Overview of Connected and Automated Vehicle Testing in Wisconsin

Civil and
Environmental Engineering
UNIVERSITY OF WISCONSIN–MADISON

Presenters

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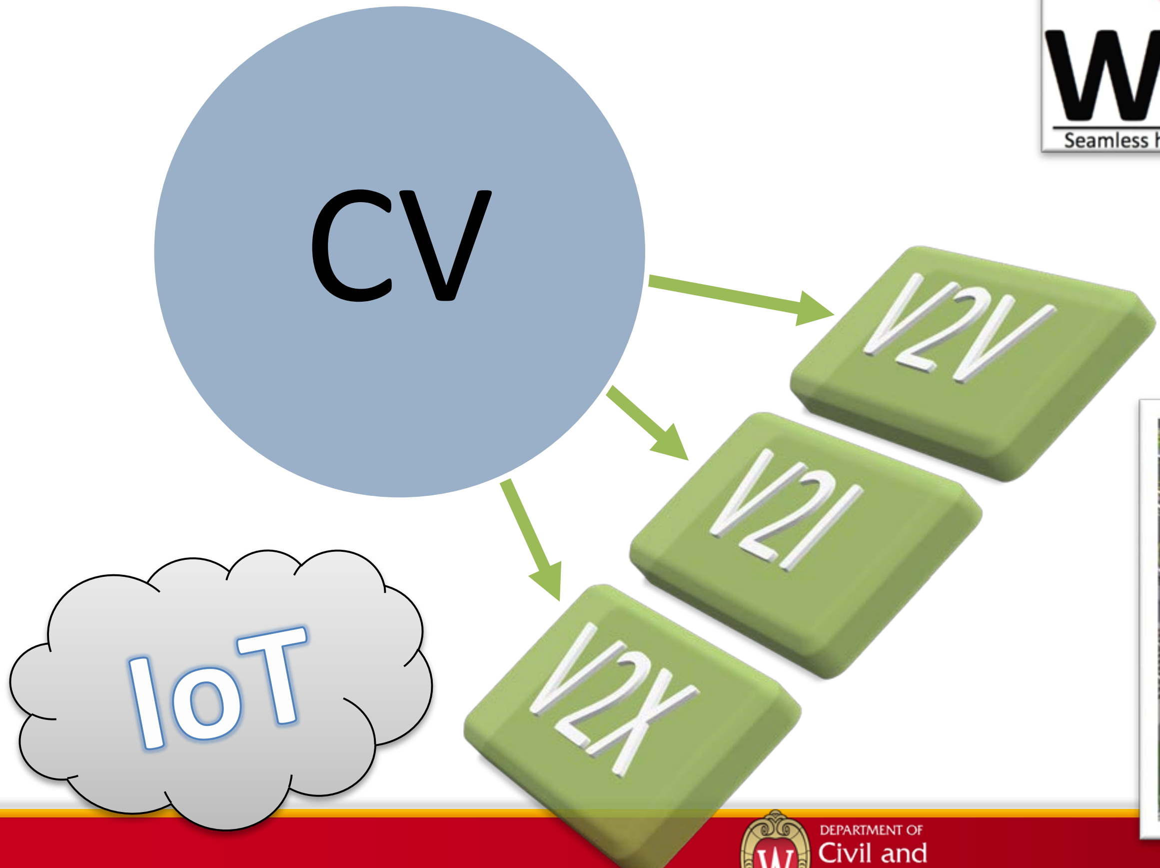
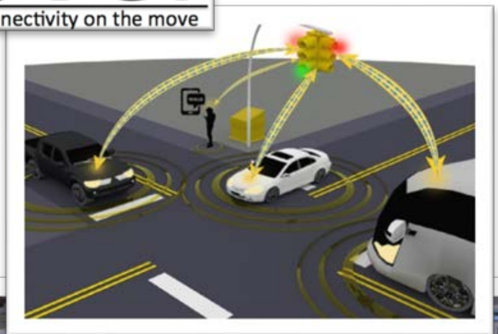
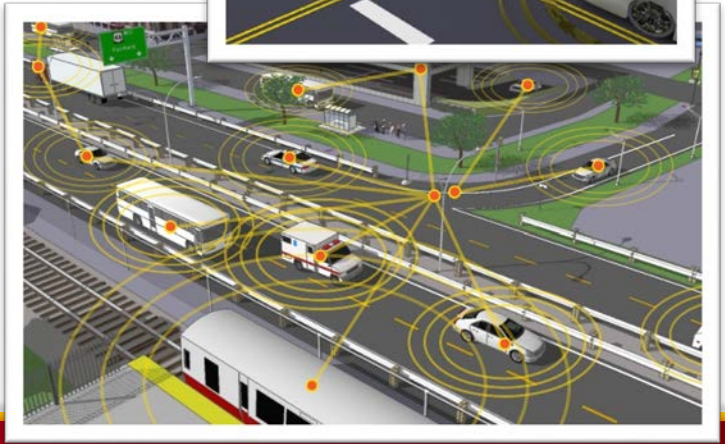
WISCONSIN TOPS
TRAFFIC OPERATIONS & SAFETY LABORATORY

Connected Vehicles



WiRover
Seamless high bandwidth connectivity on the move





Automated Vehicles

AV

Take Different Forms

How AVs Operate

CAMERAS
Cameras gather visual information from the road and traffic control and send them to the controller for processing.

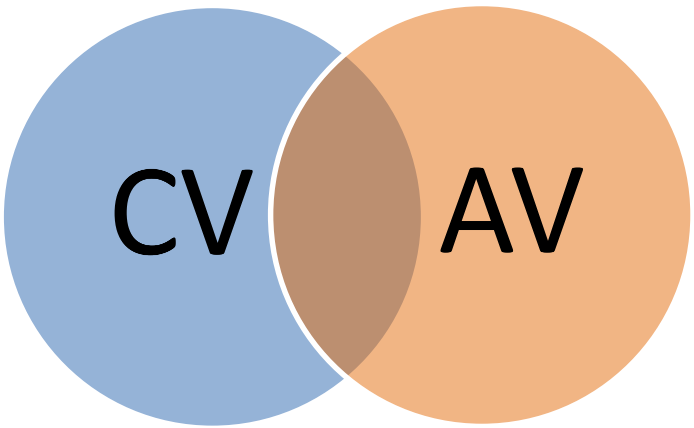
LIDAR
LiDAR sensors bounce lasers off of detected objects. LiDAR can detect road lines and assets and differentiate objects.

RADAR
Radar sensors bounce radio waves off detected objects. Radar cannot differentiate objects.

