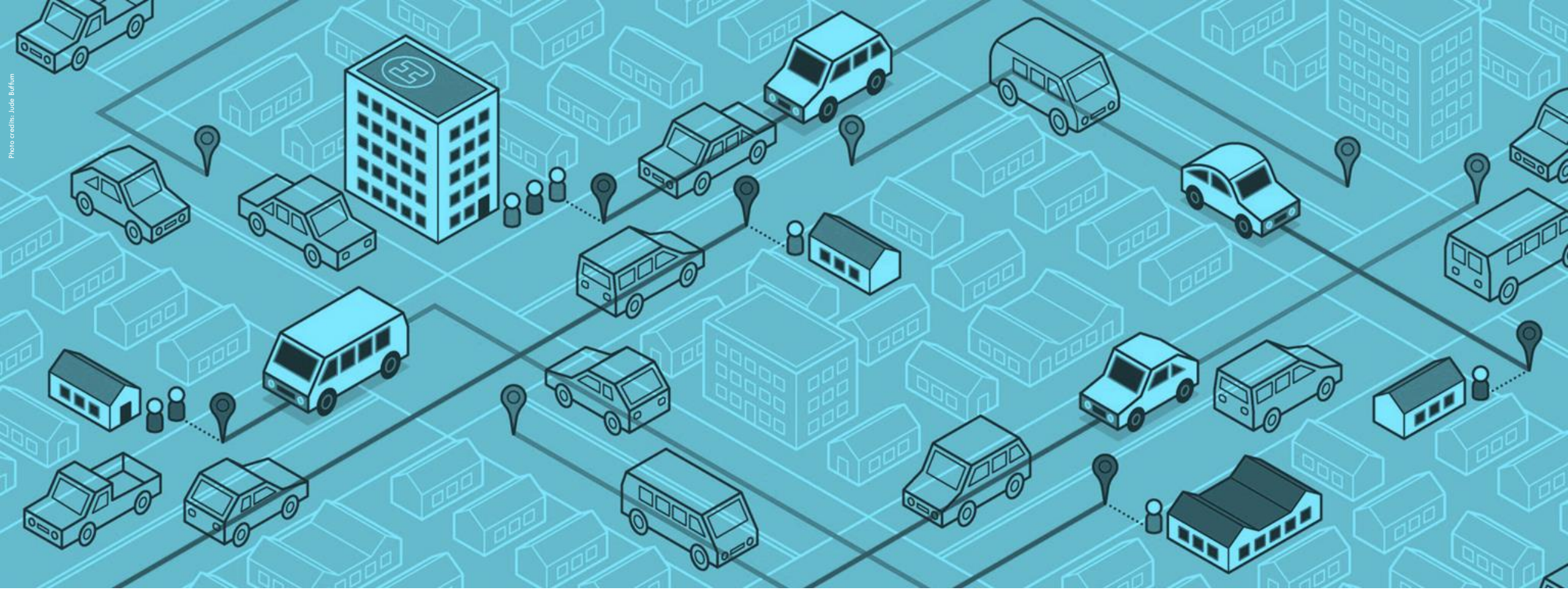
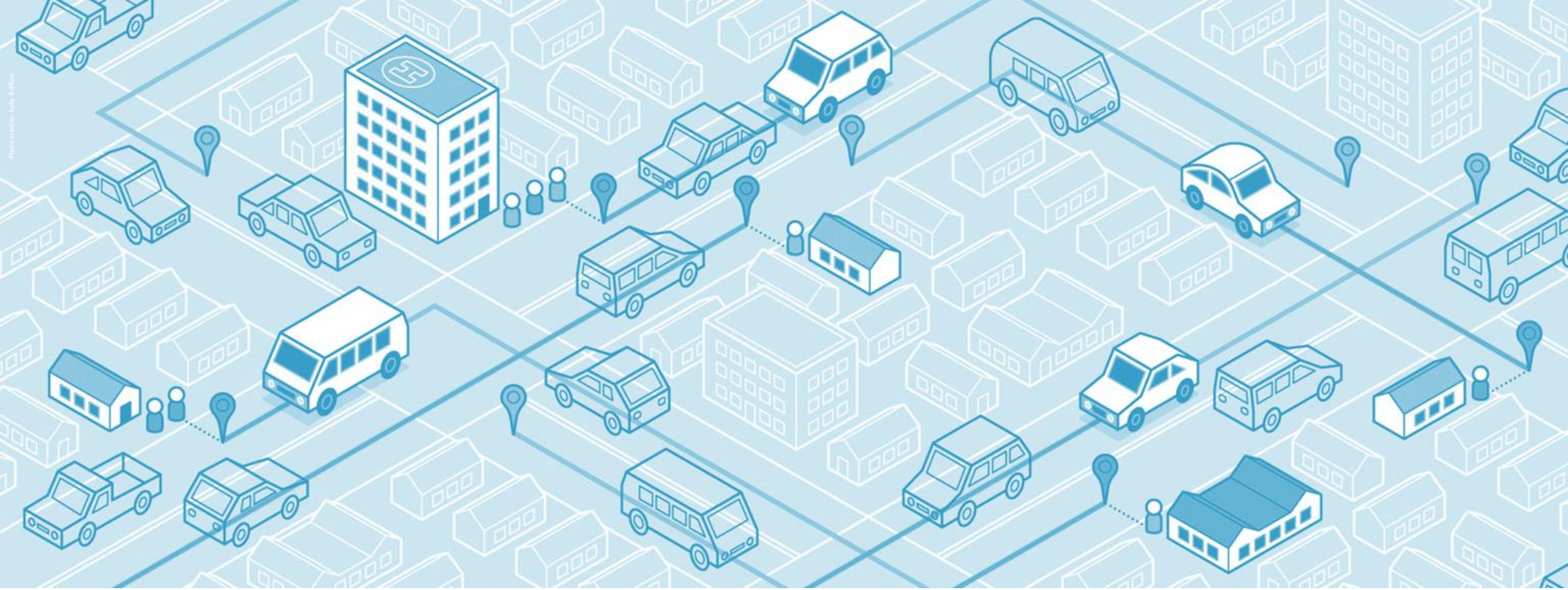


