media Arts & Science</p> <p>Research Interests: Computational Social Science, Organizational Engineering, Wearable Computing, Image Understanding</p>	 <p>Nigel Wilson Professor Emeritus</p> <p>Research Interests: Public Transportation, Transport System Design, New Transportation Systems</p>



MIT **Mobility Initiative**

mmi.mit.edu

How is MIT contributing?

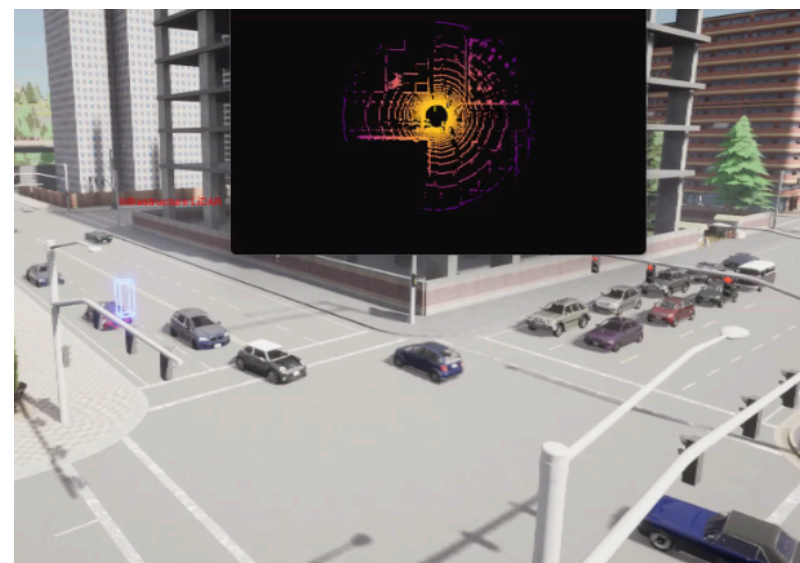
Solve short-term technical problems

Develop medium-term platforms and capacity

Catalyze strategic, institutional, and social changes

Our Mission

The MIT Mobility Initiative (MMI) is a global platform to accelerate a **safe, clean and inclusive** mobility system through research, education, entrepreneurship and engagement



Research

Catalyze cross-disciplinary research that provides insight to strategic challenges for industry and society



Education

Manage and enhance MIT's transportation degree programs and expand the executive education offering



Entrepreneurship

Leverage MIT's innovation ecosystem to spin off mobility tech startups and support existing startups



Engagement

Foster direct interaction with leaders from business and government on the "front lines" of the mobility revolution

Q1:

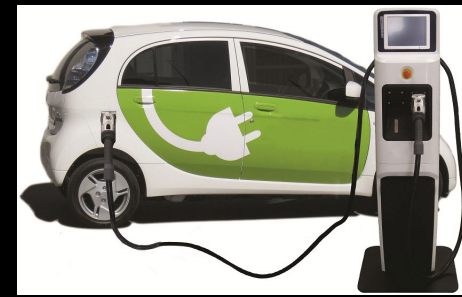
How many people were killed in road traffic crashes in the US in 2021?

42,915

42,915

0

electric
vehicles



autonomous
vehicles



road side
robotics



e-scooters
e-bikes



urban
drones



?

?

?

?

?

42,915



0

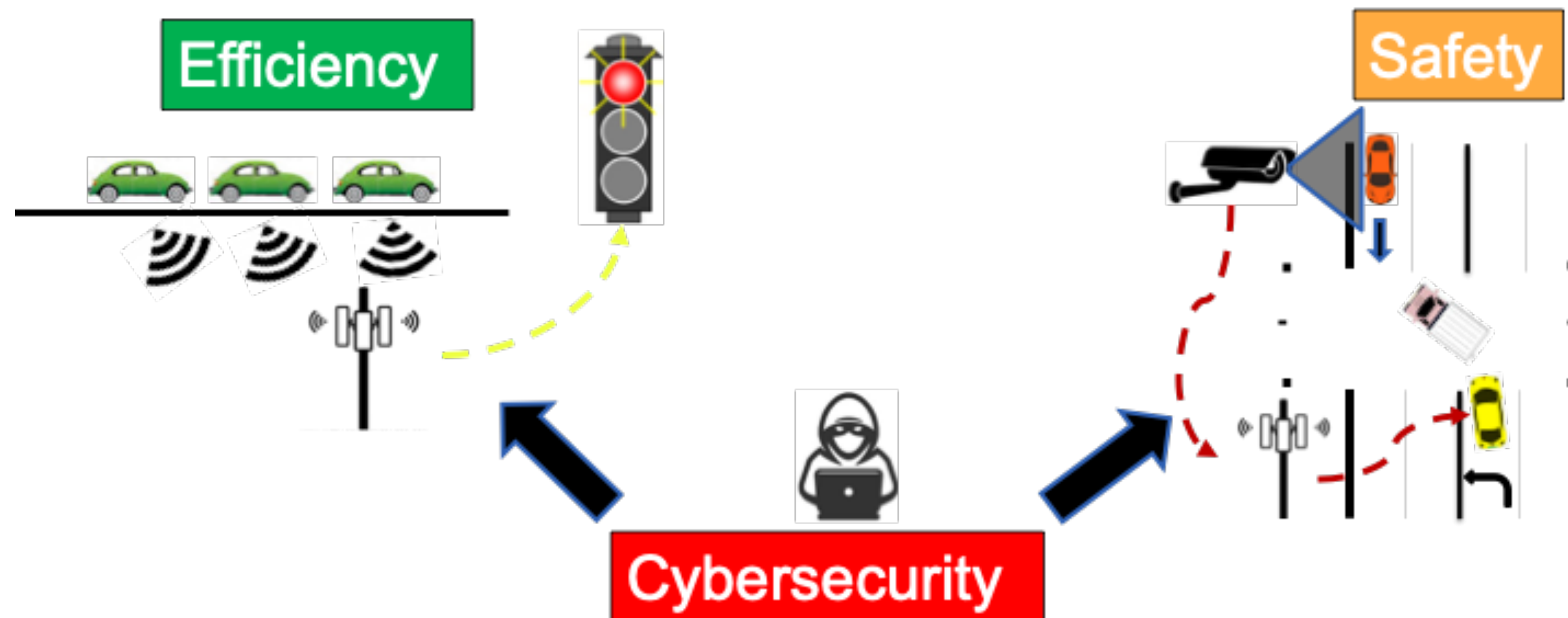
Collective Sensing for Connected Corridor Management

Principal Investigators:

- Sanjay Sarma, Professor of Mechanical Engineering
- Dajiang Suo, Research Scientist

Research Questions:

- How can infrastructure-assisted collective sensing V2X systems enhance both safety and traffic efficiency?
- How can cyber threats to infrastructure sensors be mitigated in connected vehicle deployment?
- What is the optimal allocation of sensors to balance resolution, latency and cost?