GPS UNIT
The GPS unit identifies the precise position of the vehicle and aids in navigation.

Connected vs Automated Vehicles

- Though separate technologies, they complement each other
- In their overlap lie the greatest advances and potential benefits
- Issues are sometimes unique to each, e.g., privacy, security, human factors, regulation, liability, etc.

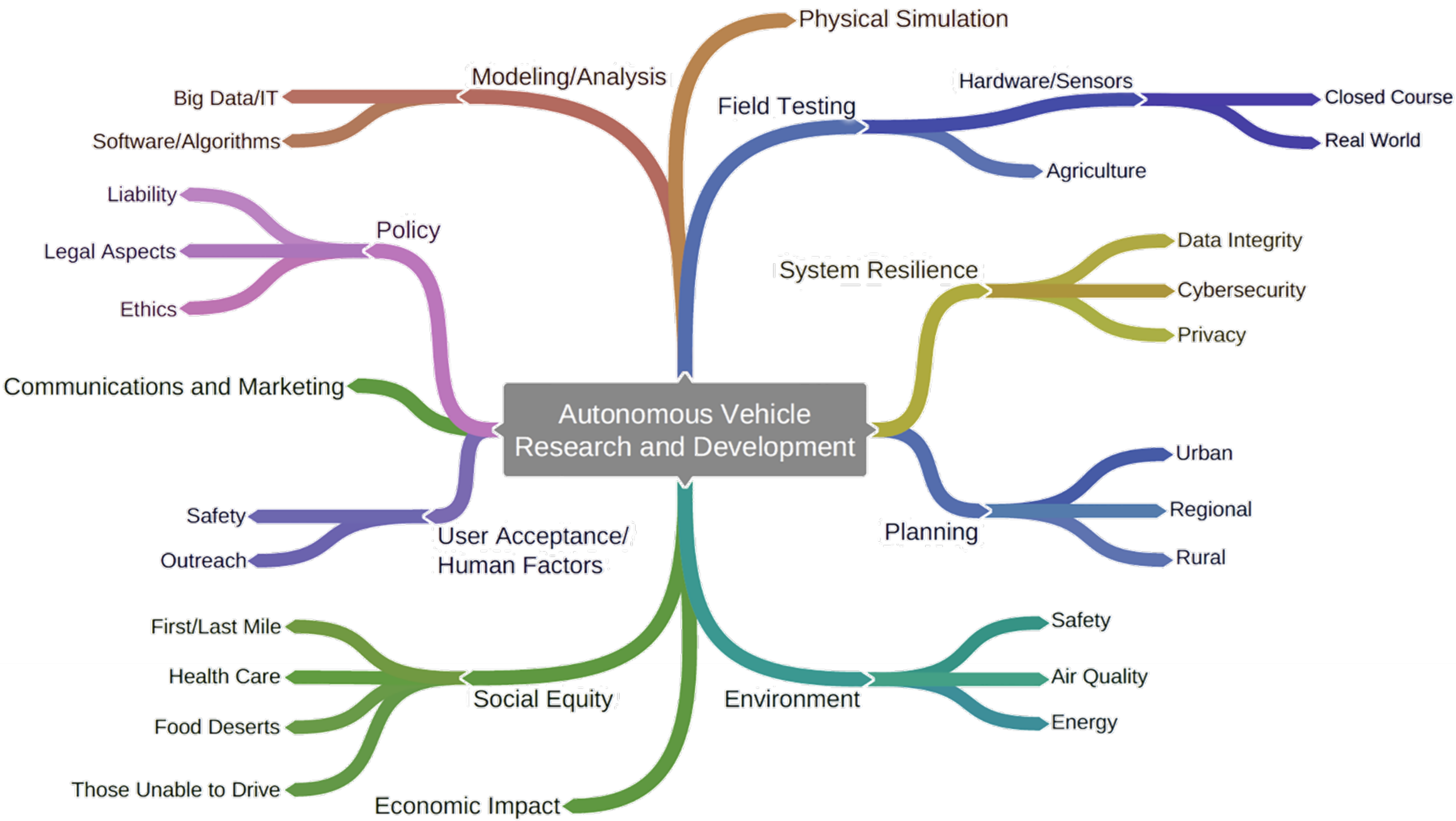


Perceived and Real Challenges

- Are AVs safe?
- What happens when an AV malfunctions?
- Can someone hack into my vehicle?
- Who is responsible when an AV crashes?
- How does an AV operate on snow and ice?
- AV reaction to deer and pedestrians?
- I like to drive – not interested in AV!
- AVs in a multi-modal and mixed use environment?

