Mobility @ MSU – The Road Ahead

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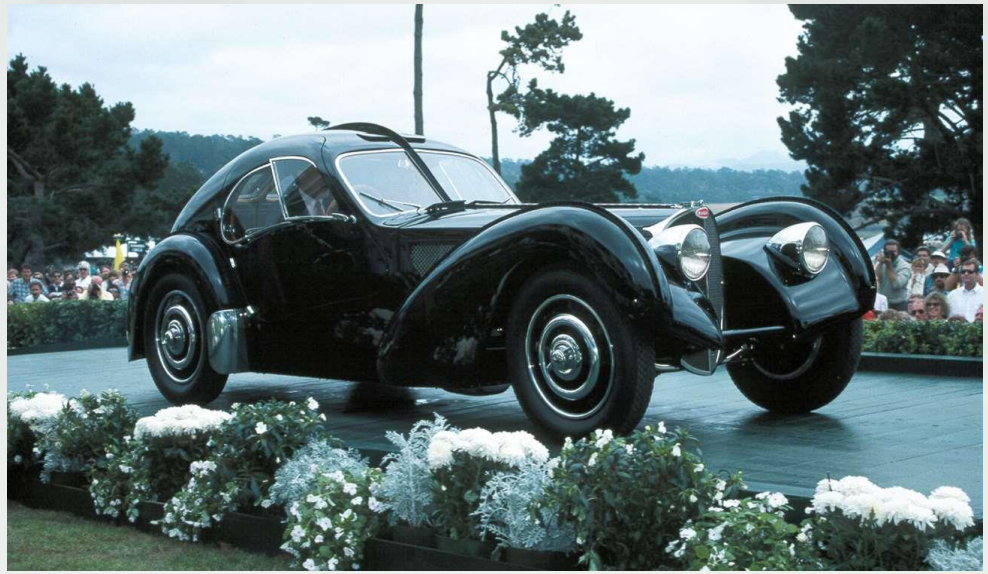
Michigan State University

Historical Context

- 1886 - Karl Benz patents Motorwagen.
- 1893 - Bicycle mechanics J. Frank and Charles Duryea of Springfield, Massachusetts design the first successful American gasoline automobile, then won the first American car race in 1895
- 1899 - 30 American manufacturers produced 2,500 motor vehicles
- 485 companies entered the business in the next decade
- 1908 - Henry Ford introduced the Model T and William Durant founded General Motors.

https://www.history.com/

Beauty In the Eye of the Beholder



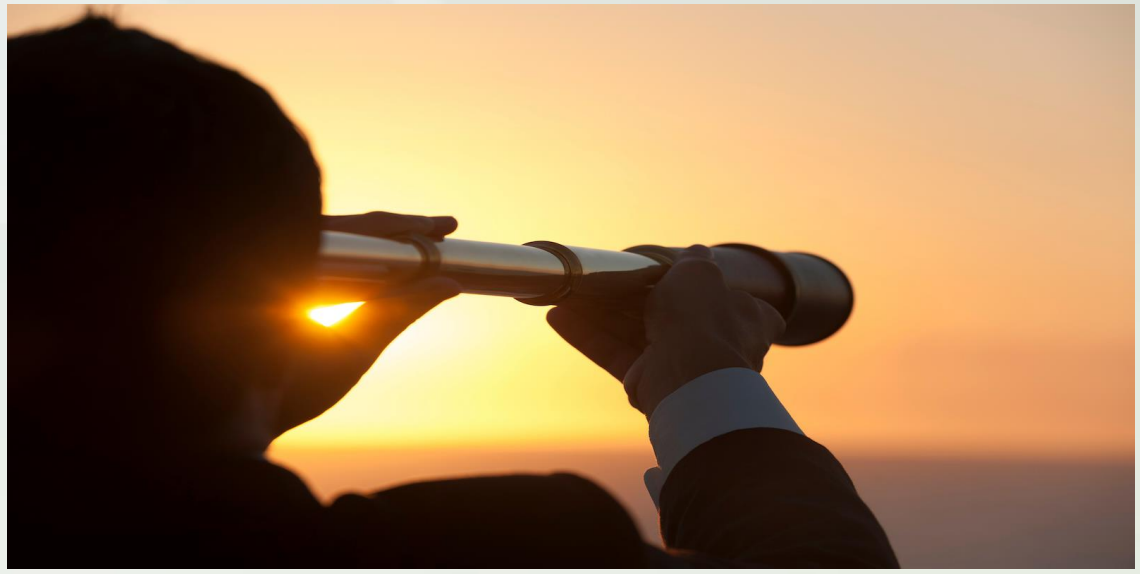
Current Context and Imperatives

- Automobile, has not changed in its fundamental form for over a century.
- Drive train has relied on the Internal Combustion Engine
- New Storm Clouds
  - Climate Change Issues (Transportation contribute 16% of 51 billion tons of carbon we release into the environment each year)
  - Confluence of New Technologies
    - High Speed Computing, High Speed Communications, New Materials, Battery Technologies, Artificial Intelligence, Automation/Robotics. New Sensors

Single Biggest Market Disruption the Industry has Seen in a 100 Years

Looking Into the Future

- Replacement of Internal Combustion Engine by Electric Motors
- Goodbye to fossil fuels for most transportation needs
- Poised to remove the man behind the steering wheel
- Self-driving/autonomous cars are not years away



