A Collaborative Approach

Towards a Regional Research and Technology Center

Connected and Automated Vehicles Summit

October 17, 2019

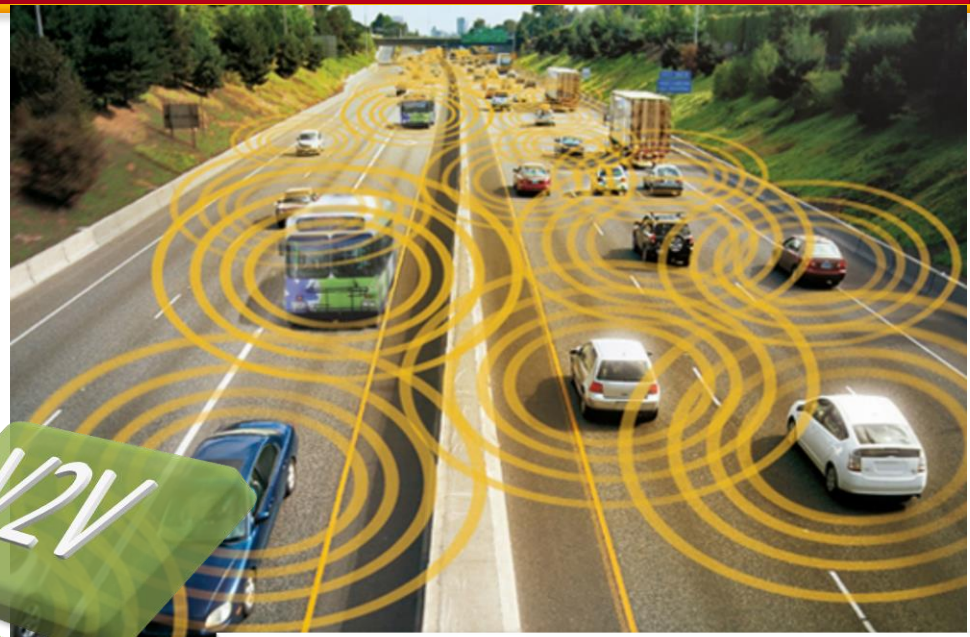
Civil and
Environmental Engineering

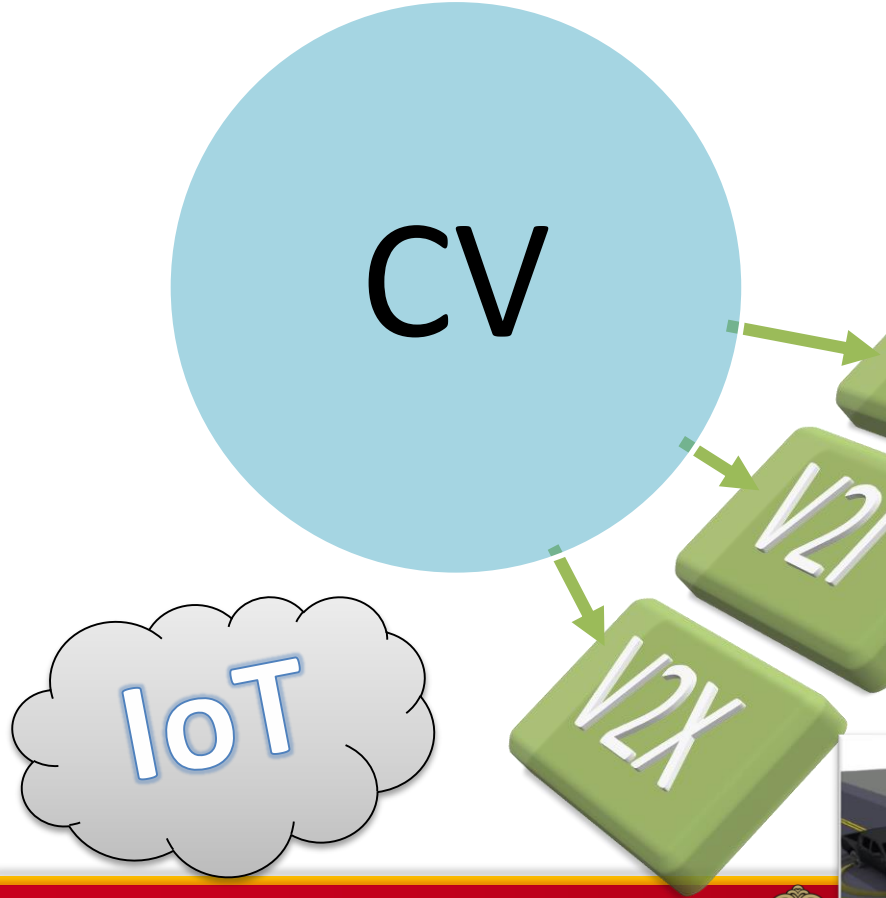
UNIVERSITY OF WISCONSIN–MADISON

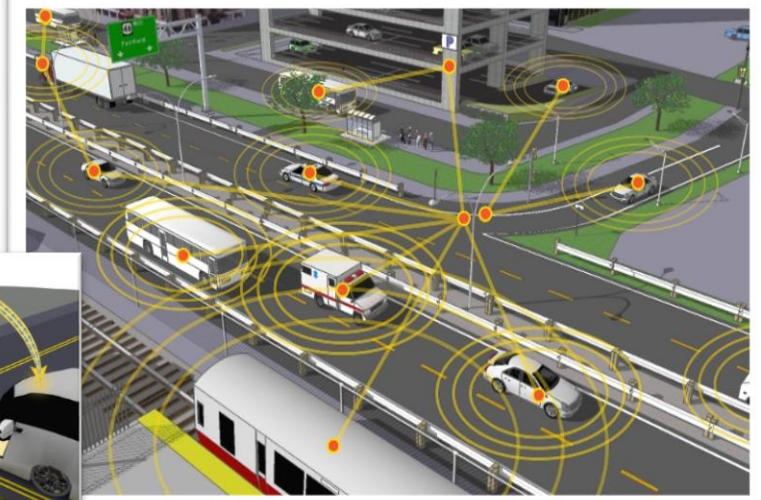
Welcome!

Madison, Wisconsin USA

Connected Vehicles







CV/AV Simultaneous Operation

Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors

Connected Automated Vehicle