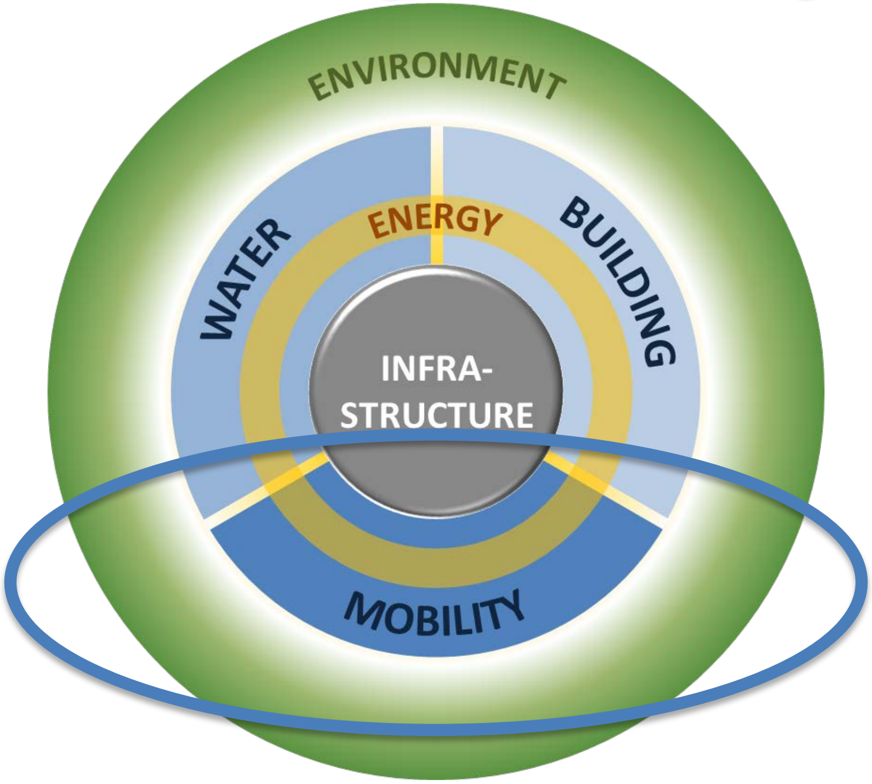
Tesla Crash, May 2016, Florida

Breadth, Complexity, Edge Cases



CEE Strategic Themes

Cross-Cutting Areas in College



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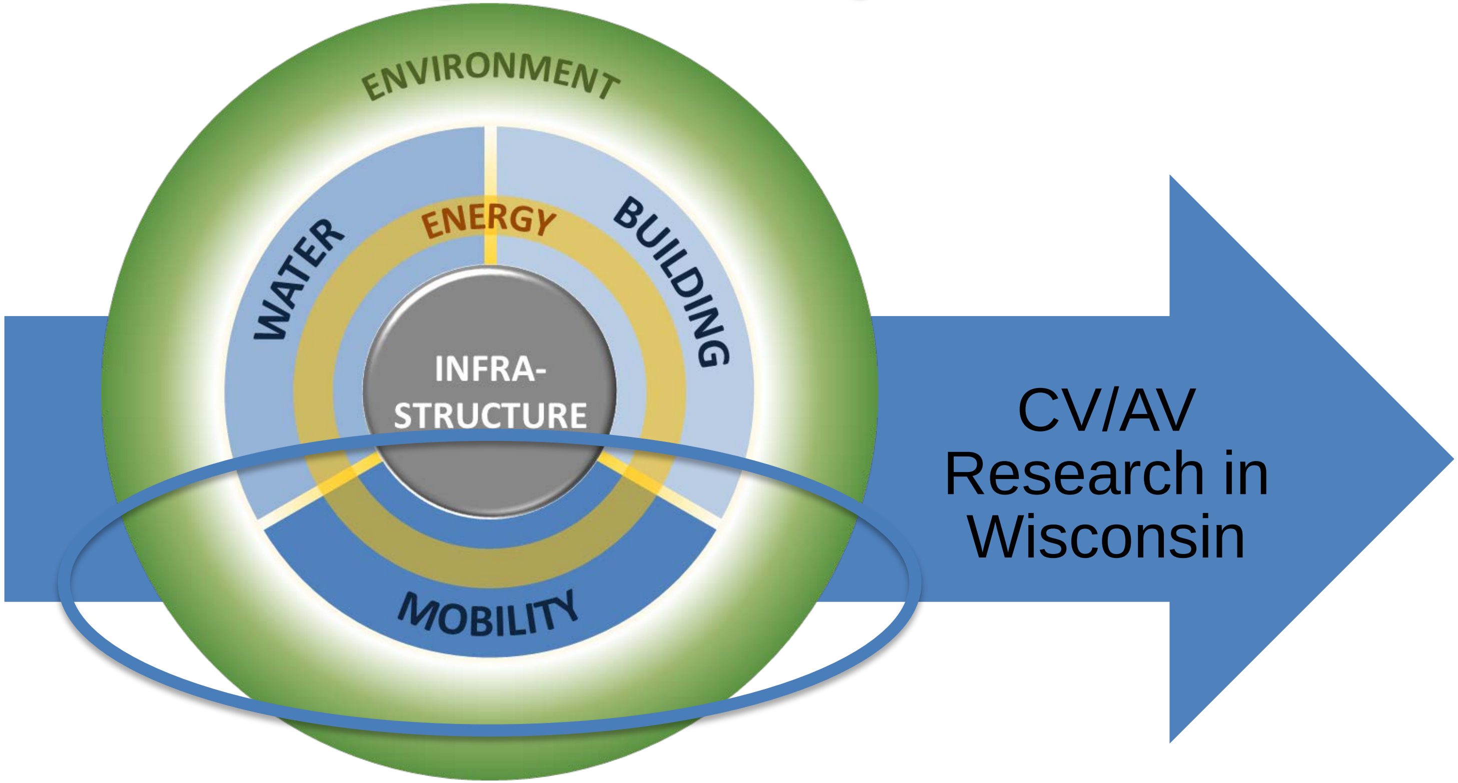
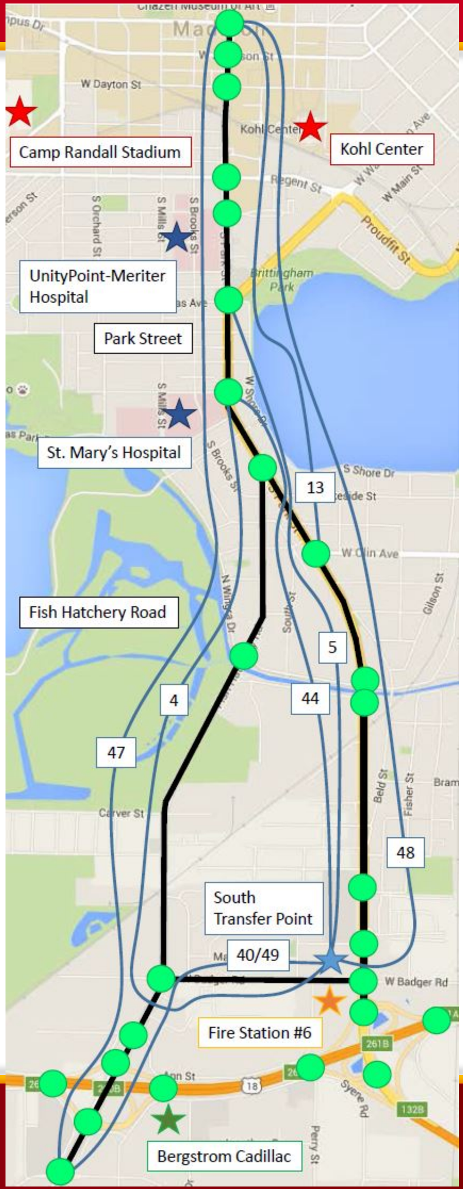


Connected Park Street Corridor

- Piloting CV technology to improve:
  - Safety
  - Mobility
  - Bus on-time performance
  - Equity
- V2I, V2V, V2X
- Madison and Wisconsin as the Upper Midwest hub for CV & AV development



Micro-Simulation
Simulation Based Engineering Lab (SBEL)