PLANNING FOR CONNECTED AND AUTOMATED VEHICLES

November 17, 2016
Ann Arbor

AGENDA

- Present and discuss the following topics:
  - Connected and Automated Vehicle Systems
  - Transportation Systems
  - Infrastructure Investments
  - Land Use
  - Legal and Regulatory Considerations
- Collect stakeholder feedback



CONNECTED AND AUTOMATED VEHICLE SYSTEMS

ADVANCED TRANSPORTATION TECHNOLOGIES

DEFINITIONS

Intelligent Transportation Systems (ITS)

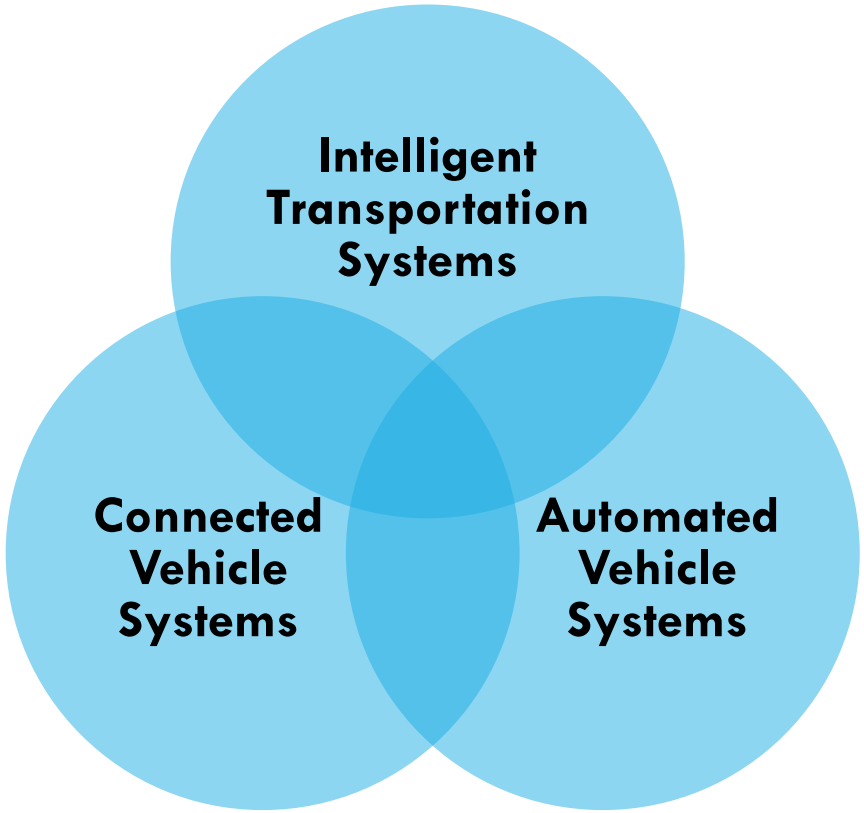
- Electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system (CFR 940.1)