Mobility @ MSU

SAE Level 4 Autonomous Vehicles

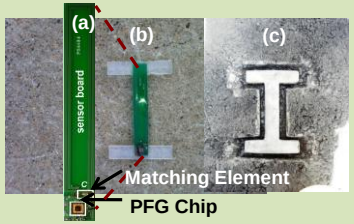
Autonomous Bus

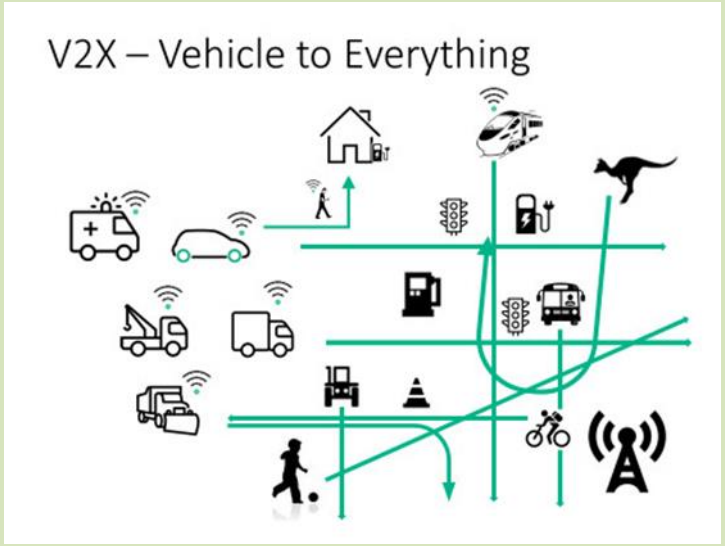
Engineering the Future

MOBILITY R&D

VEHICULAR TECHNOLOGIES

SMART INFRASTRUCTURE





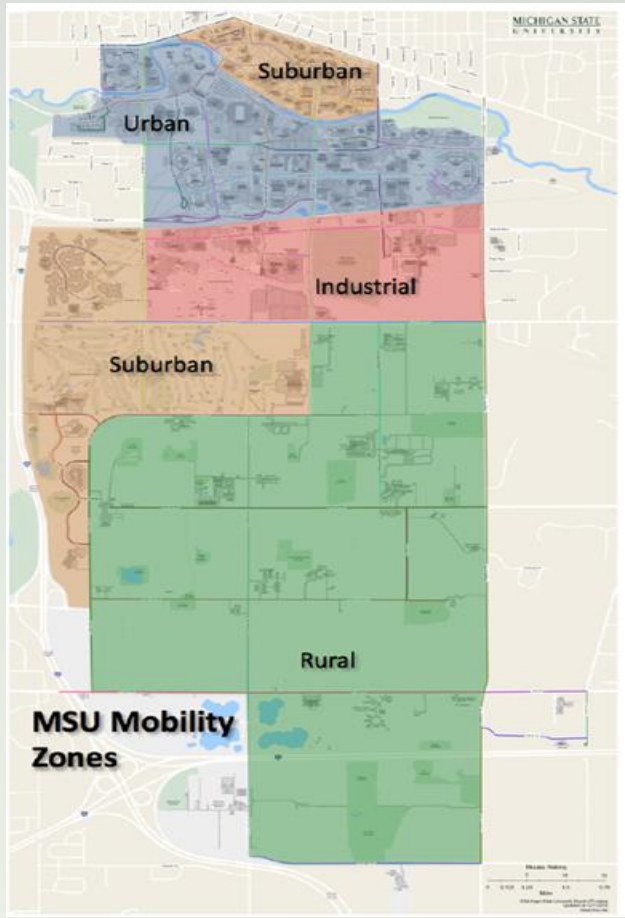
Social Aspects of new Technology (SOCIOMOBILITY)

MSU Facts and Figures

- Students: 49,695
- Faculty & Staff: 12,780
- Central Campus: 5,300 Acres
- Parking Spots: 14,000+
- Colleges: 17
- Academic Programs: 200+
- Research: $735 Million (2019 Expenditures)
- Roads 57 Lane Miles
- University Vehicles 1060
- Buildings 545
- MSU Police Force 85

Test Bed/Smart Infrastructure

- Traffic light controllers (Econolite Cobalt) installed and controllers updated (Econolite Centracs)
- HD Cameras (Iteris VantageNext) installed at intersections and linked to traffic controller
- Intersections linked to Central Traffic Control through Fiber
- RSUs (Siemens) installed along Farm Lane
- Cloud based Data Storage
- Eddy Current Sensors at Intersections
- Electric vehicle charging stations
  - IPF installs on demand in spots across campus
  - Bus Charging Facility
- Mobility App Developed and Distributed
- Mobility Operations Centered Planned