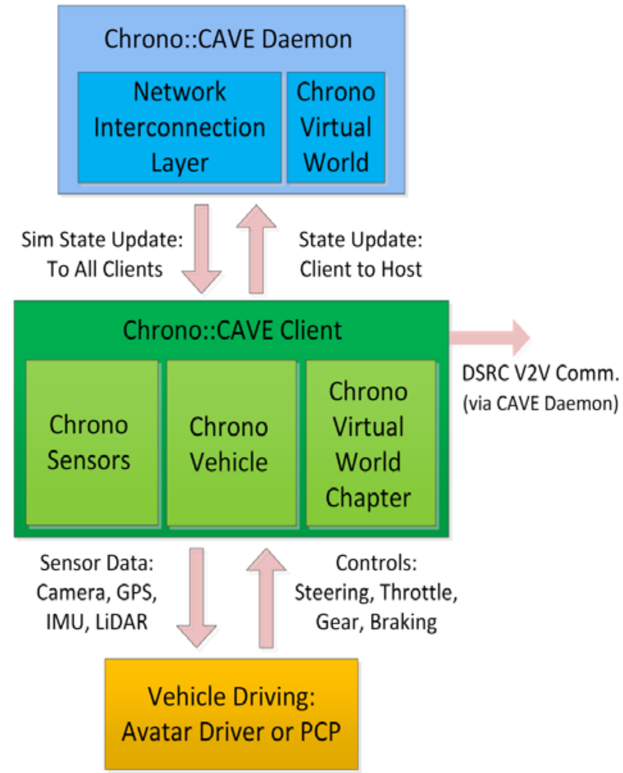
- University of Wisconsin-Madison colleague Professor Dan Negrut
  - Dylan Hatch
  - Radu Serban

- Funding from College of Engineering at UW-Madison

Overview of CAVE

- Connected Autonomous Vehicle Emulator (CAVE)
  - Connected – simulated connectivity, V2V
  - Autonomous – Chrono sensors
  - Vehicle – Chrono vehicle support
  - Emulator – virtual world support

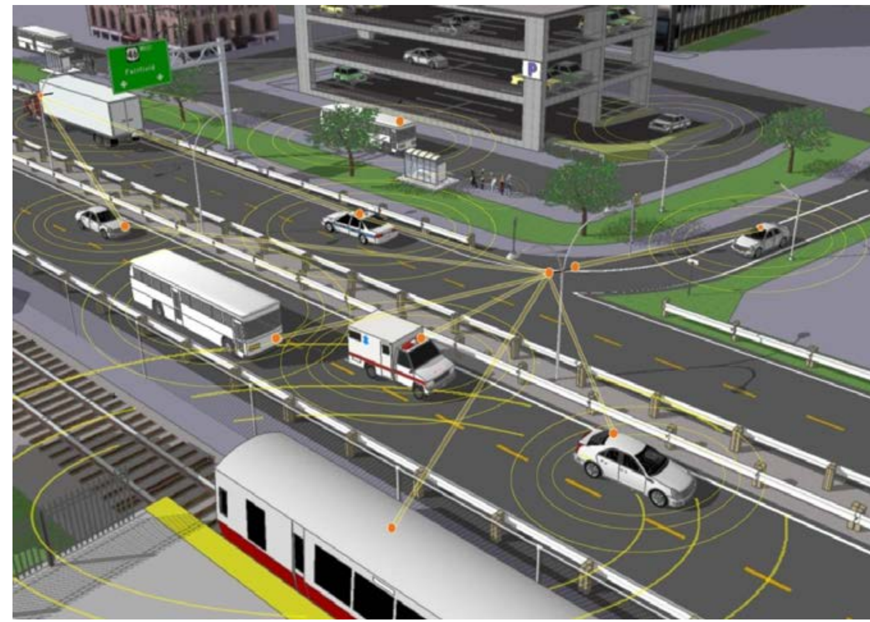
- Multi-agent support
  - Autonomous vehicles
  - Avatar vehicles
  - Pedestrians
  - Bicyclists



Simulated Vehicle to Vehicle Connectivity

- Dedicated Short-Range Communication (DSRC)
  - Vehicle-to-vehicle
    - Can send vehicle position, velocity, acceleration data to nearby vehicle
  - Vehicle-to-infrastructure communication
    - Traffic light updating, other beacon notifications

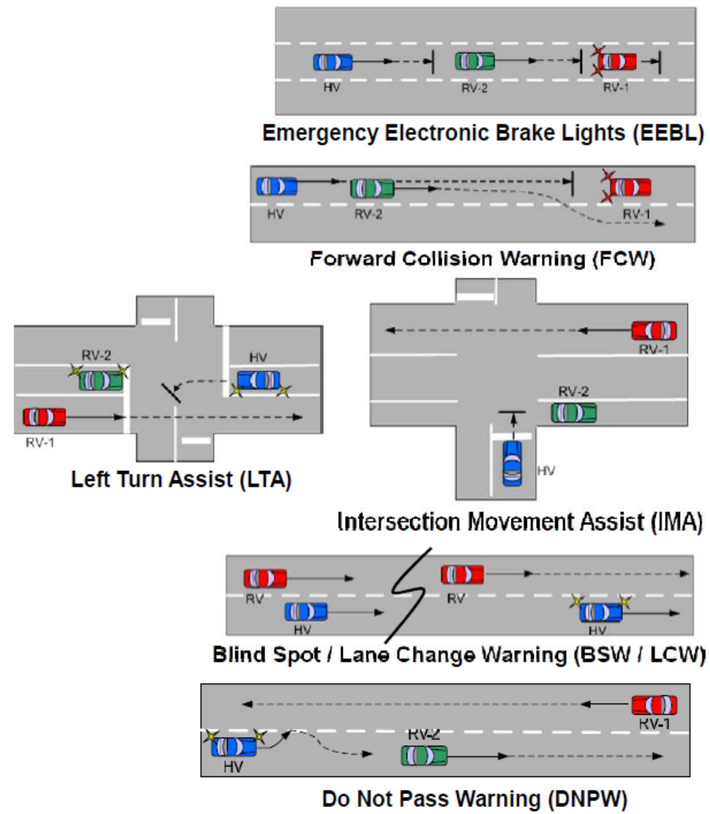
- We simulate this communication protocol to enable virtual testing of algorithms



NHTSA (National Highway Traffic Safety Administration)

Dedicated Short-Range Communications (DSRC)

- Primary motivation is to enable collision prevention applications
- Can be used for many other applications beyond collision avoidance. (Mostly involve communication to roadside unit (RSUs)).
- Vehicles broadcast location, speed, acceleration, etc.