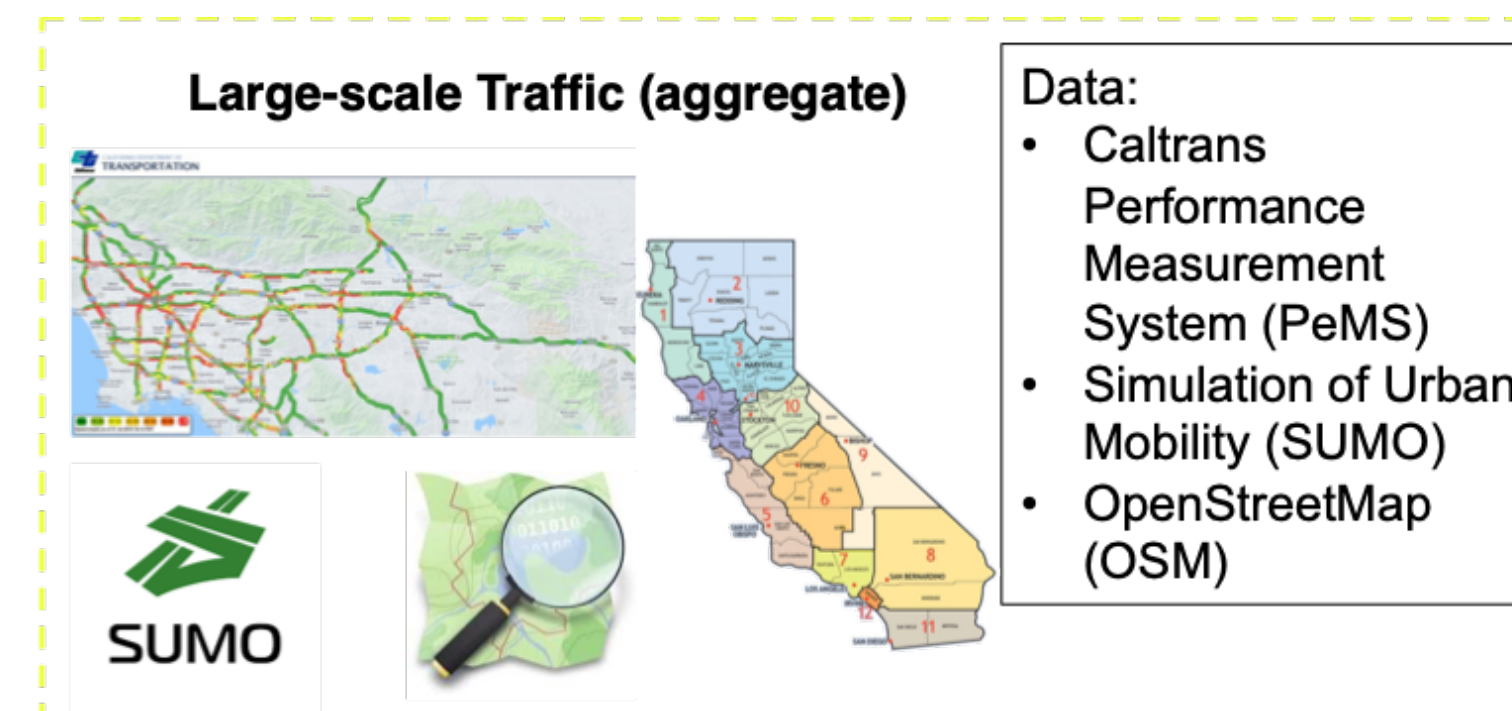
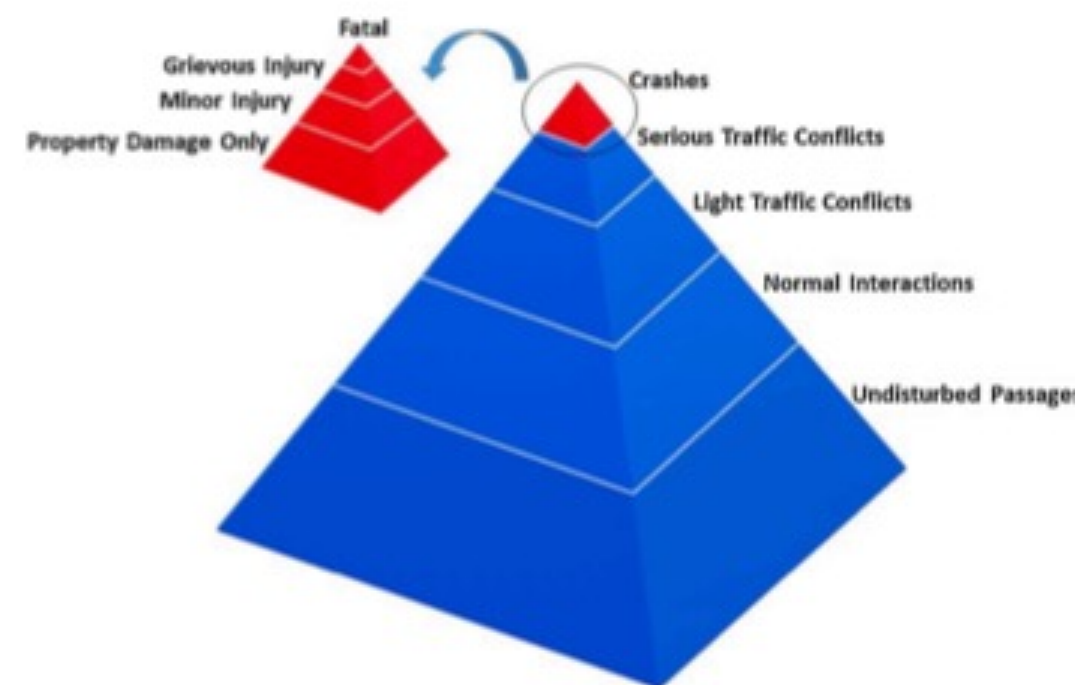
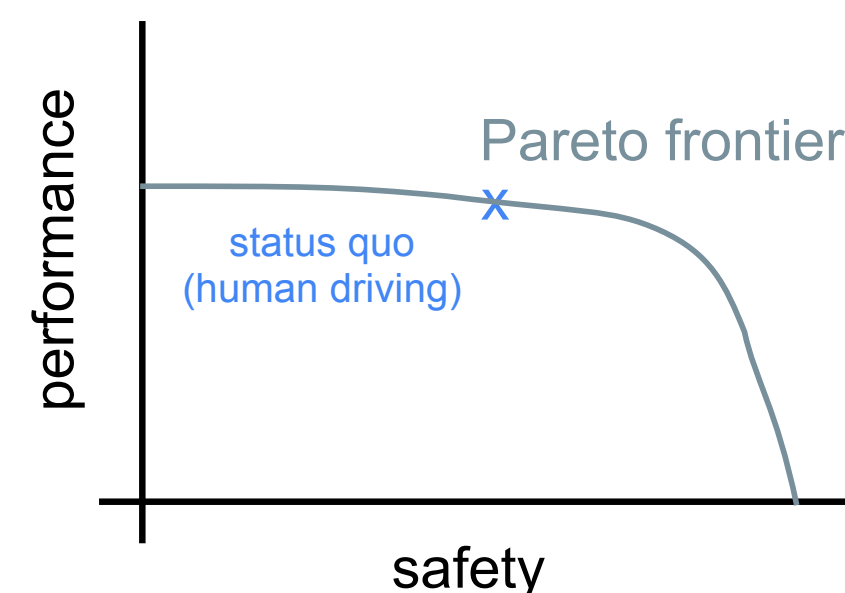
Safety as a Performance Measure for Autonomous Mobility