Autonomous Operations

- Autonomous Grass Mowers
- Autonomous Snow Removal
- Robotic Custodial Services

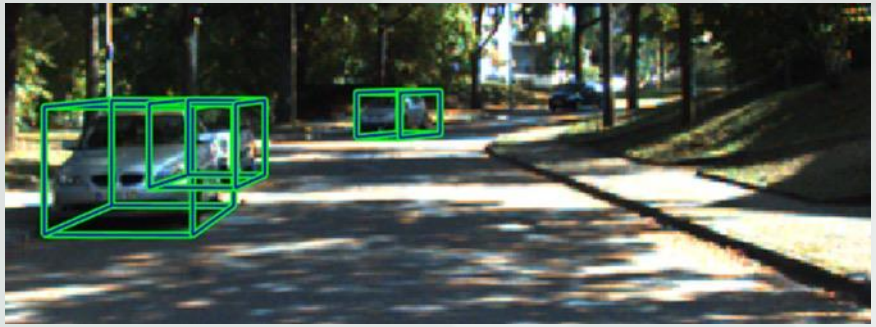
NS CENTER
launch anticipated

Vehicular Technologies

- Examples
  - Autonomous Driving
  - Machine/Deep Learning
  - Connectivity
  - 5G/CV2X
  - Cybersecurity/Repair
  - Energy Storage
  - Control Systems
  - Radar Design/RF Circuits
  - Drive Train, Battery Management
  - Infrastructure

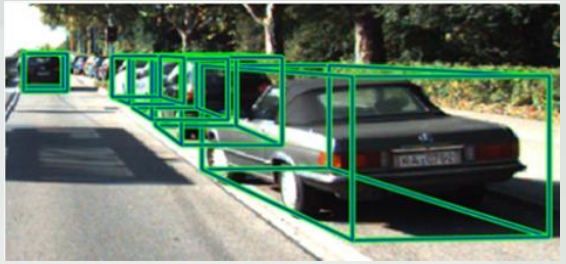
Autonomous Driving

- Hayder Radha, Dan Morris
  - Multimodal Sensor Data Fusion
  - Navigation under Extreme Conditions
  - 3D Scene Estimation