Vehicle Support in Chrono

- Vehicle built from subsystems
  - Drive system
  - Wheels
  - Tires
  - Chassis
  - Suspension

Embedded video removed for web posting, but please see the example videos here:

- *http://sbel.wisc.edu/Animations/*
- *https://vimeo.com/uwsbel/videos*

Virtual Sensor Support

- Physically realistic noise models
  - Virtual sensor data should be close to physical sensor data
  - Understand and mimic noise
- Lidar/Radar
  - Current “idealistic” sensor
  - True rays degrade over distance, environmental effects
  - Rain, Fog, Snow, etc
  - Glass, water, reflective material, etc
- Camera (future support)
  - Similar environmental and material dependencies as lidar
  - Noise at night, contrast, etc

Demonstration of Capability

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- *https://vimeo.com/uwsbel/videos*

- 4 full Chrono::Vehicle systems
- Lead vehicle: interactively driven
- Follow the leader
  - Each vehicle follows the one before it

- Throttle and braking based on LiDAR data
- All data overlaid is for vehicle 4
  - LiDAR data shown on lower left
  - Approximate GPS/IMU data overlaid on map (right)

Wisconsin Full-Scale Driving Simulator

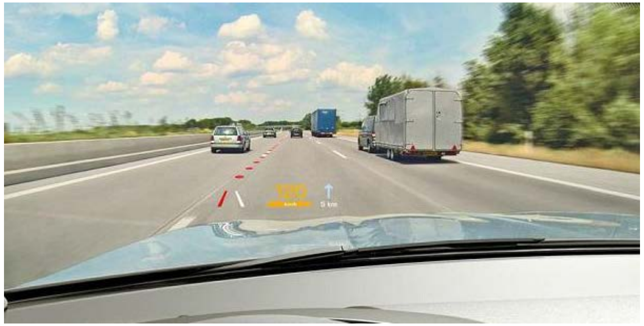
Wisconsin Driving Simulator

Embedded video removed for web posting,
but learn more here:

- *http://www.topslab.wisc.edu/content/simulator/*

In-Vehicle Technologies

- Augmented Reality Head-up Displays (AR-HUD)



- Applications:
  - Lane Departure Warnings
  - Automated Cruise Control
  - Blind Spot Monitoring

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PROVING GROUNDS

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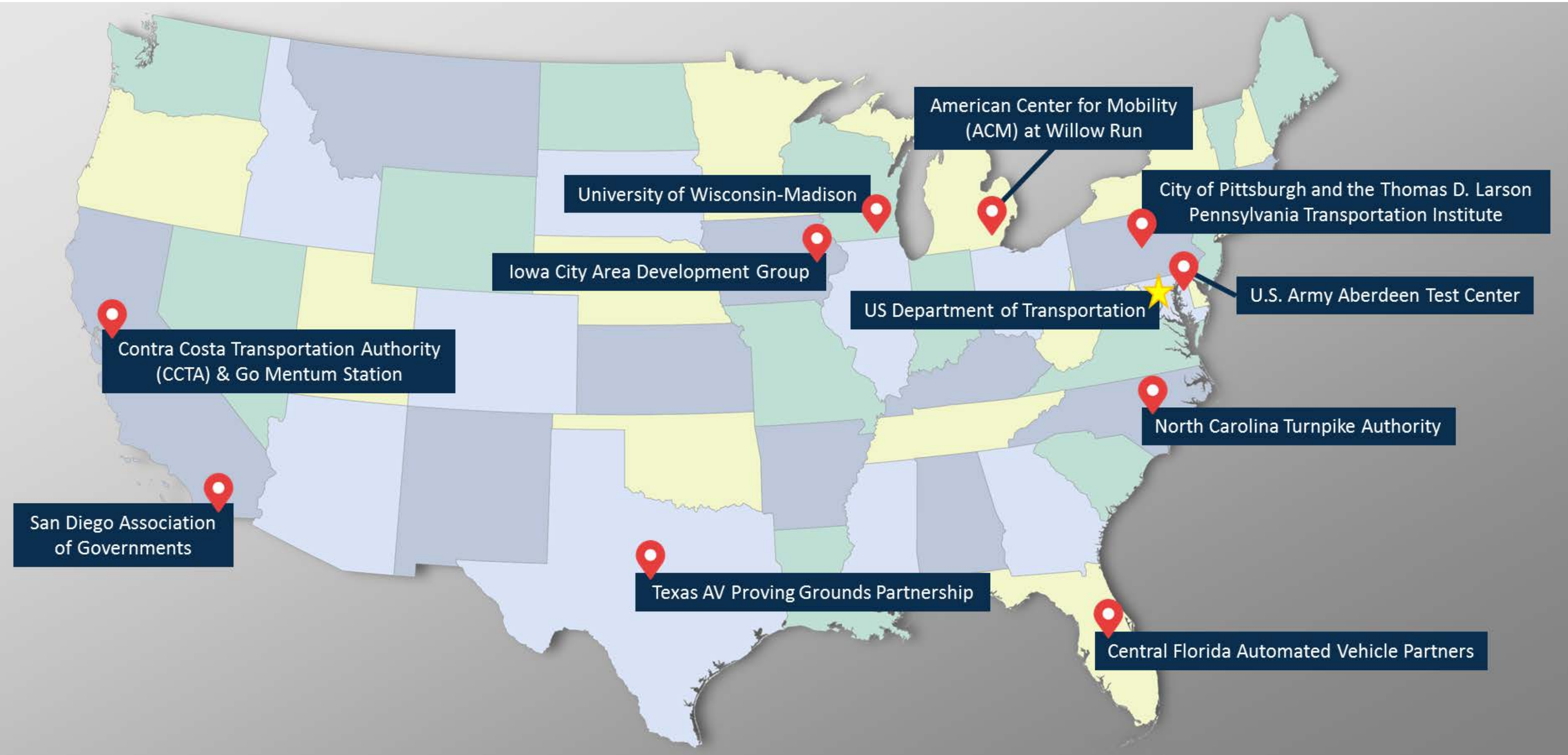
Ten Designated AV Proving Grounds



Wisconsin Facilities

MGA Research Facility - Burlington, WI
Early Stage | Closed Track | Low Speed
Safety | Durability | Transit

Road America - Elkhart Lake, WI
Early Stage | Closed Track | High Speed
Mobility | Long Distance | Freight

UW-Madison / Epic Campus
Mid-Stage | Limited-Use Facility | Low Speed
Safety | Durability | Transit

City of Madison
Mid/Late-Stage | Public Roads | Low Speed
Safety | Mobility | Durability | Transit