Connected Vehicle Systems

- Any system enabling the exchange of digital information between a vehicle and the world (e.g., another vehicle, infrastructure)

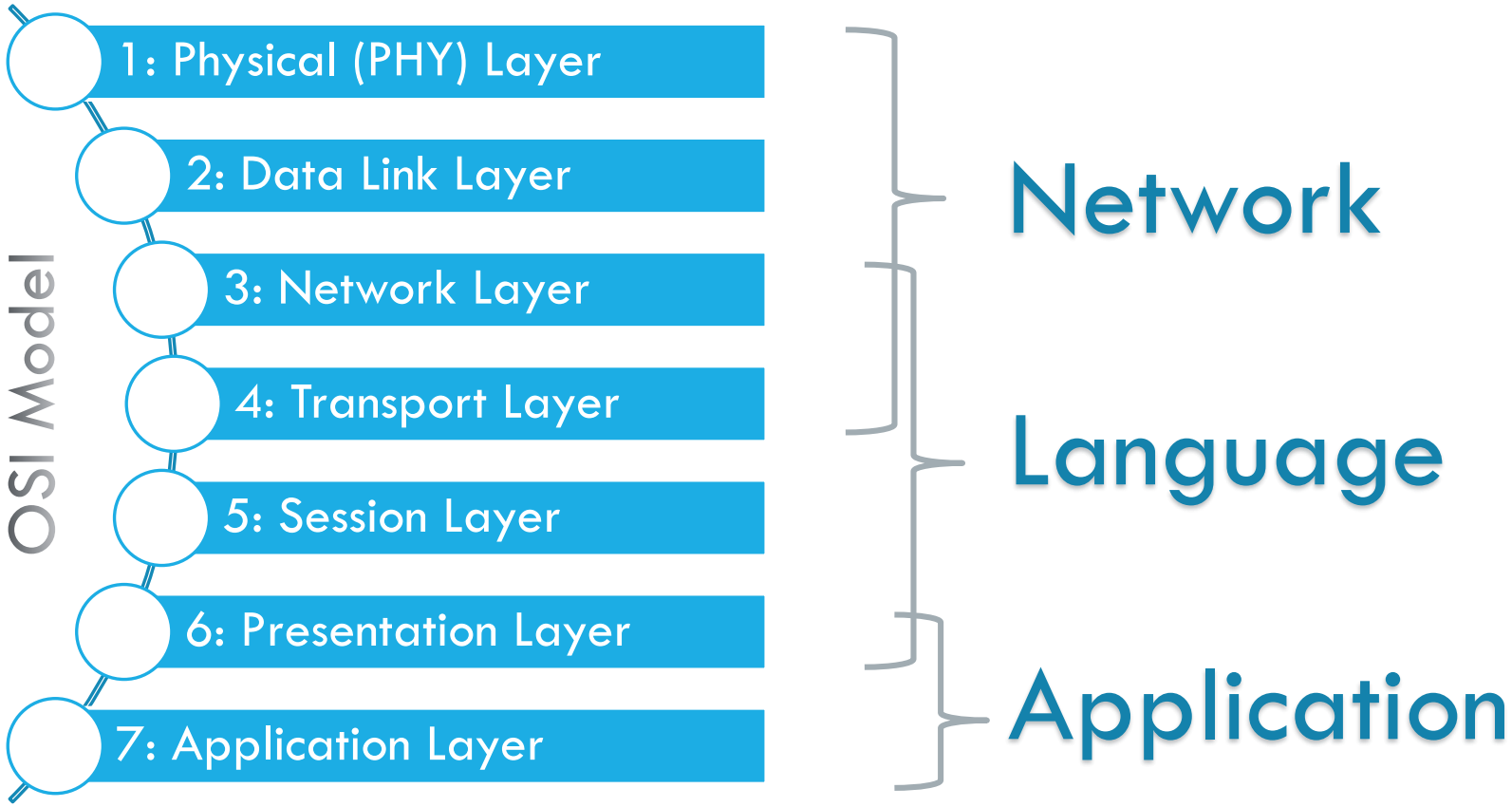
Automated Vehicle Systems

- Any electronic system that influences the lateral or longitudinal operation (or both) of a vehicle