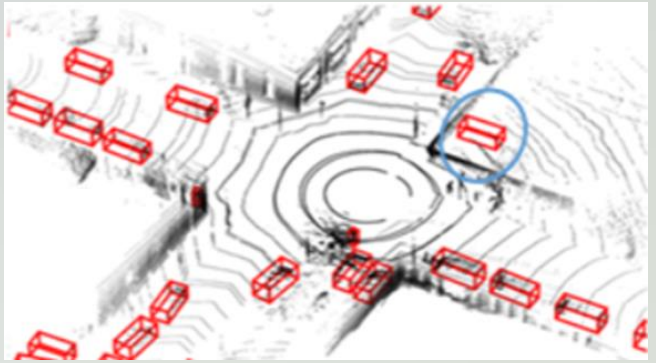


Occluded Object Detection

Radar Camera Fusion



Lidar Camera Fusion

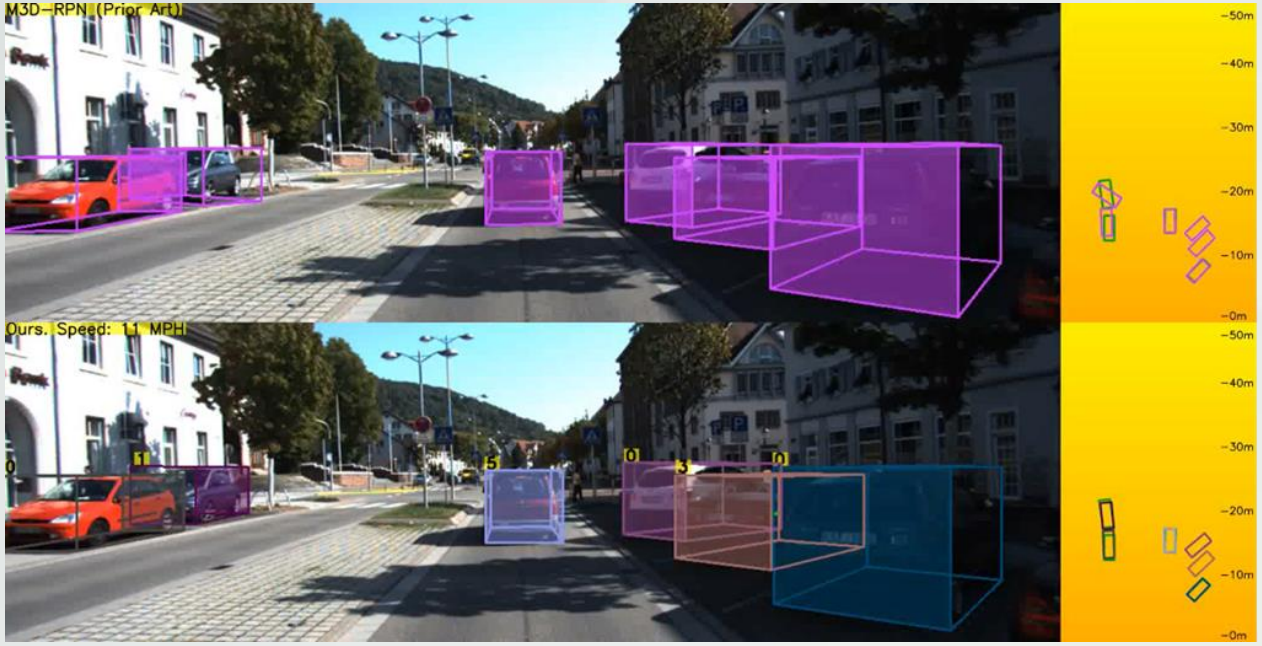


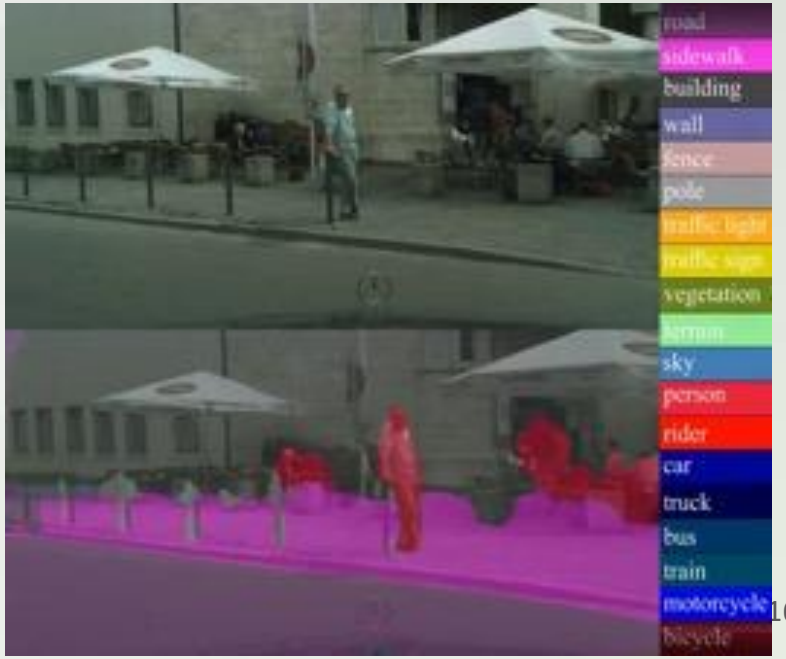
Global Track Association
for Vehicle Tracking

Object Detection Under Foggy or Smoky Conditions

Machine/Deep Learning, AI

- Xiaoming Liu, Vishnu Bodetti
  - 3D Object Detection with Velocity Estimation
  - Monocular Depth Estimation
  - Intent Perception
  - Situational Awareness

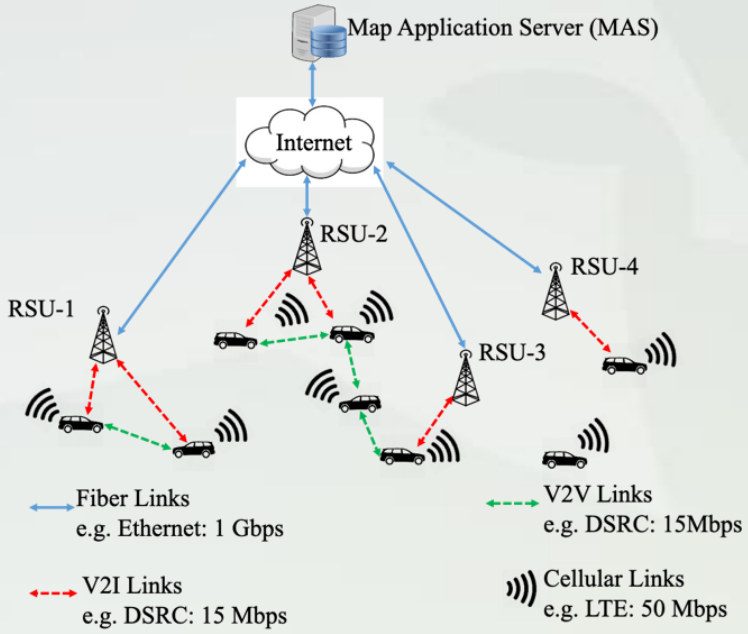


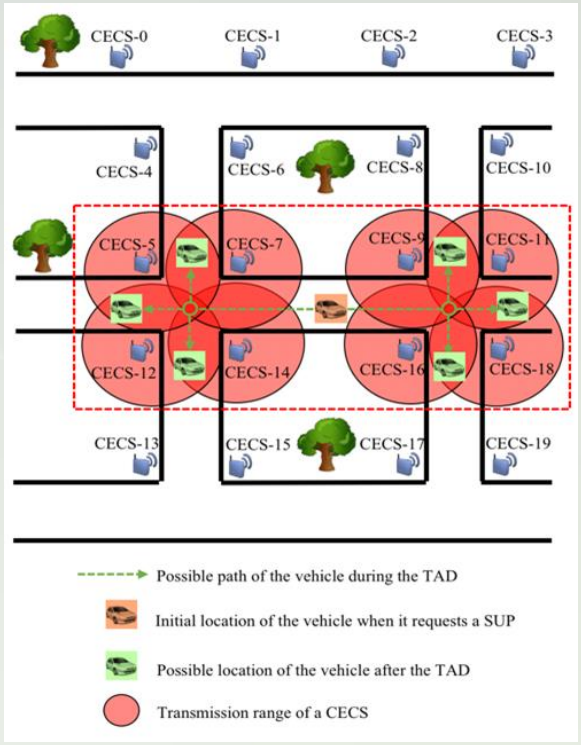


Connectivity

- Josh Siegel, Subir Biswas
  - V2X, V2V, V2I, V2P
  - CV2X
  - ATSC 3.0
  - Repair Code Broadcast