Wisconsin DOT (W-Highway)
Late-Stage | Public Roads | High Speed
Mobility | Long Distance | Freight

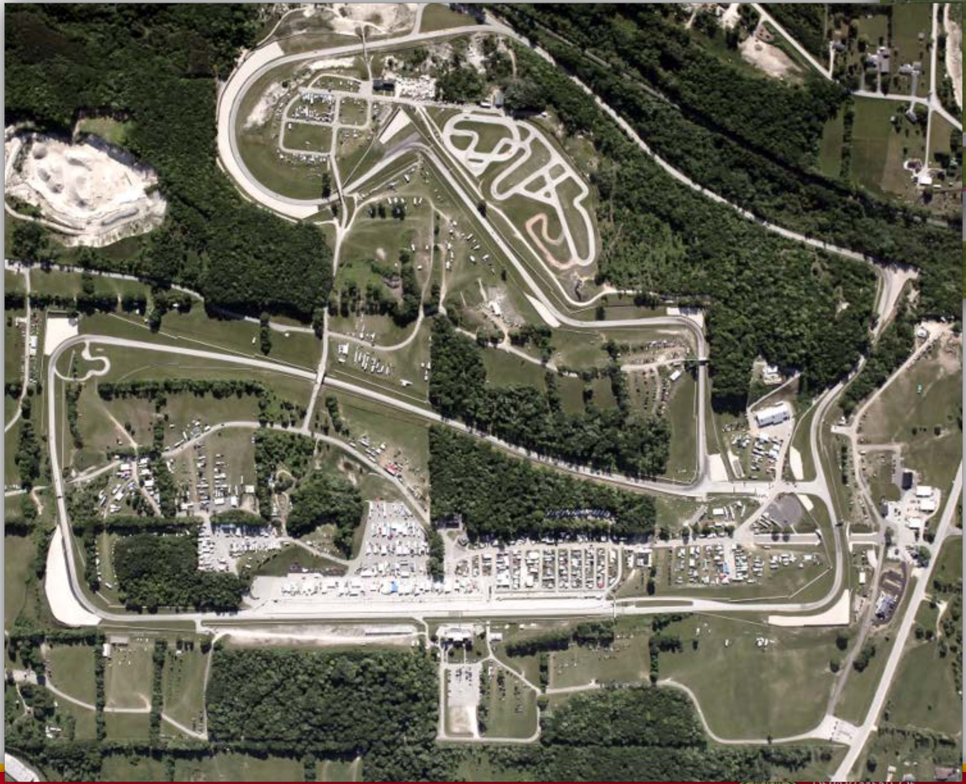
Wisconsin Facilities

MGA Research, Burlington

400 acres, private and secure, numerous testing capabilities

Wisconsin Facilities

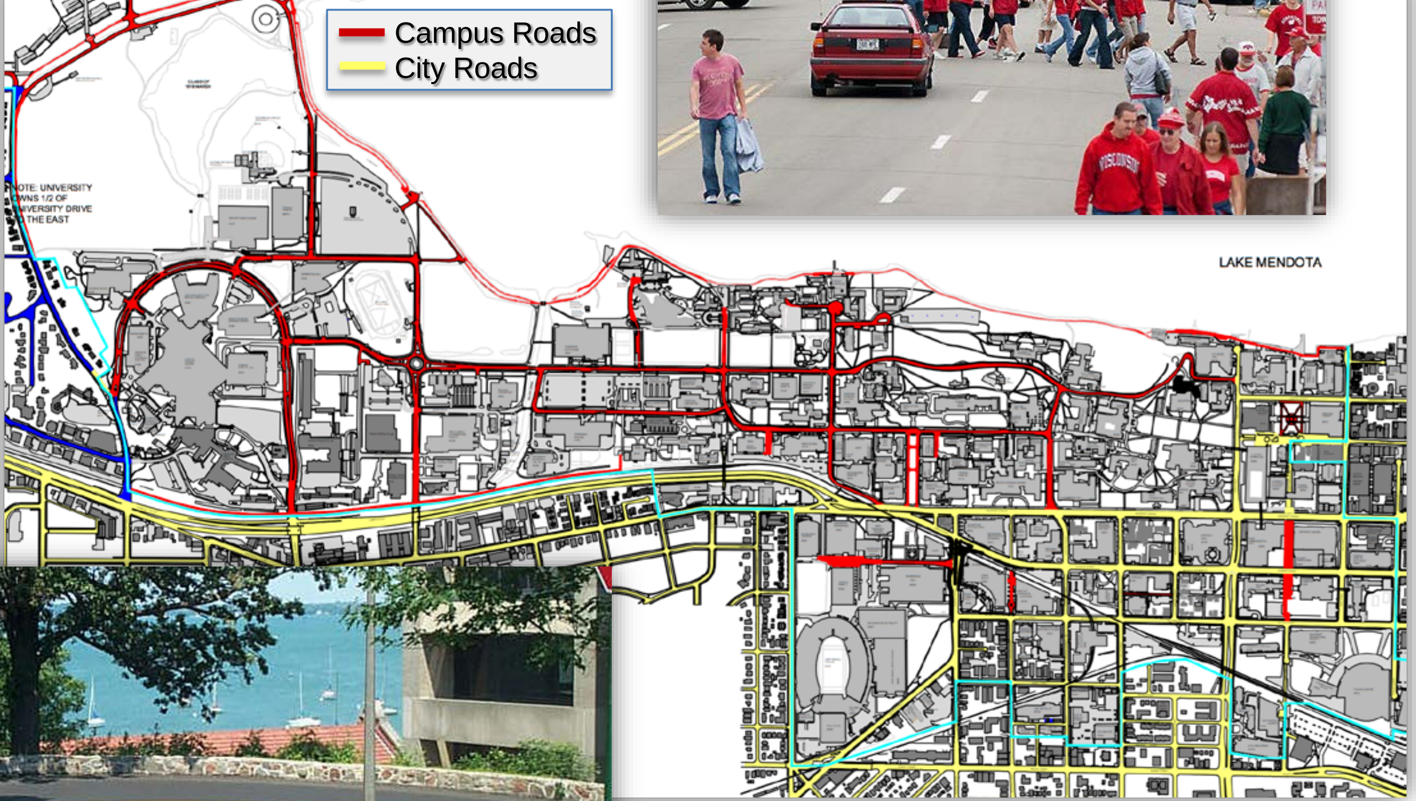
Road America, Elkhart Lake



- Road track: 4.05-mile length, 30-foot width
- 1-mile combo paved-dirt track
- 12+ miles off-road
- 10+ miles access roads
- Major race events and media presence

Wisconsin Facilities

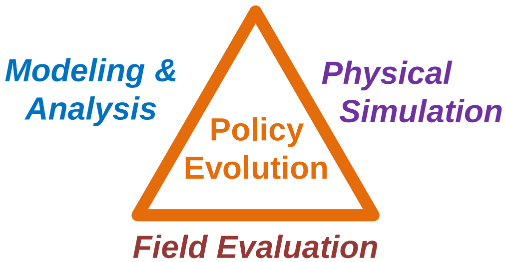
UW-Madison Campus and City of Madison



Wisconsin Facilities

Mandli / Roadview

Focus Areas



Data and sensing—including LIDAR, GPS, cameras, communications, and other sensors.