Leverages autonomous and connected vehicle capabilities

Connected Vehicle

Communicates with nearby vehicles and infrastructure

SAE Levels of Vehicle Automation

0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

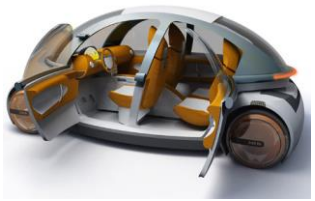
Why the rush to AVs?

Safety!

Smart Cities

What will transport look like in 2069?

- All vehicles SAE Level 5, fully IoT capable, and non-fossil fuel

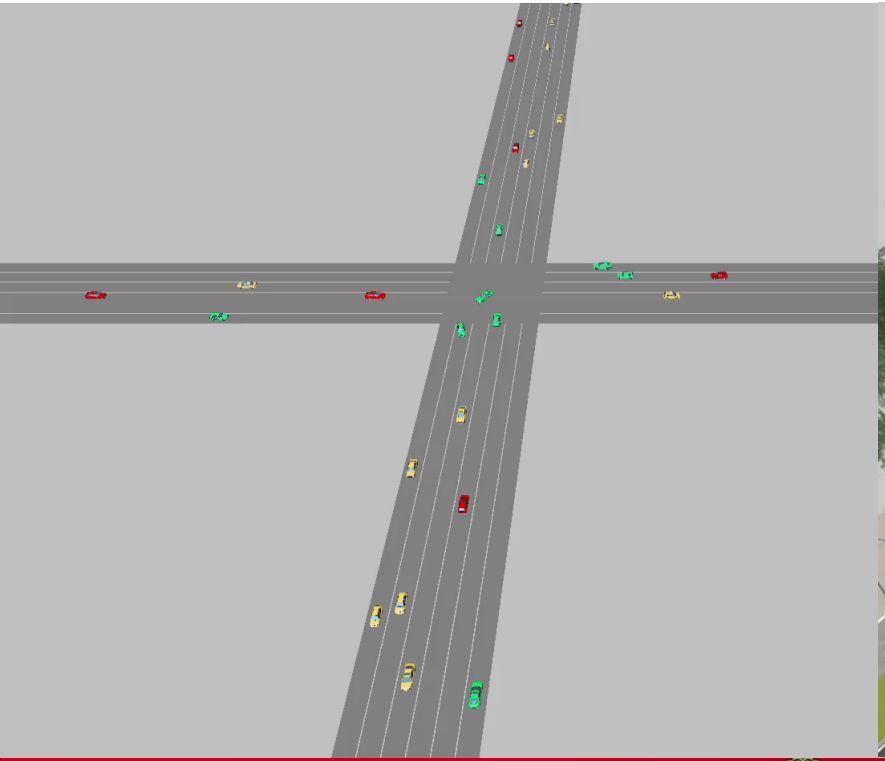


What will transport look like in 2069?