V2X Applications





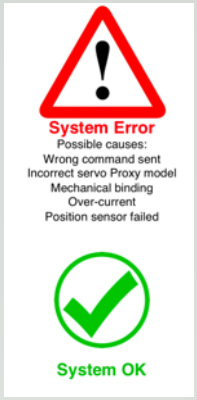
V2V Communications

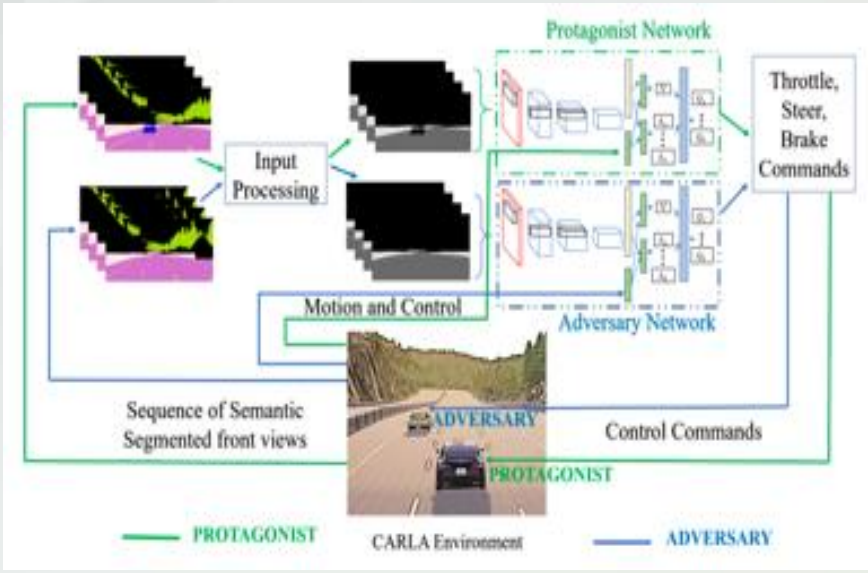
Connectivity 5G, CV2X

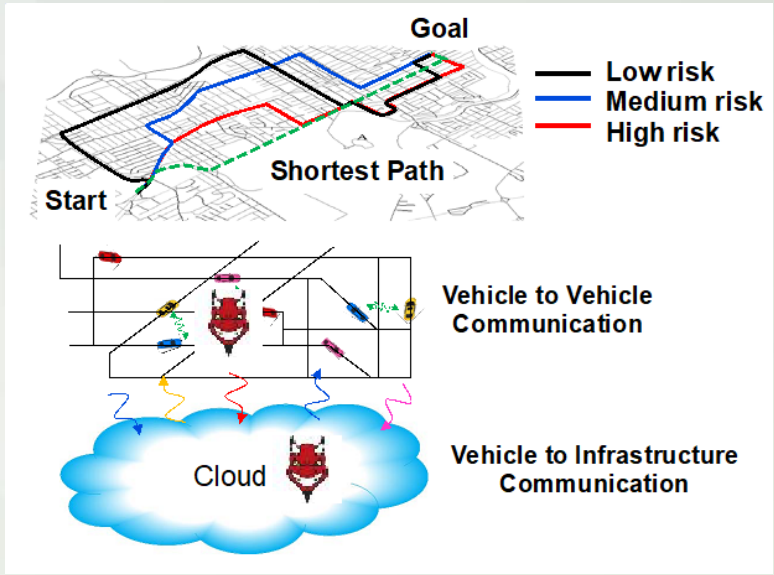
- Tongtong Li
  - What can unified connectivity with 5G offer by way of improved services
    - Ultra-precise positioning
    - Pedestrian Services
    - Shockwave Damping

Cybersecurity, Repair

- Betty Cheng, Josh Siegel, Shaunak Bopardikar
  - Assurance Certification
  - Secure and Efficient Autonomous Systems
  - Repair code broadcast

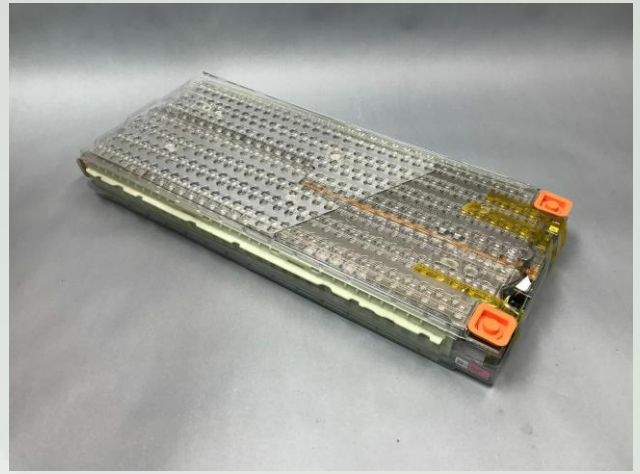






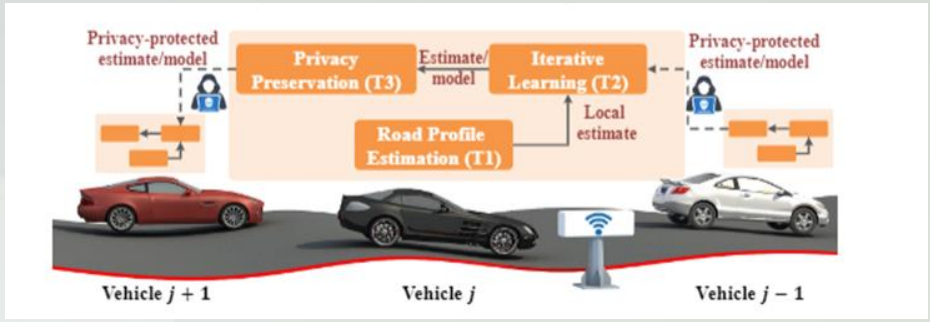
Energy Storage

- Xiaobo Tan, Vaibhav Srivastava, Chengcheng Fang, Jason Nicholas, Jeorg Petrasch, Tom Guarr
  - Automation in battery recycling
  - Battery Electrolytes
  - Battery chemistry
  - Redox Batteries
  - Hydrogen Cells