Principal Investigators:

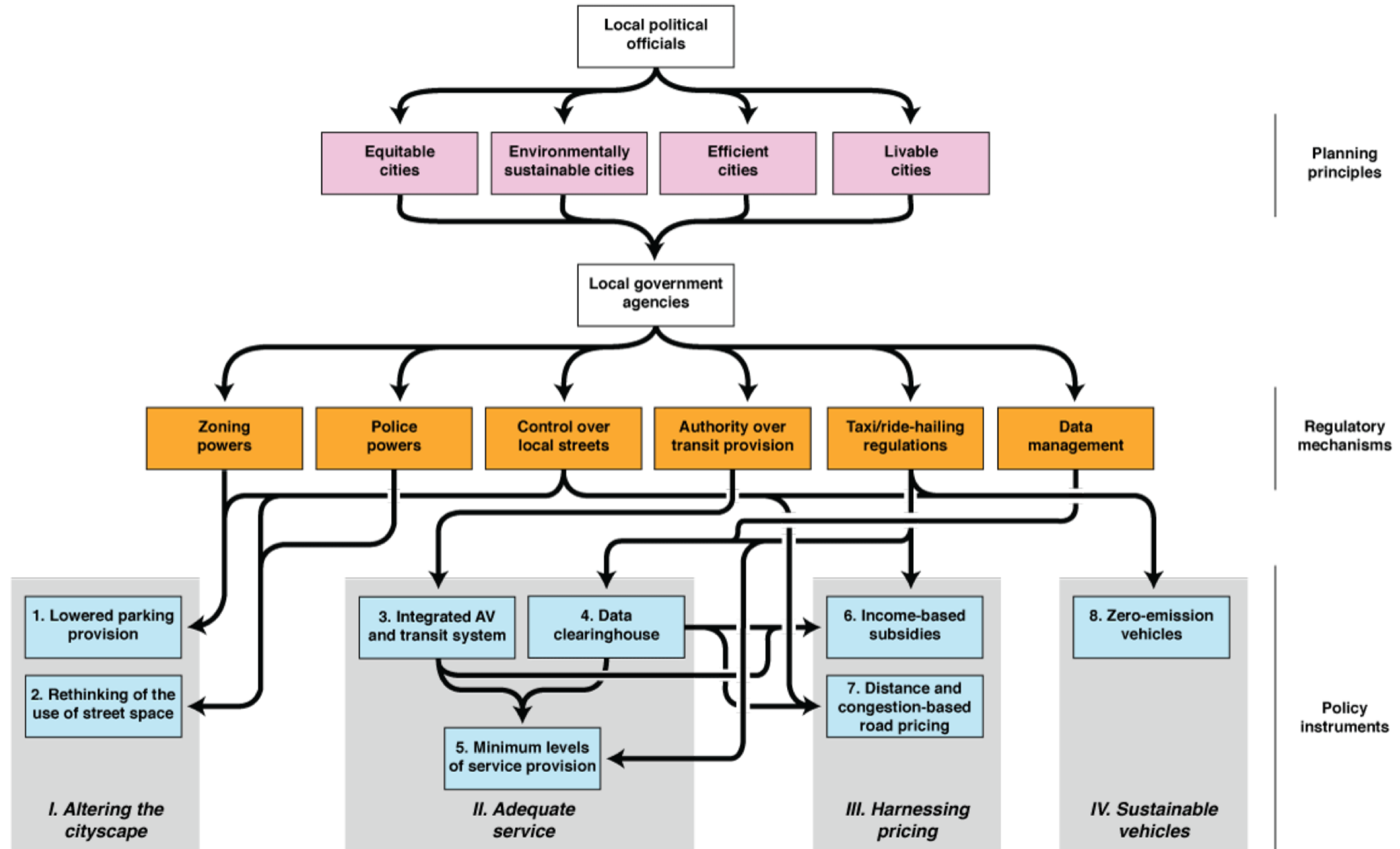
- Cathy Wu, Assistant Professor of Civil & Environmental Engineering & MIT Institute for Data, Systems and Society
- Ao Qu, MIT Graduate Student

Research Questions:

- What is the trade-off between safety and system performance for human-driven vehicles? How would this differ for autonomous vehicles?
- To what extent can large-scale traffic reconstruction contribute to the question "how safe is safe enough" for autonomous vehicles?



An urban agenda for the deployment of autonomous vehicles



Q2:

What finances the US

transportation infrastructure?