- All commercial trucking driverless and platooned

What will transport look like in 2069?

Signal-less intersections the norm – vehicles negotiate space-time dynamically



What will transport look like in 2069?

What do you predict??

What will transport look like in 2069?

- It depends on a combination of how we plan it, what people place emphasis on as important, and what the incentives are
- With connected and automated vehicles, this can be a wide spectrum
- How do we get there?
    - Multidisciplinary Private/Public Collaboration
    - Research
    - Testing and Validation
    - Public Engagement
    - Urban, Regional, and Rural Planning
    - Artificial Intelligence
    - Navigating the "messy middle"

Human Factors

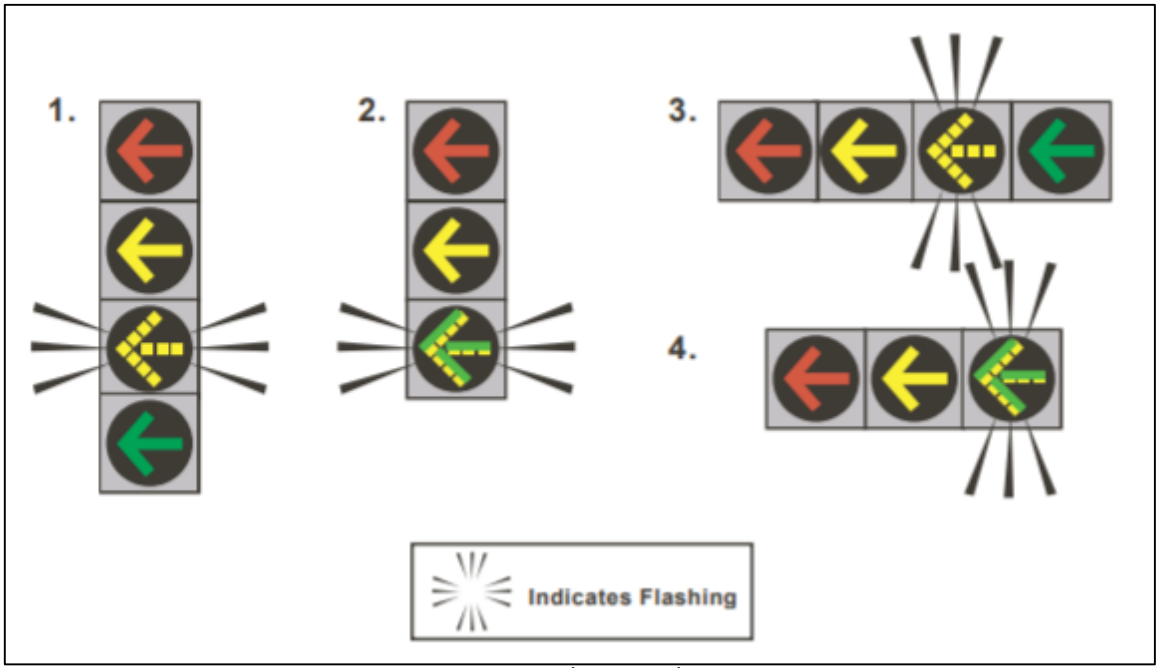
https://towardsdatascience.com/deep-learning-for-self-driving-cars-7f198ef4cfa2

Wisconsin Full-Scale Driving Simulator

Left-Turn Traffic Signal Operations

FYA Implementation

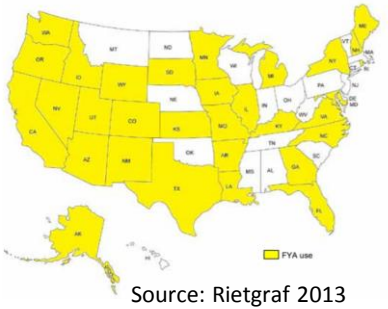
NCHRP Report 493: Evaluation of Traffic Signal Displays for Protected/Permissive Left-Turn Control