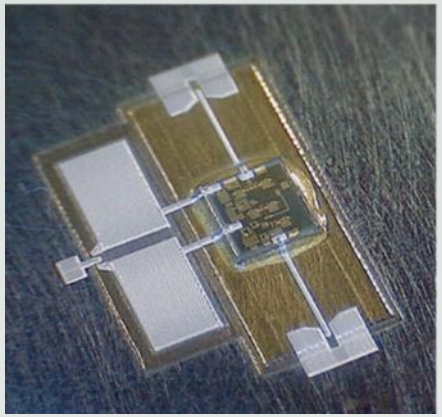
Control Systems

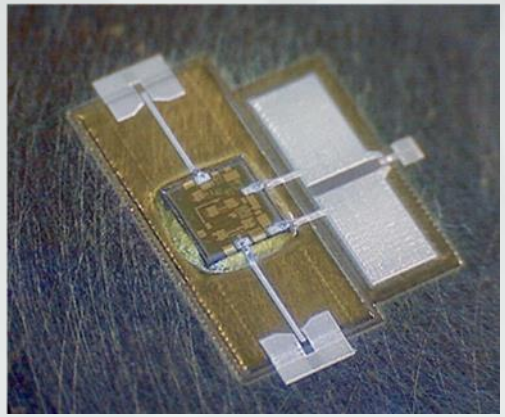
- Zhaojian Li, Xiaobo Tan, Nizar Lajnef, Vaibhav Srivastava
  - Vehicle Dynamics and Control
  - Control of Autonomous Systems
  - Sensors and Actuators
  - Self-Powered Sensors
  - Long term monitoring of civil infrastructure
  - Asphalt and concrete embedded sensors

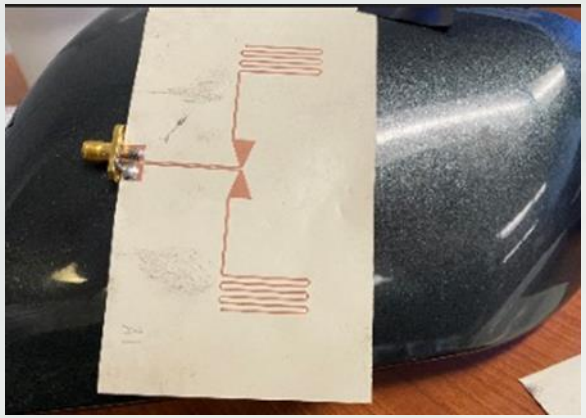


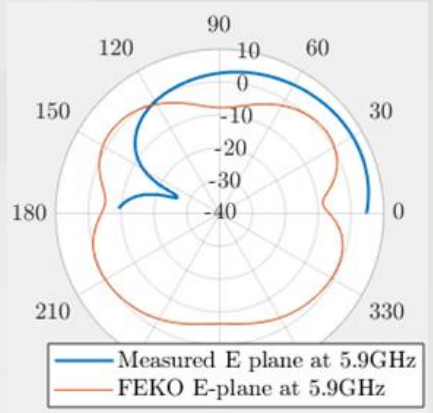
Radar Design, RF Circuits

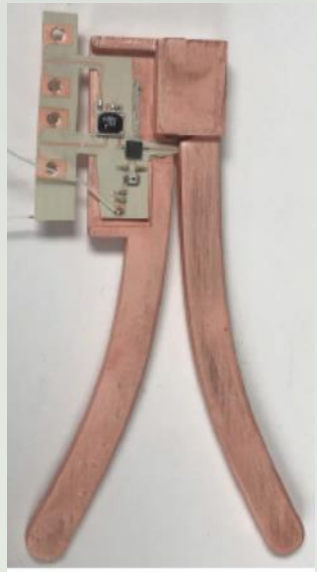
- John Papapolymerou, Jeffrey Nanzer, Prem Chahal
  - 77 GHz Automotive Radar Design
  - RF/Microwave & mm-wave circuits