US Transportation Finance: Beyond the Gas Tax



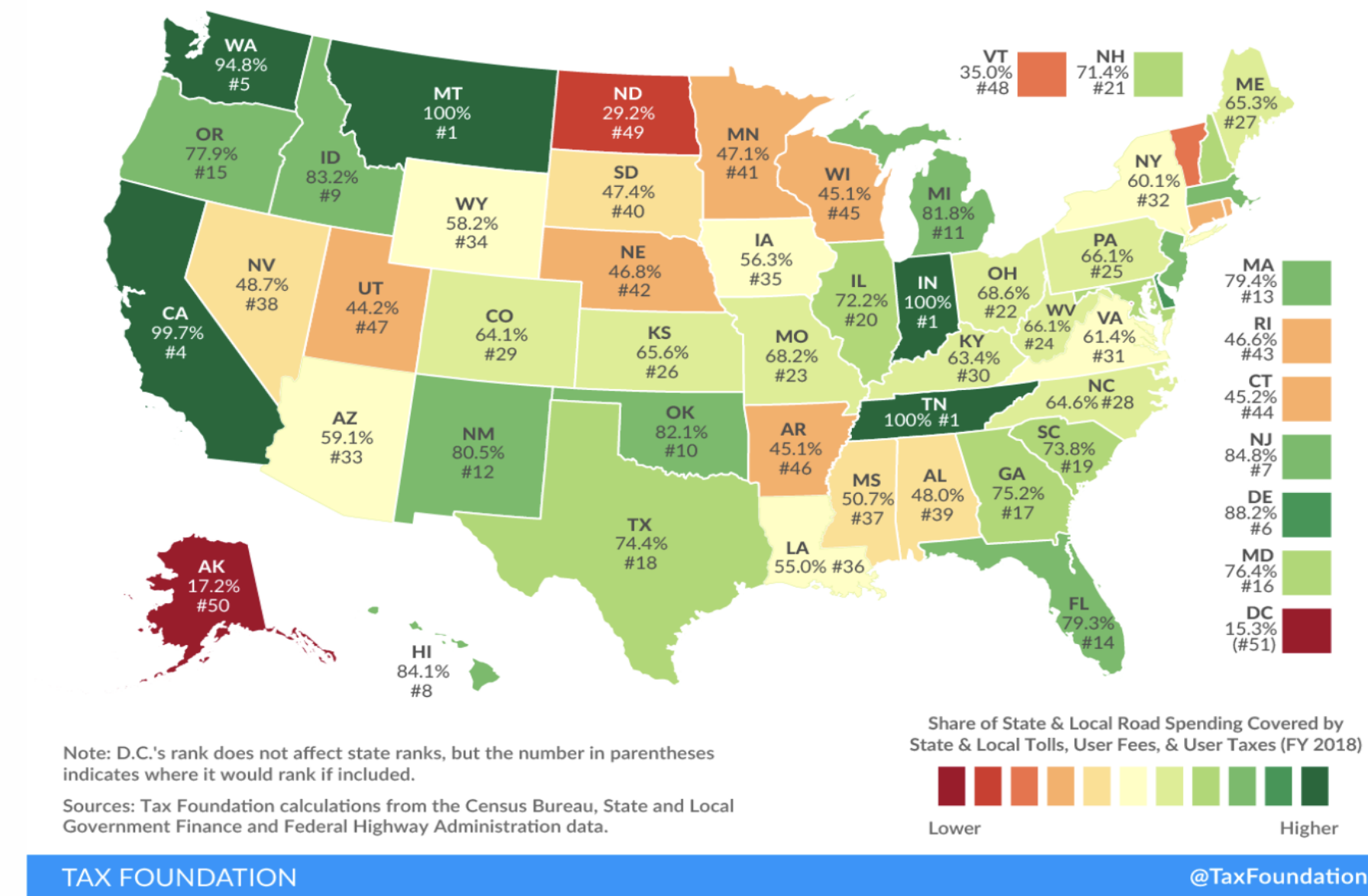
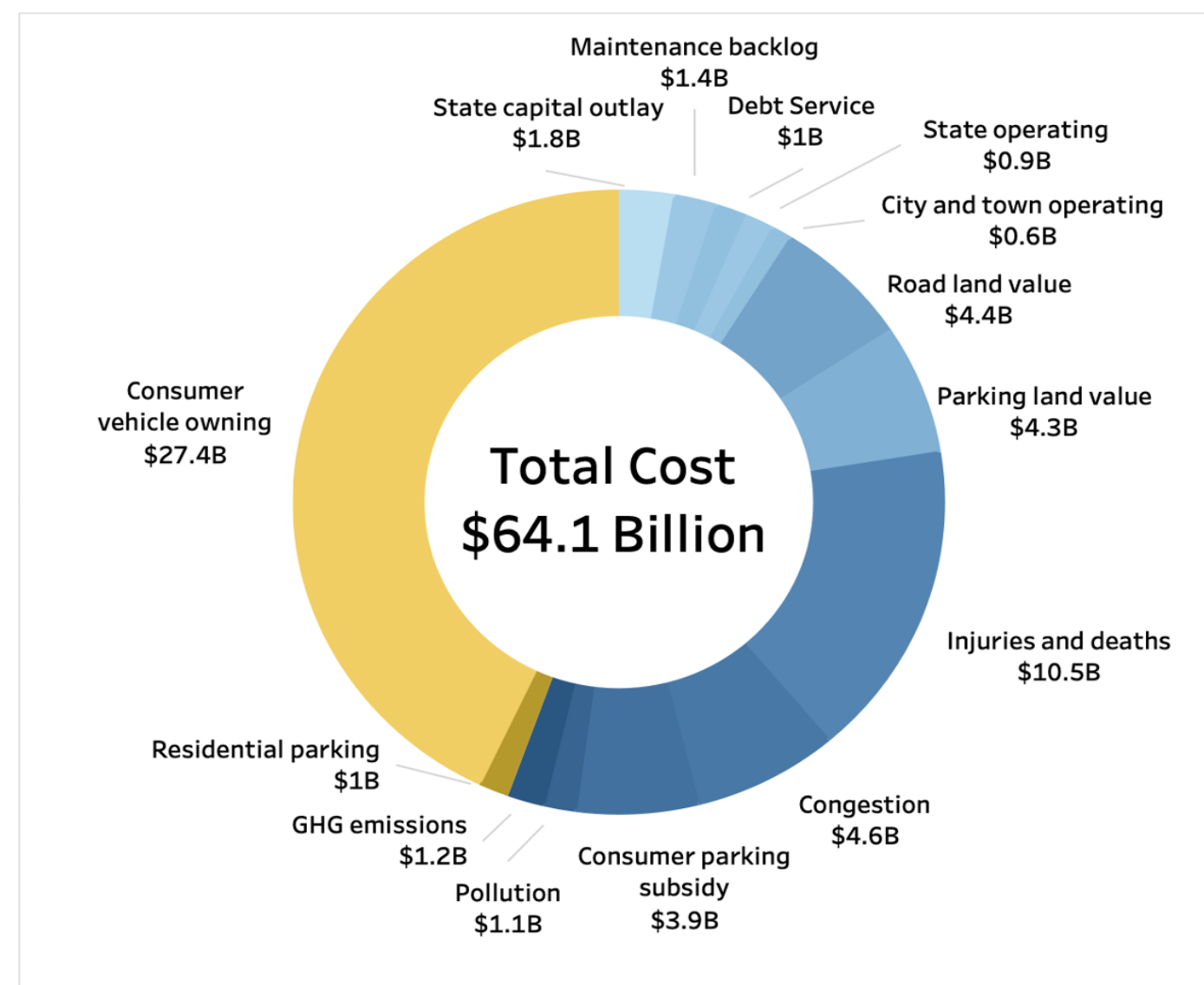
Principal Investigator:

- Jim Aloisi, Lecturer and MMI Researcher

Research Questions:

- What will be the impact of rising EV adoption on gas tax revenue?
- What are the alternatives to replace lost revenue?

Annual cost of the vehicle economy in Massachusetts



Convergence of three industries?

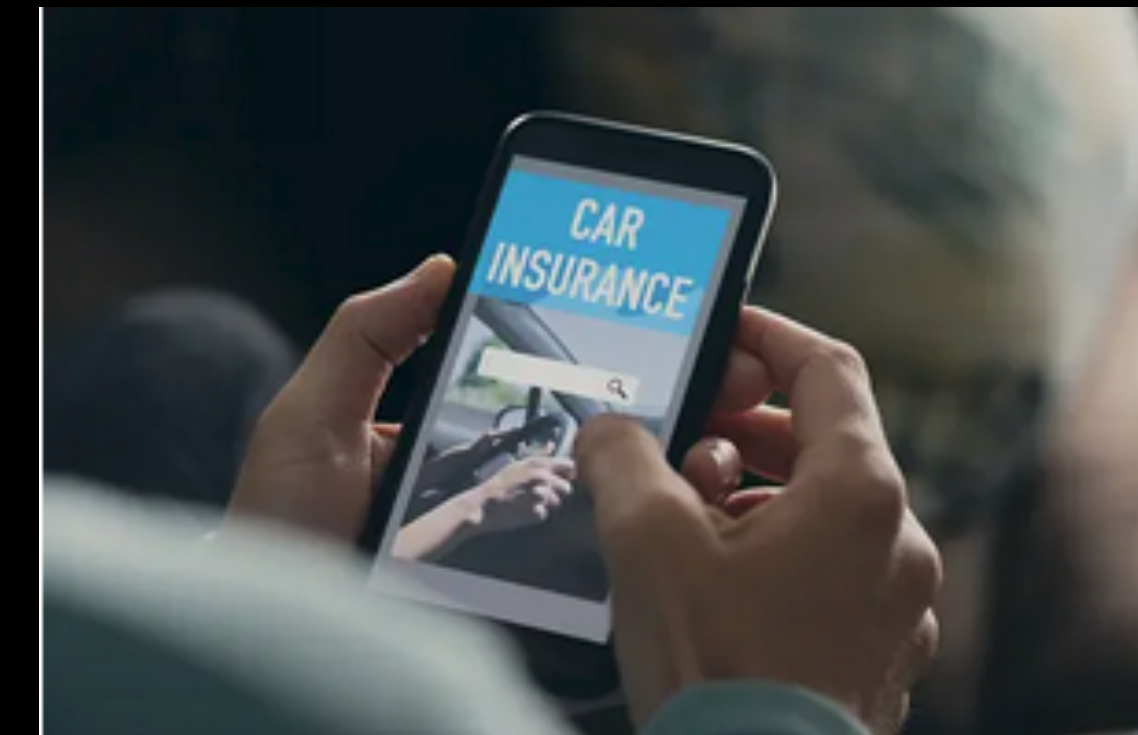
Gas Tax



Toll Road



Car Insurance



EV Charging Infrastructure Reliability in the United States

Principal Investigators:

- David Keith, Assistant Professor of System Dynamics, Sloan School of Management
- Jim Womack, MMI Fellow

Research Questions:

- Why is the reliability of US public charging infrastructure so poor?
- What could be done to improve the situation?

ENVIRONMENTAL RESEARCH LETTERS

PERSPECTIVES

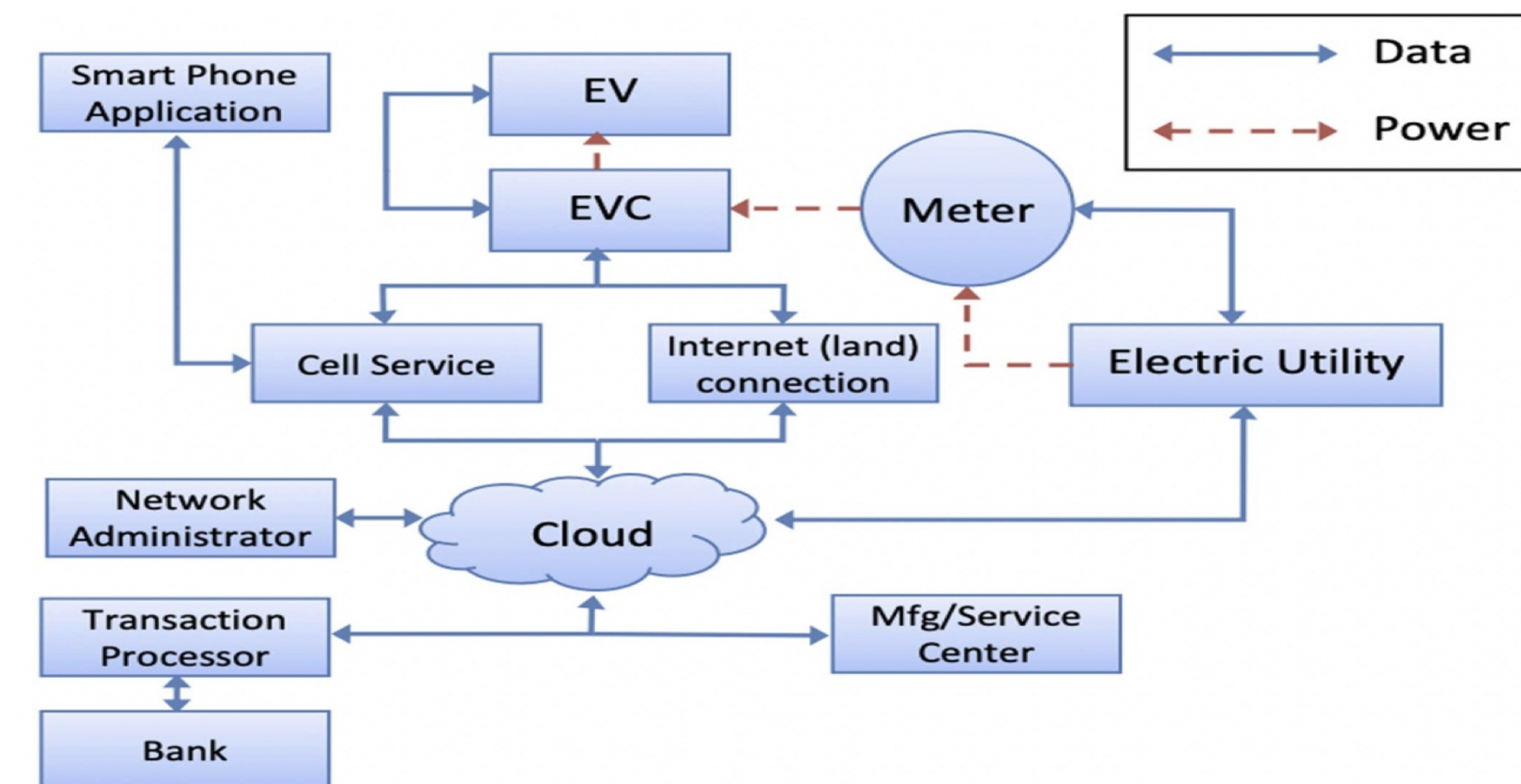
Building and sustaining reliable public EV charging in the United States

David Keith* and Jim Womack
MIT Mobility Initiative, Massachusetts Institute of Technology, Cambridge, MA, United States of America
* Author to whom any correspondence should be addressed.
E-mail: dkeith@mit.edu

Keywords: electric vehicles, EV charging, infrastructure, reliability

1. Introduction

The US electric vehicle (EV) market appears to be taking off. EV sales are at record levels in 2022 thanks to both sky-high gasoline prices and the increasing availability of desirable EV models in all shapes and sizes. But the reliability of the public charging infrastructure needed to power these EVs is not keeping pace. Anecdotes from EV drivers report frequent outages, government grants that lead to systemic underinvestment in maintenance, a fragmented charging infrastructure is emerging in which the reliability needs of end users—EV drivers—are neglected. As a result, a rapid and successful transition from internal combustion engine (ICE) vehicles to EVs may be imperiled. Active design and troubleshooting of the EV charging system is needed if the potential of the EV transition is to be realized.



Electric Vehicle Charging Urban Optimization

Principal Investigators:

- Alex Jacquilat, Asst Professor of Operations Research and Statistics, MIT Sloan School of Management
- Daniel Freund, Asst Professor of Operations, MIT Sloan School of Management

Research Questions:

- Where to locate public electric vehicle chargers in an urban setting?
- How many and what type (power) of chargers should be used in which locations?
- How to optimize charging infrastructure for access, utilization, equity, etc.?



Why does the US Public Transit Suffer and How to Improve it?