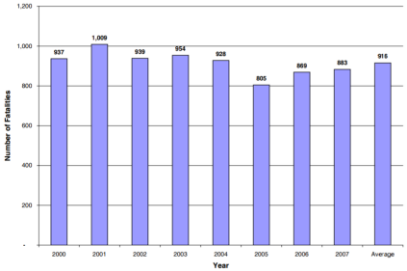
Source: Brehmer et al. 2003

Implementation Flashing Yellow Arrows

- Impacts from exposure to FYA permissive indication
  - Knodler et. al. 2007a, 2007b, 2009
  - Noyce et al. 2007
- FYA and CG indications with and without supplementary signage
  - Brehmer, 2003
  - Schattler et al. 2013, 2015
- Red-light running is a leading cause for intersection crashes in the United States
  - FHWA, 2009



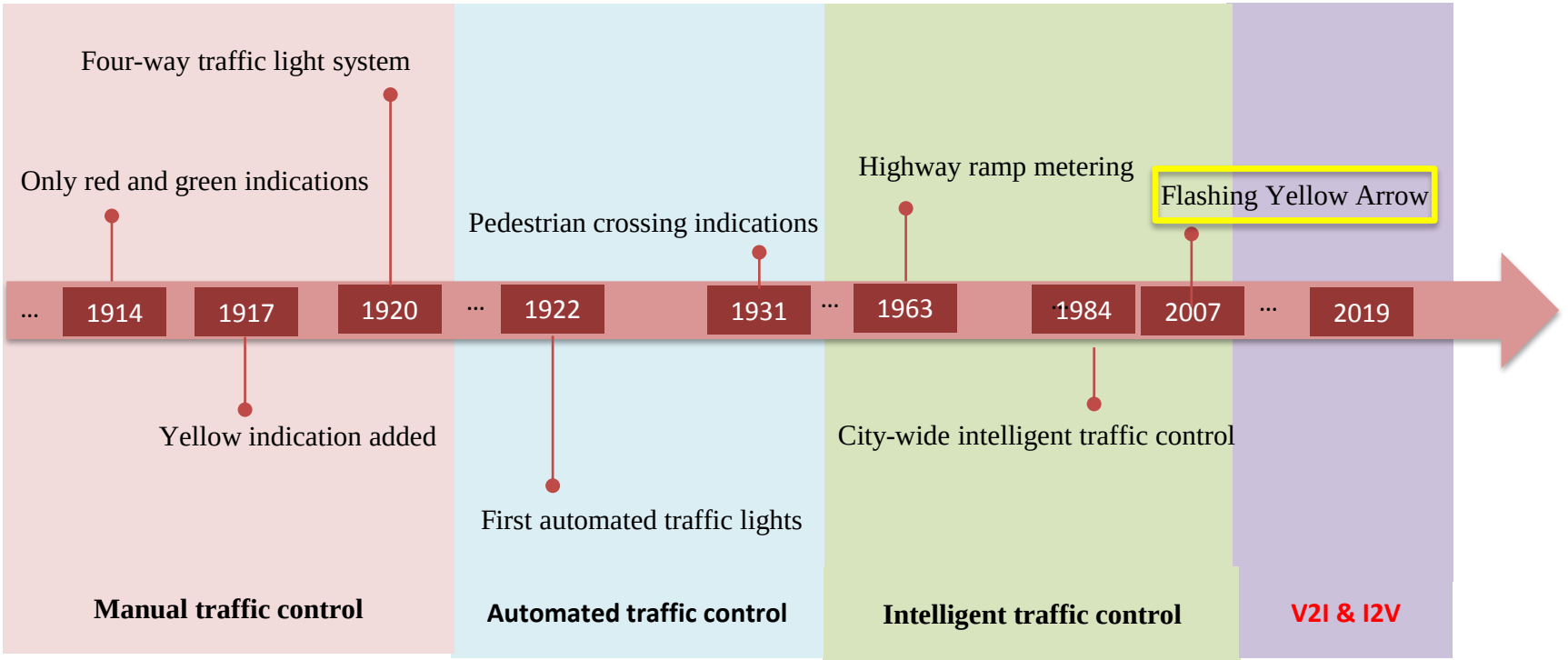
Source: Rietgraf 2013



Source: "Red Light Running Fatalities" FHWA, 2009

SAFER SIM
SAFETY RESEARCH USING SIMULATION
UNIVERSITY TRANSPORTATION CENTER

Traffic Control



Decision-Making Automation

(source: https://www.shutterstock.com/video/clip-7837867-rush-hour-traffic-midtown-manhattan-night-illuminated)

Research Questions

Automation disengagements

Drivers' take-over performance

Are drivers capable of cooperating with a shared automation system?

Drivers' performance after resume control when using a SAE L3 automaton?

How do different situations affect drivers' reaction time and take-over performance?

How are different automation surprises associated with necessary different lead time?