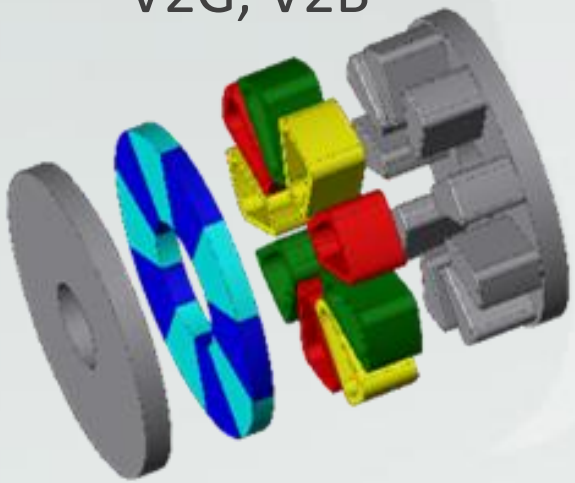


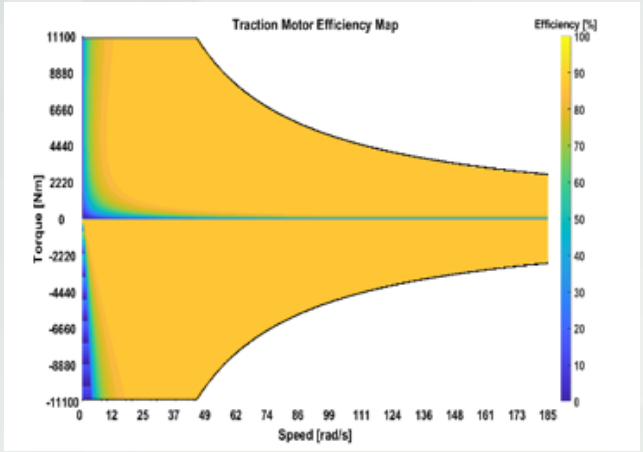


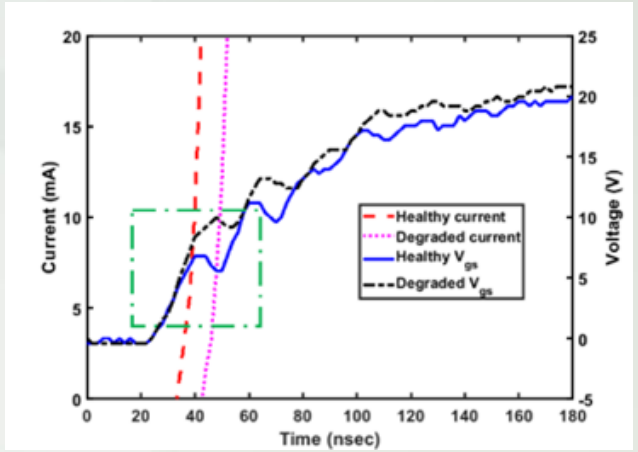


Drive Train and Battery Management

- Shanelle Foster, Matt Woongkul
  - High Performance Electrical Machine and Drive Design
  - Power Electronics, Fast Charging Systems
  - Diamond Electronics
  - V2G, V2B

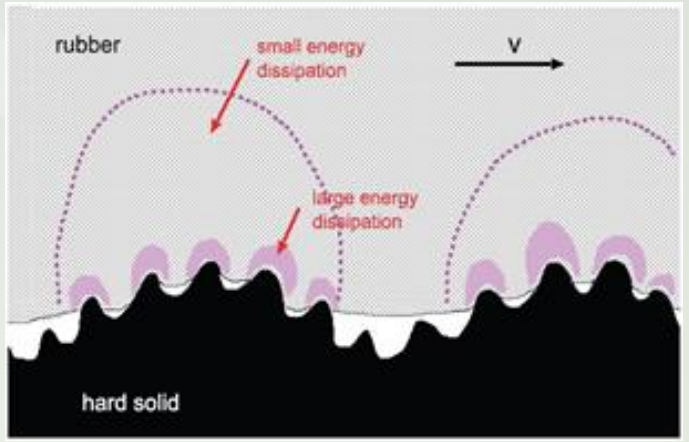






Infrastructure

- Peter Savolainen, Tim Gates, Mehrnaz Ghamami, Ali Zockaie, Roozbeh Dargazany
  - Infrastructure Enhancements to promote vehicle safety
  - Statistical and Econometric Methods
  - Traffic Operations
  - Intelligent Transportation Systems (ITS)
  - Optimal Placement of Charging Stations
  - Network Modeling
  - New pavement designs to improve grip & rolling resistance



Sociomobility @ MSU

- Transportation Safety
- Connected and Autonomous Vehicle Traffic Operations
- Designs for commuters with disabilities
- Transportation Needs of Aging Populations and Underserved Communities
- Accessible Transportation
- Broadband Enabled Internet Technologies
- Impacts on State and Local Government Finances
- Model Regulations for Autonomous Vehicles
- Micromobility Related Behaviors
- Passenger and Freight Rail Issues

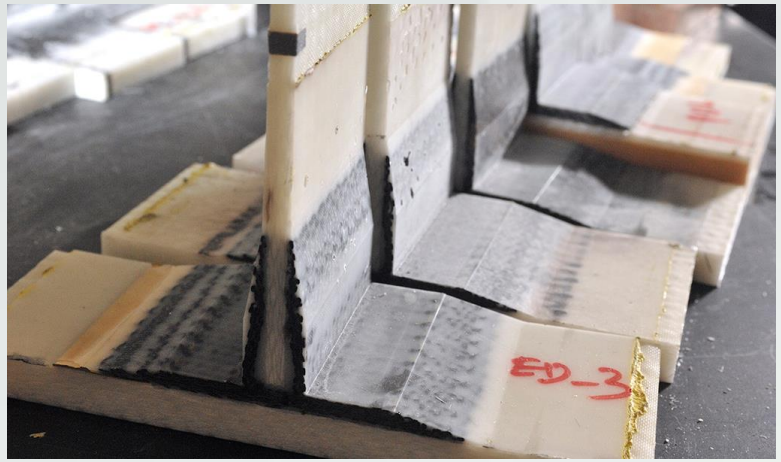
The Road Ahead

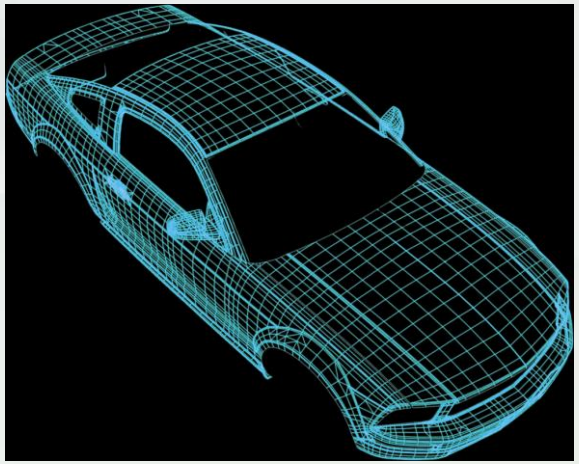
The Road Ahead

- Light-weighting
  - Structural Light-weighting
  - Battery Light-weighting
  - Recyclable Composites
  - End-of-Life Management
    - Structural Elements
    - Battery Elements
    - Drive Train