Principal Investigators:

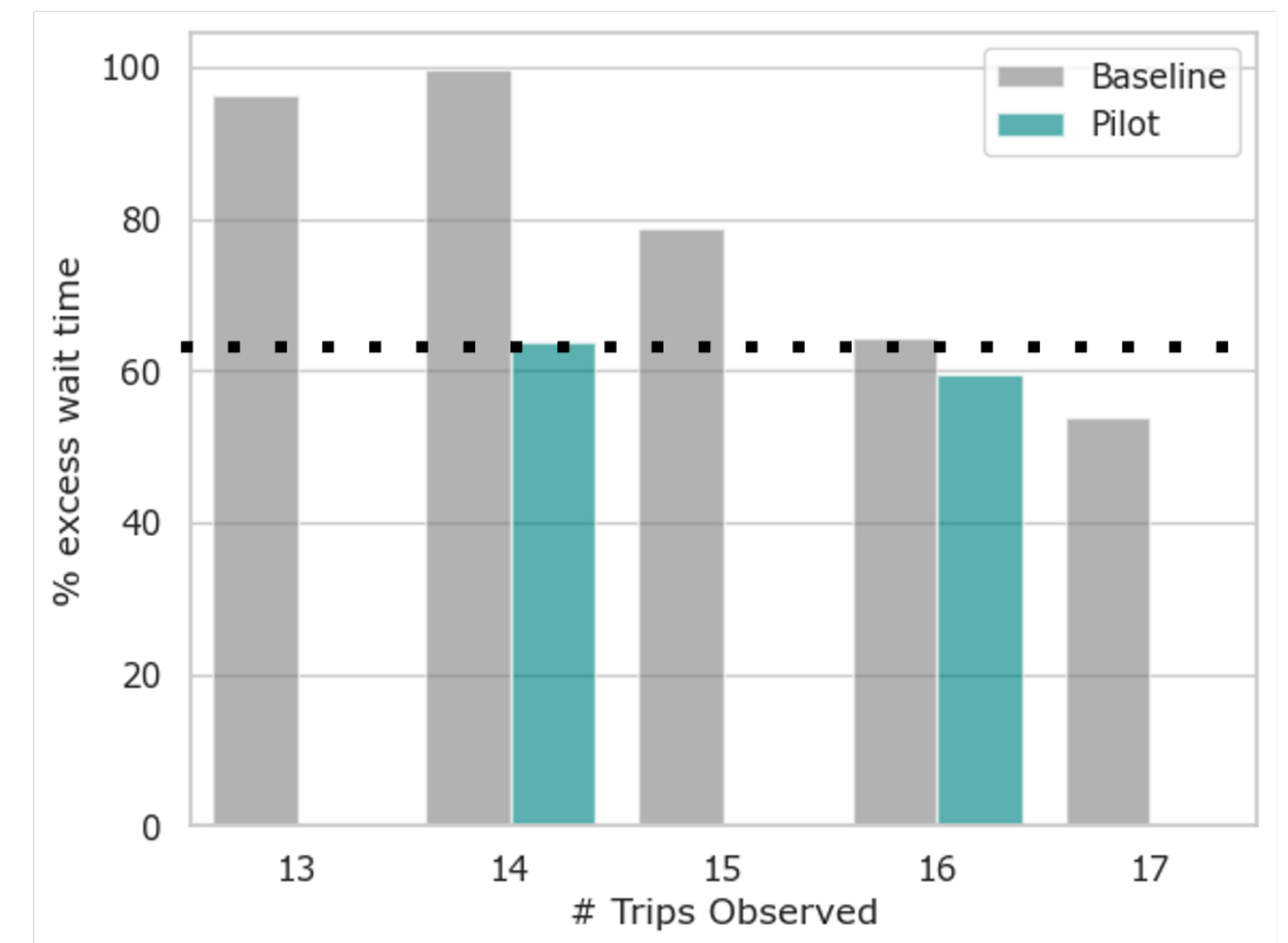
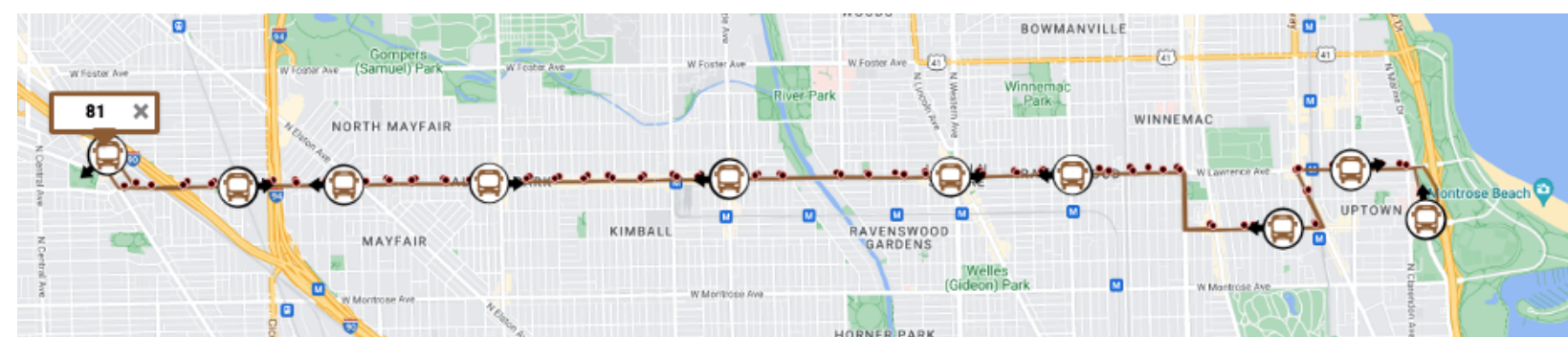
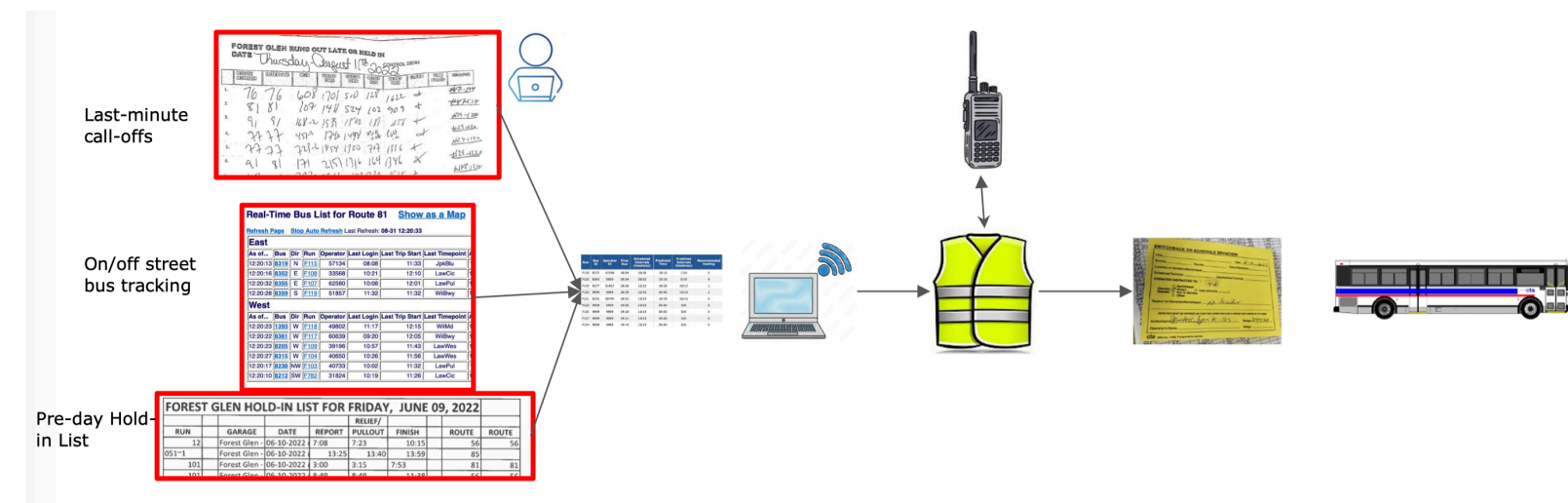
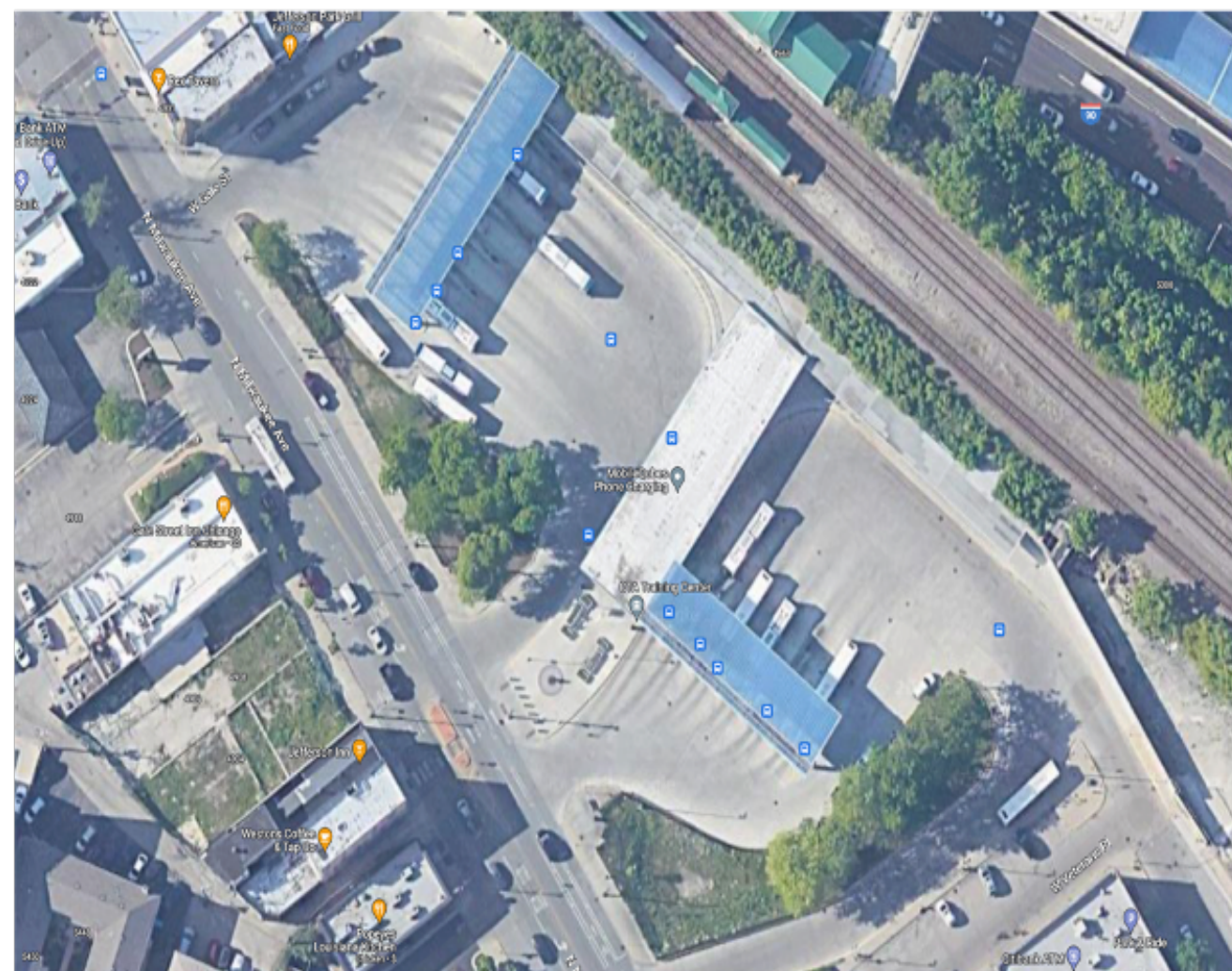
- Jim Aloisi, Lecturer and MMI Researcher
- Jinhua Zhao, MMI Faculty Director