Vehicle operations—including speed, acceleration and deceleration, performance on grades and curves, and electric vehicle range and charging time.

Inclement weather operations—including snow, ice, fog, and high winds.

Human-machine interfaces—such as sensors, communications, and responses.

Interaction with surroundings—including pedestrians, bicycles, mopeds, cars, and traffic control devices.

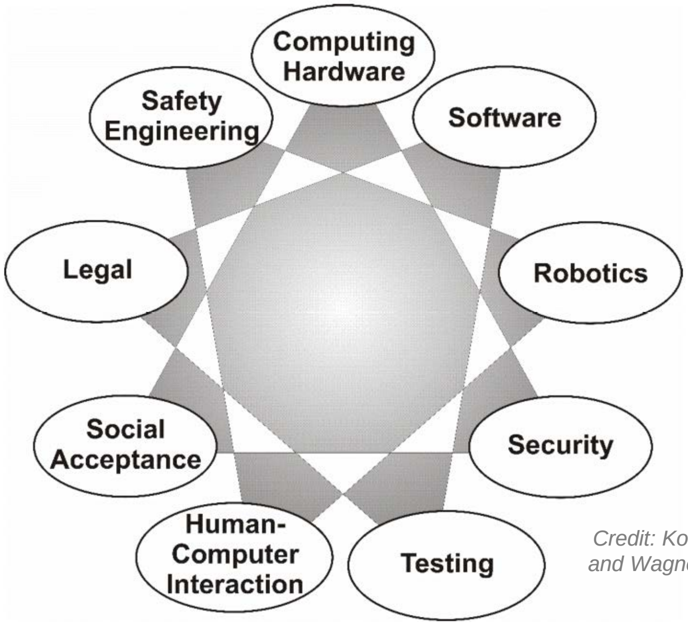
User acceptance—Passenger comfort, public perception, safety, and ethics.

System resilience—Advancing standards, safety protocols, and security.

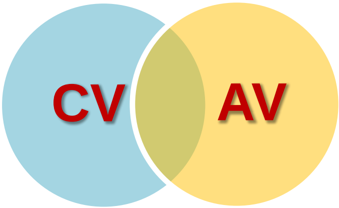
Shared mobility—Automated vehicle microtransit developments, enhancements, and testing.

R & D Priorities

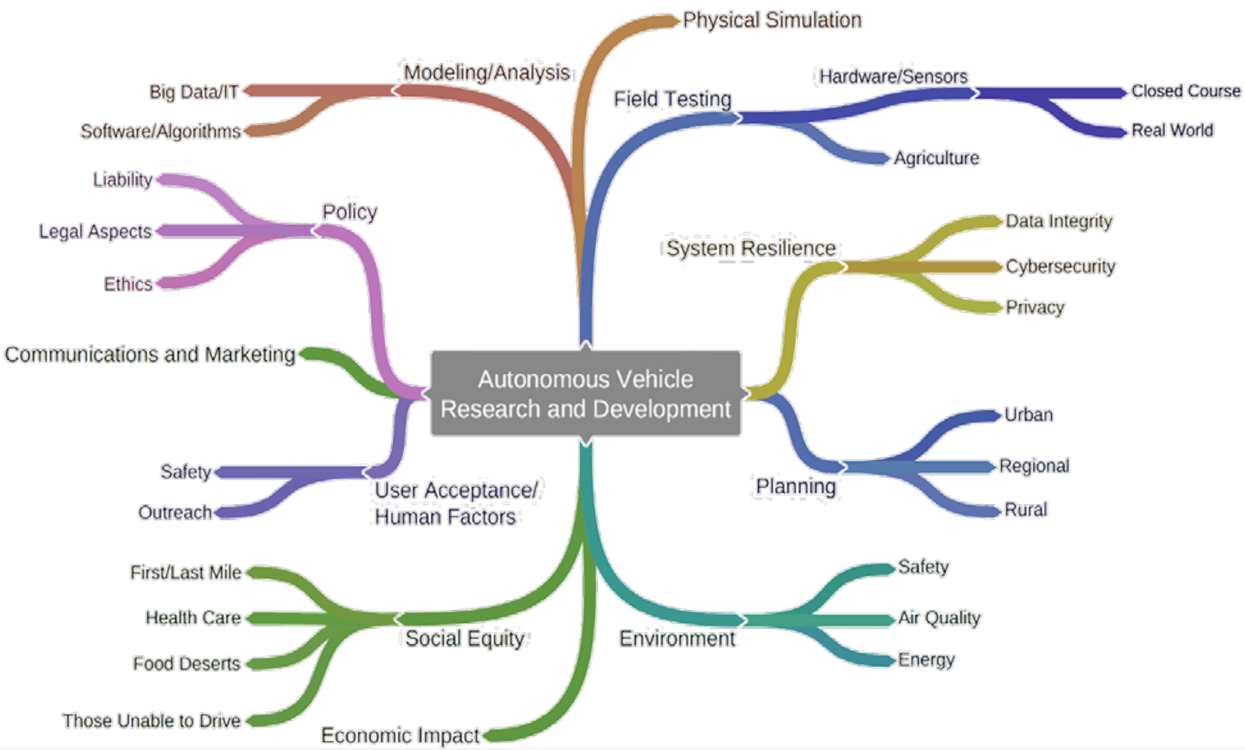
- Data and sensing technologies
- System integration validation methods
- Vehicle performance
- Winter and other adverse weather conditions
- Transportation infrastructure
- Work zones and road hazards
- Security, both passenger and vehicle
- Privacy
- Theory to application
- Interaction with pedestrians, bicycles, scooters motorcycles and non-automated vehicles
- Human-machine interfaces
- Bringing connected vehicle and autonomous technology together
- Driving decision-making
- Automated to manual transitions