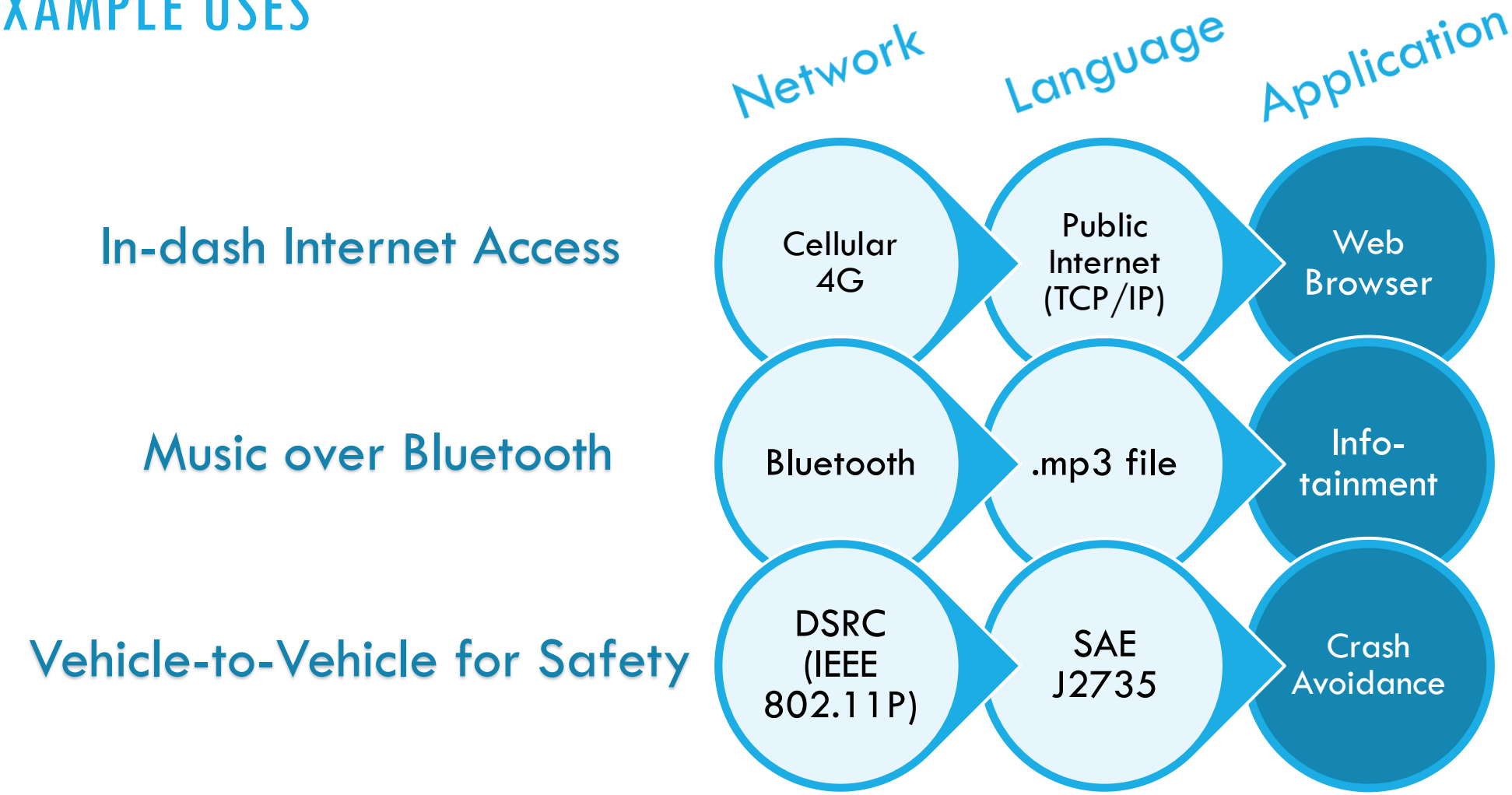
CONNECTED VEHICLE SYSTEMS

ENABLING THE EXCHANGE OF DIGITAL INFORMATION BETWEEN A VEHICLE AND THE WORLD



CONNECTED VEHICLE SYSTEMS

EXAMPLE USES



U.S. DOT CONNECTED VEHICLE PROGRAM

A CONNECTED INTELLIGENT TRANSPORTATION SYSTEM

Network

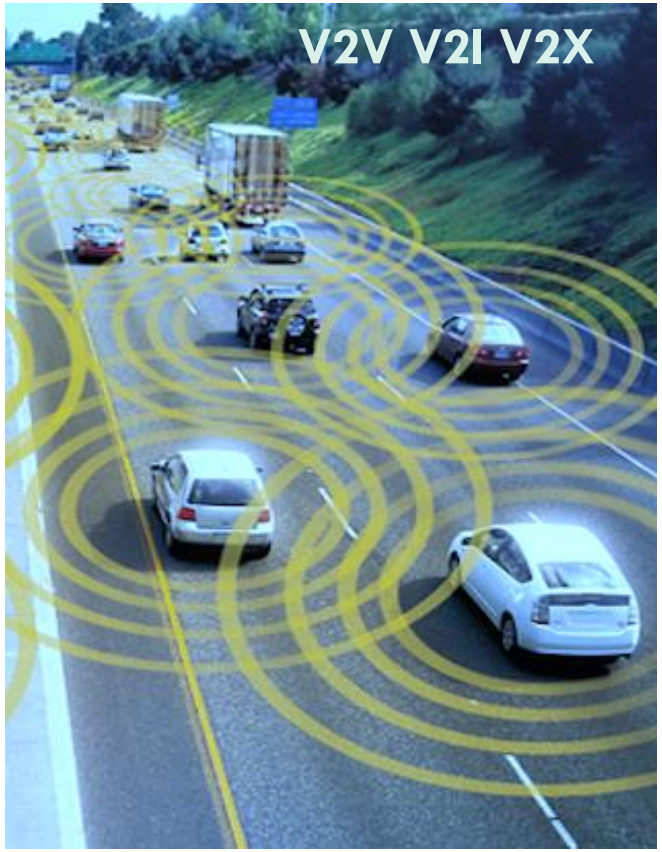
- Government-licensed 5.9 GHz wireless band using specific family of industry standards including IEEE 802.11p

Language

- Vehicles and infrastructure on public dedicated short-range communications (DSRC) network using SAE J2735 data dictionary

Applications

- To improve safety, mobility, and environmental impacts of highway travel



Basis of Ann Arbor Safety Pilot

U.S. DOT CONNECTED VEHICLE PROGRAM

APPLICATIONS

Highlighted in NHTSA Regulatory Proposal:

- Left-Turn Assist
- Intersection Movement Assist
- Forward Collision Warning + Electronic Emergency Brake Lights
- Do Not Pass Warning
- Blind Spot + Lane Change Warning

Full U.S. DOT List of Applications

V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lane Change Warning (BSW/LCW)
Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus Warning (Transit)

Agency Data

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
Vehicle Classification-based Traffic Studies
CV-enabled Turning Movement & Intersection Analysis
CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Environment

Eco-Approach and Departure at Signalized Intersections
Eco-Traffic Signal Timing
Eco-Traffic Signal Priority
Connected Eco-Driving
Wireless Inductive/Resonance Charging
Eco-Lanes Management
Eco-Speed Harmonization
Eco-Cooperative Adaptive Cruise Control
Eco-Traveler Information
Eco-Ramp Metering
Low Emissions Zone Management
AFV Charging / Fueling Information
Eco-Smart Parking
Dynamic Eco-Routing (light vehicle, transit, freight)
Eco-ICM Decision Support System

Road Weather

Motorist Advisories and Warnings (MAW)
Enhanced MDSS
Vehicle Data Translator (VDT)
Weather Response Traffic Information (WxTINFO)

Mobility

Advanced Traveler Information System
Intelligent Traffic Signal System (I-SIG)
Signal Priority (transit, freight)
Mobile Accessible Pedestrian Signal System (PED-SIG)
Emergency Vehicle Preemption (PREEMPT)
Dynamic Speed Harmonization (SPD-HARM)
Queue Warning (Q-WARN)
Cooperative Adaptive Cruise Control (CACC)
Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
Emergency Communications and Evacuation (EVAC)
Connection Protection (T-CONNECT)
Dynamic Transit Operations (T-DISP)
Dynamic Ridesharing (D-RIDE)
Freight-Specific Dynamic Travel Planning and Performance
Drayage Optimization

Smart Roadside

Wireless Inspection
Smart Truck Parking

CONNECTED VEHICLE SYSTEMS

KEY POINTS

The term “connected vehicle” can apply to dozens of unique technologies and applications.

Connected vehicle systems can be combined with automated vehicle systems and ITS.

The USDOT Connected Vehicle Program is one example.

- This concept is also known as connected ITS (C-ITS).
- Uses dedicated short-range communication (DSRC) at 5.9 GHz.
- NHTSA is pursuing a potential mandate for vehicle-to-vehicle (V2V) connectivity.
- Vehicle-to-infrastructure (V2I) applications also are in development.

Michigan DOT is actively pursuing DSRC-based solutions.

AUTOMATED VEHICLE SYSTEMS

ANY ELECTRONIC SYSTEM THAT INFLUENCES LATERAL AND/OR LONGITUDINAL OPERATION OF A VEHICLE

Monitoring

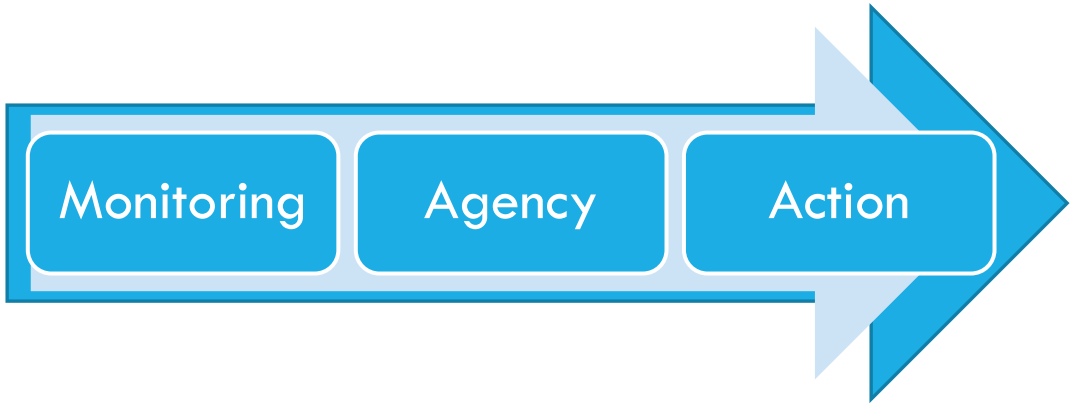
- Sensors, cameras, radar, etc.