Consortium Members:

- Seven top transit agencies in the US: New York, Chicago, San Francisco, Seattle, Los Angeles, Washington DC and Boston

Sample Research

- Future of work and transit ridership growth
- Improve transit operation and planning with machine learning



MIT serving the public

MMI Mobility Forum



Launched in 2020, the MMI Mobility Forum has run 85 sessions, reaching ~14,000 audience across the globe. All sessions are open to the public, recorded and annotated, serving as free education and training resource for universities, corporations, and public sectors.

Spring 2023 MMI Forum Series



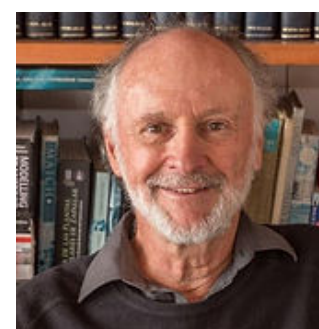
Envisioning Profitable Autonomous Transit Networks
Alain Kornhauser
Director Transportation Program, Princeton University



Telemobility, Hybrid Work and the Next Normal
Hani Mahmassani
Director Northwestern University Transportation Center



Tectonic Shifts in Science, Technology and Industrial Policy
Liz Reynolds
MIT Lecturer, Former Special Asst. to the President for Manufacturing
David Mindell
MIT Professor



Modelling Sustainable Options: Habit and Perceptions
Juan de Dios Ortuzar
Emeritus Professor, Pontificia Universidad Católica de Chile



The Case Against EVs as Transportation Policy One
Robin Chase
Co-Founder and former CEO of Zipcar, Buzzcar and GoLoco



Reinforcement Learning to Sequential Decision Analytics: Transportation Applications
Warren Powell
Professor Emeritus at Princeton; Chief Innovation Officer at Optimal Dynamics



How Safe is Safe Enough for Autonomous Vehicles?
Philip Koopman
Professor, Carnegie Mellon University



From Citations to Collective Wisdom in Travel Behavior Research
Joan Walker
Professor, Univ. of California, Berkeley



What About Pedestrians in Urban Mobility?
Andres Sevstuk
MIT Professor
Peter Norton
Professor, University of Virginia
Kris Carter
Chair, New Urban Mechanics, City of Boston



Last-Mile Logistics on Steroids: Delivering the Future Needs of Consumers
Matthias Winkenbach
Director, MIT Megacity Logistics Lab



Traffic Management Challenges in Advanced Air Mobility
Hamsa Balakrishnan
MIT Professor



AI and Public Transit
Jinhua Zhao
MIT Professor and Founding Director, MIT Mobility Initiative



Entrepreneurship Returns to the Auto Industry: Electric Vehicle Case Study
Charlie Fine
MIT Professor