How does the timing of warnings affect the traffic efficiency as the traffic volume increases ?

Does control transitions have an impact on intersection efficiency/safety?

How do different types of messages affect drivers' permissive left-turn behavior?

Research Gaps and Hypotheses

Automation levels

- SAE Level 3

Situations

- Urban environments
- Signalized intersections
- Permissive left turns

Driving behavior

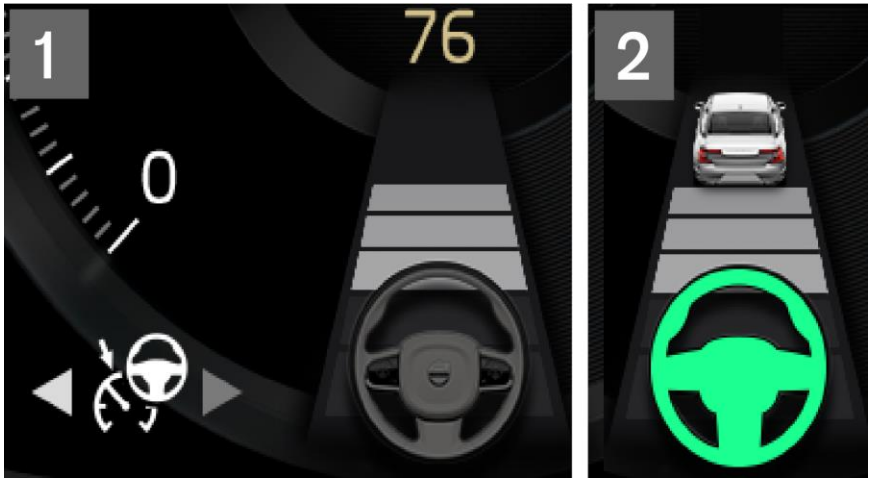
- Non-driving related tasks
- Take-Over Request design
- Takeover performance

Impact

- Traffic operations and safety at signalized intersections

Take-Over Request Design in Industry

TOR interface when the traffic jam pilot of Audi A8 request drivers to take back control (source: AUDI AG, Image No: A1710305)



The virtual cockpit display of Pilot Assist: (1) Pilot Assist is off when the steering wheel symbol is grey, and (2) Pilot Assist is on when the steering wheel symbol is green (Volvo, 2019).

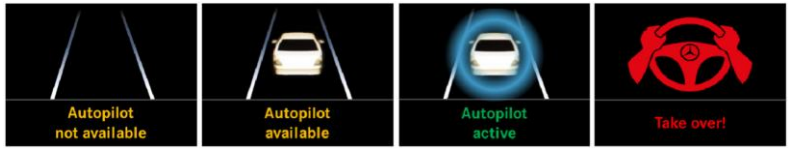
Take-Over Request Design in Academia

"Caution Fog" alert and the takeover request (Walch et al, 2015)

“Heavy rain" alert and the takeover request (Vogelpohl et al, 2018)

Automation available (left) and request-to-intervene (right): (Jarosch et al, 2019)

Takeover-request icon shown on the instrument cluster left: (Erikson and Stanton, 2017); middle: (Naujoks et al., 2018), right (Petermeijer, etal, 2017)

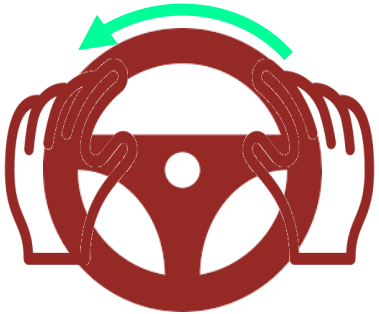


Takeover-request icon design (zeeb et al, 2017)

TOR Design

Please resume control and turn left !

Please resume control and turn left !



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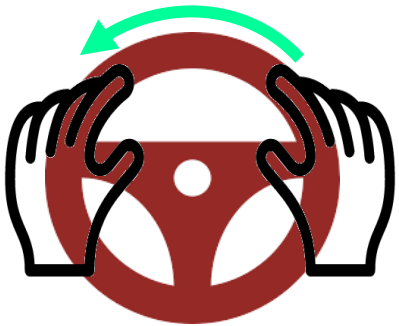

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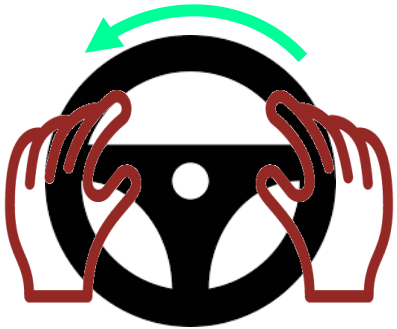