Credit: Koopman and Wagner 2016



Connected Transportation Research and Policy Enterprise



- Government – University – Industry collaboration
- Public-private partnerships
- Multiple disciplines required to address multiple facets
- Facilities and networks for development and commercialization
- Statewide university collaboration

Moving CV/AV Forward in Wisconsin

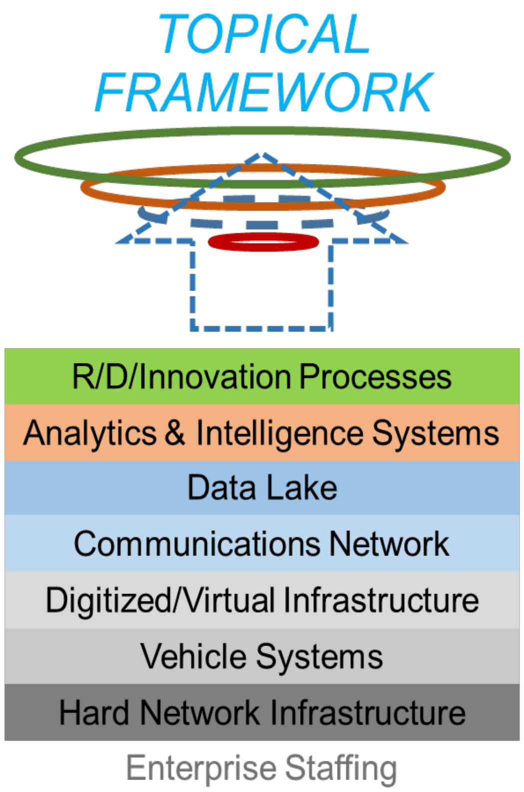
Committee on Automated and Connected Vehicles

"the removal of barriers to the testing and deployment of automated and connected vehicle technology in Wisconsin"

- May 2017 EO #245
- Sept 2017 Kickoff
- June 2018 Report Due

Wisconsin's Strategic Advantages

- Broad and interdisciplinary expertise
  - Sensing, robotics, safety, human factors, big data, cybersecurity, artificial intelligence, internet of things
- Hierarchy of test environments
  - Private, university/corporate campus, and public test sites
- Collaboration with industry
- Adverse winter weather
- Freight movement and agriculture applications
- Leaders in all modes
- Data infrastructure
- Leading research university partner
- Workforce development



(An) AV Timeline

2015
- driver assistance common
- some partial automation available to consumers

2020
- limited / conditional AVs widely available to consumers

2025
- autonomous shared mobility fleets

2030
- high automation required in all new vehicles

2035
- human operation is the exception in many places

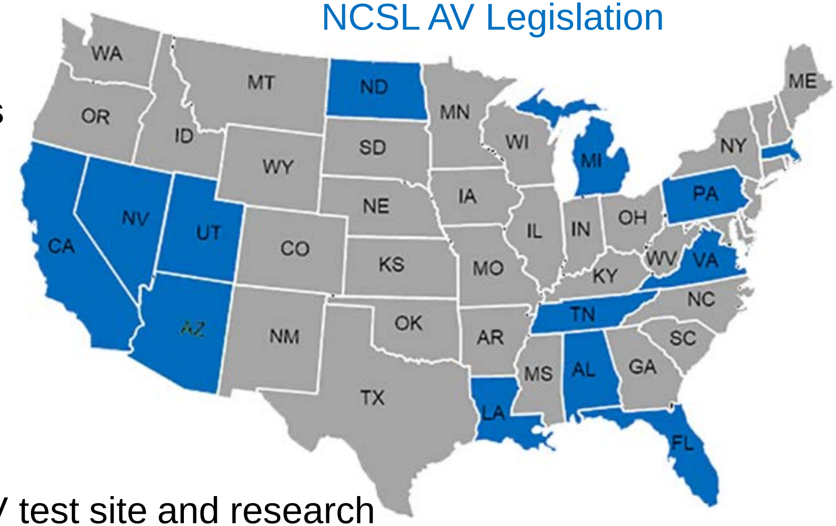
2040
- transition to driverless largely complete
- fleet turnover continues…

2100

- Any estimate is debatable
- We are only at the beginning of a long transition period

What are Other States and Federal Agencies Doing?

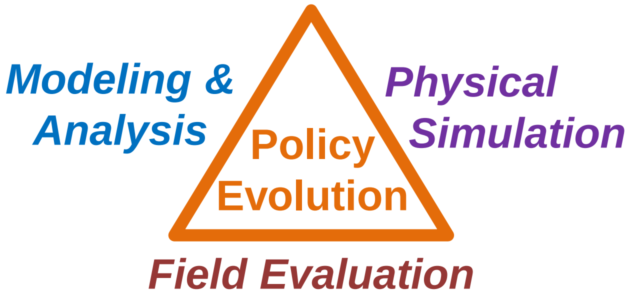
NCSL AV Legislation



- Many private industry sites, testing, and collaborations
    - Toyota with MIT/UM/Stanford
    - Uber in Pittsburgh, research center near Detroit
- Nevada Center for Advance Mobility, a branch of the Governor's Office of Economic Development
- Ohio: $15M upgrade of 35-mile stretch of road; state contributing $20M along with Ohio State's $49M for AV test site and research
- Michigan: $80M ($20M from the state) to developed 300-acre test site
- USDOT awarded $45M to three Connected Vehicle Pilot Deployment Sites
- Potential USDOT funding of AV pilot sites
- Designated AV Proving Grounds

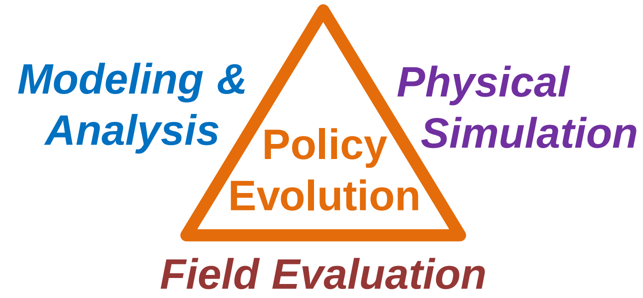
The Future of CV/AV in Wisconsin

- CV test corridors underway
- AVs will proliferate regardless, but many questions remain to be addressed
- Adapting the transportation system to be smarter is enabled by automated and related technologies
- An “open door” to AV development and integration can quickly move Wisconsin into a leadership position and bring research and private sector investment to our state



The Future of CV/AV in Wisconsin

- Wisconsin is behind and needs to move rapidly
- State must invest in research, testing, and implementation of CV/AV technology



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THANK YOU.