Light-weighting

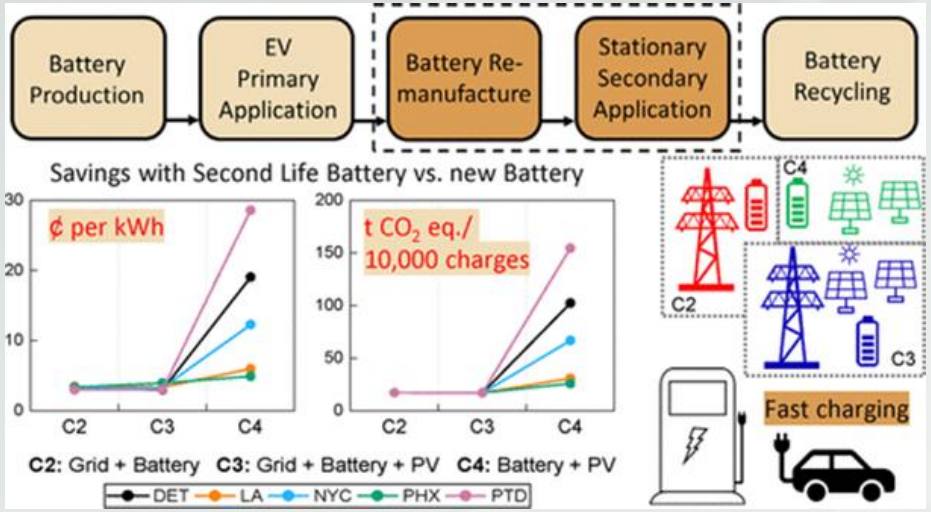
- Mahmoodul Haq, Lalita Udpa, Tamara Bush
  - Composite Materials and Structures
  - Rapid joining technologies for assembly, dis-assembly and re-assembly
  - Crash energy absorption via kinetic energy redistribution
  - Health monitoring systems for continuously monitoring structural health and vehicular performance
  - Seating Mechanics, Injury Protection, Design for Disability

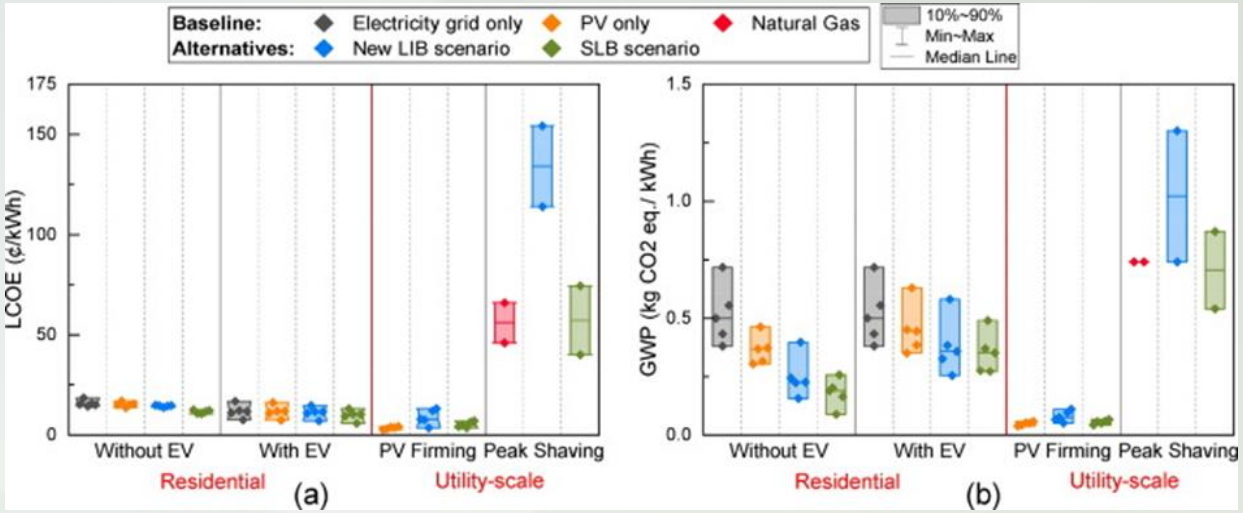




Life Cycle Management

- Annick Anctil
  - Life-cycle assessment, Remanufacturing Batteries





Summary

- Wide variety of technologies and expertise
- One Stop Shop for Technology, Sociomobility and Legal Issues
- Ability to view issues synergistically through multiple lens
- Living laboratory test bed for evaluating for First Mile/Last Mile Issues
  - pedestrian intense environment
  - Known cycles of pedestrian and vehicular traffic
  - Ability to modify campus and test environment