Vehicle to Anything Communications Turning Crosswalk Pedestrian Warning

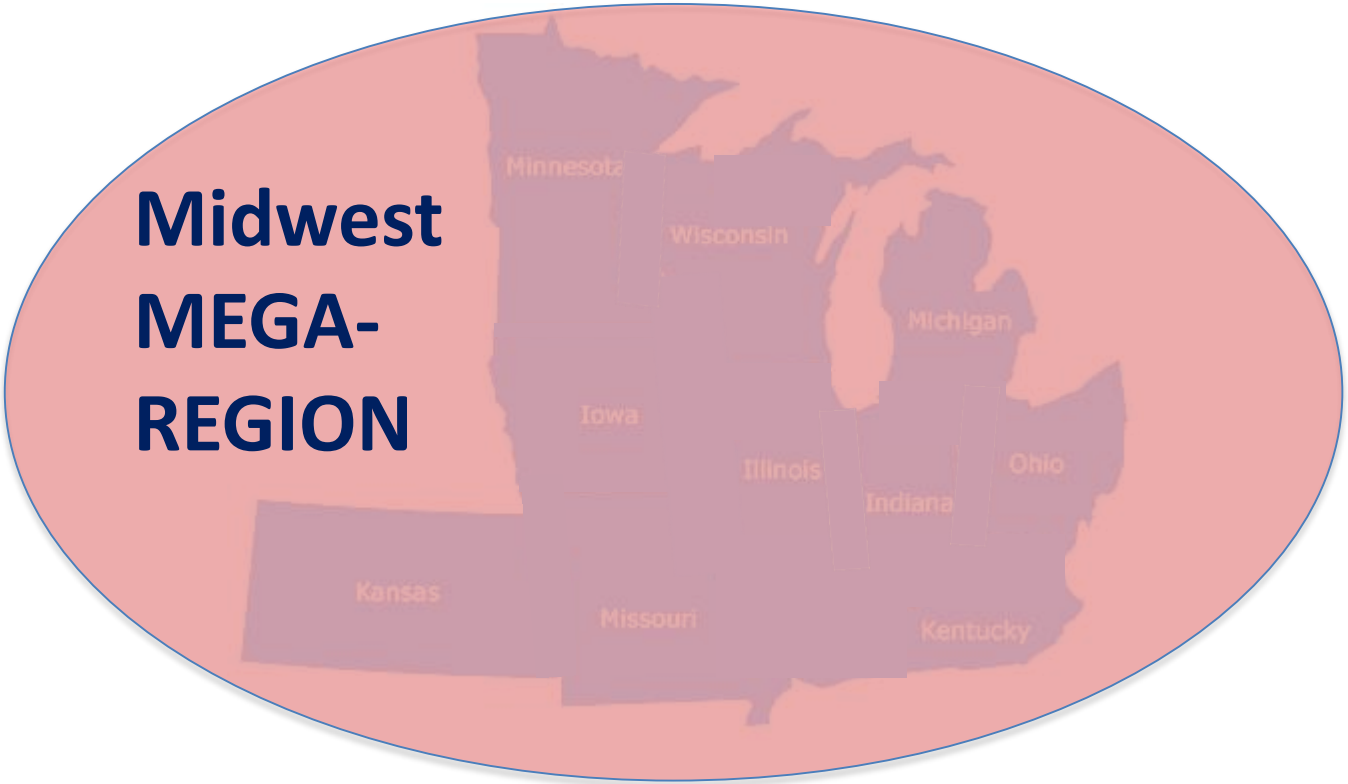
Source: NYC CV Pilot

Issues Surrounding CV/AV

- Data
- Vehicle Cybersecurity
- Information Privacy
- Vehicle Ethics
- Crashworthiness
- System Disengagements / Driver Re-Engagement
- Complex Driving Situations
- Deep Learning / Artificial Intelligence
- Vehicle Assertiveness
- **Technology – Will we shape it or let it shape us?**

MAASHTO States

MAASHTO States



Automated, Connected, Electrified, and Shared (ACES) transportation innovation ecosystem

WISCONSIN AUTOMATED VEHICLE PROVING GROUNDS

MAVRC
MEGAREGION AUTONOMOUS VEHICLES RESEARCH COALITION

Cooperative Research

- Regional Research and Technology Center
- Agency – University – Industry Collaborations

Thank You!

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