MMI Mobility Forum



Theme One: Clean, Safe and Inclusive Mobility

Decarbonization 12

Safety, Security and Resilience 7

Society and Equity 6

Theme Two: Community, Policy, and Cities

Community 6

Cities and Pedestrians 10

Policy 10

Theme Five: Investment, Finance and Entrepreneurship

Investment 1

Finance 1

Entrepreneurship 1

Theme Three: Computation & Behavioral Analytics

Control and Optimization 9

Machine Learning 9

Behavior 11

Future of Work 3

Theme Four: Technology and Systems

Aerial Mobility 6

Automation 12

Public Transport 8

Shared Mobility 6

Supply Chain 5

MMF Sub-Series

Women Leaders in Transportation

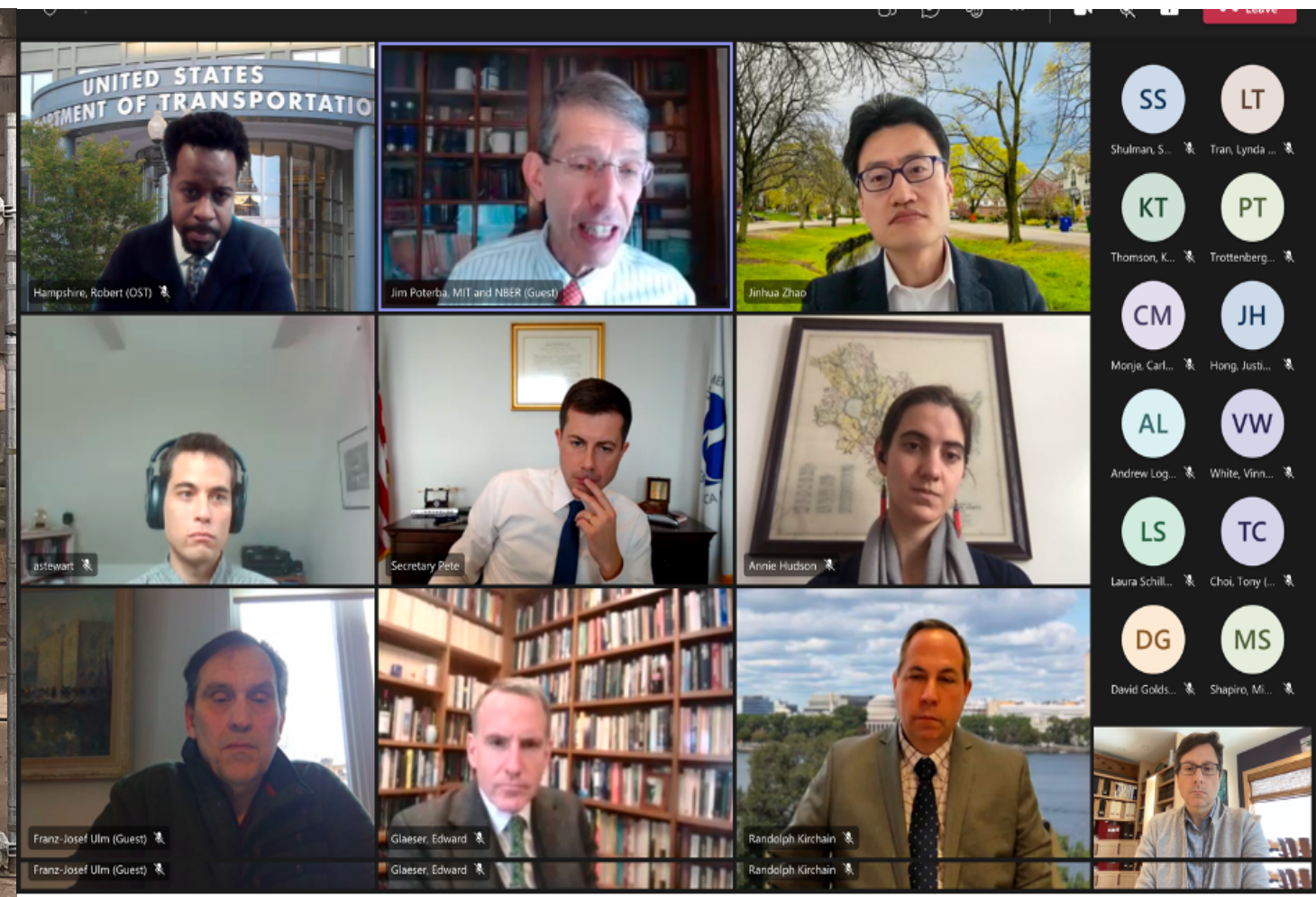
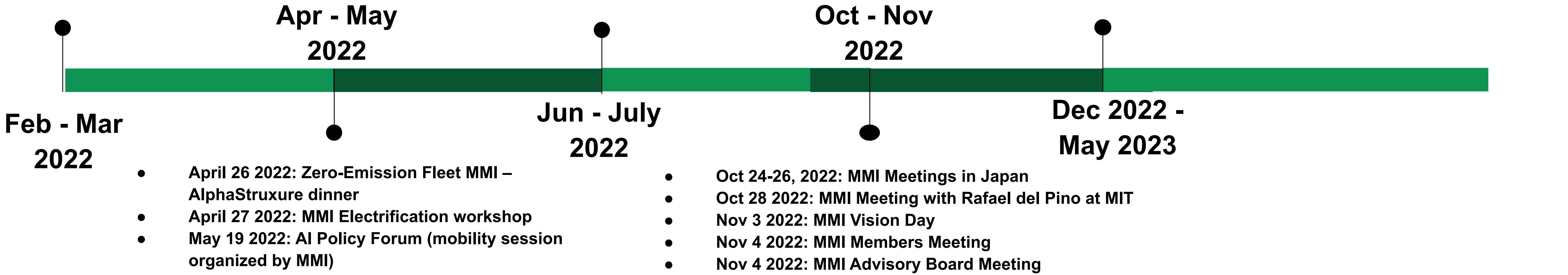
Wheels and Deals: Investment in Mobility

VC and Startups in Mobility

mml.mml.mit.edu/forum

Engagement: 2022 MMI Events

- Feb 1 2022: USDOT Briefing with Secretary Buttigieg (see photo)
- Feb 16 2022: Michigan Central Visit (see photo)
- March 24 2022: MMI Members Meeting
- July 7 2022: MMI Meetings with Ferrovial in Madrid
- July 14 2022: MMI Members Meeting
- July 26 2022: Imagining ARPA-I workshop (with The Engine and MIT Washington Office)
- Dec 8 2022: Jinhua attends ARPA-I workshop with Sec Buttigieg, Robert Hampshire
- Jan 10 2023: MMI hosts MIT TRB Reception
- Feb 2 2023 – MMI Academic Advisory Council
- April 25-26 – Michigan Central Visit
- April 27 – MMI Members Meeting
- May 31st – Global Advisory Board Meeting





MIT **Mobility Initiative**

mmi.mit.edu

10 Trends in Mobility ...

John Moavenzadeh

Q1: What topics in transportation
should MMI focus on?

Q2: One wish for your local or
global transportation?

(Be as specific as possible)

**Q3: Who should we invite to speak
at the MIT Mobility Forum (MMF)?**

Breakout Room

(10 person per room)

Breakout Room

(10 person per room)

Questions

Q1: What topics in transportation should MMI focus on?

Q2: One wish for the local or world transportation?

Q3: Who should we invite to speak at the MMF?

Please add your responses to [the google doc](#)