Agency

- Information processing

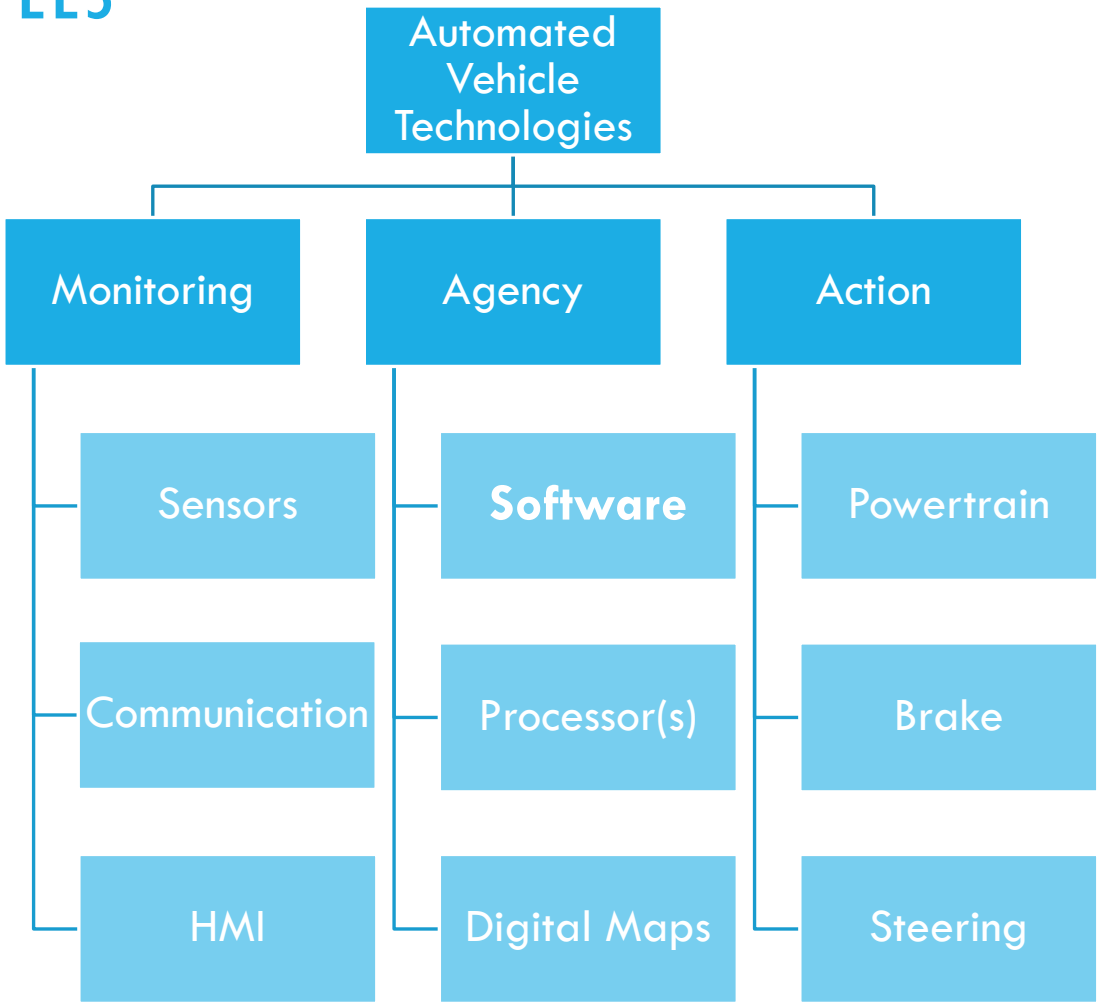
Action

- Physical actuation systems



AUTOMATED VEHICLE SYSTEMS

COMPONENT EXAMPLES



AUTOMATED VEHICLE SYSTEMS

SAE INTERNATIONAL TAXONOMY

Levels 0-2
Available Today

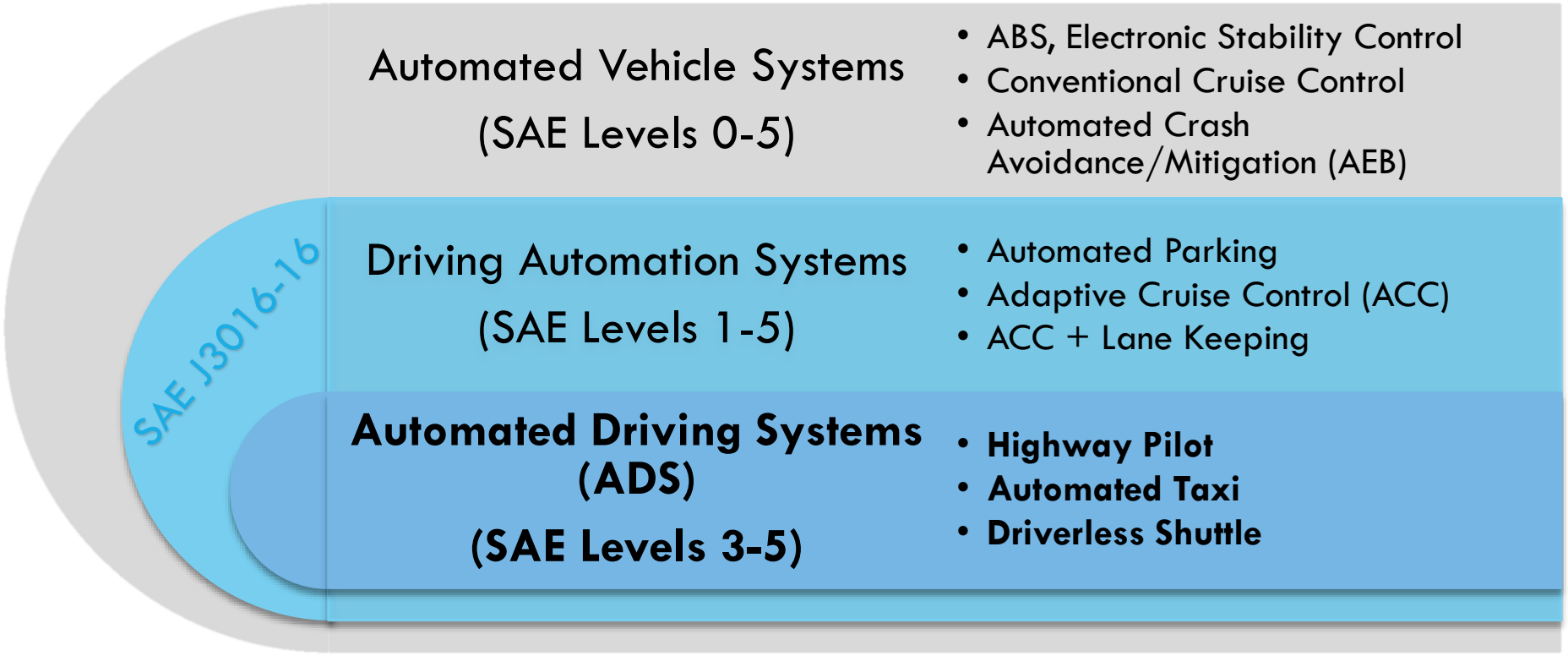
- 0: No Driving Automation
- 1: Driver Assistance
- 2: Partial Driving Automation

Levels 3-5
Automated Driving Systems
(ADS)
Future

- 3: Conditional Driving Automation
- 4: High Driving Automation
- 5: Full Driving Automation

AUTOMATED VEHICLE SYSTEMS

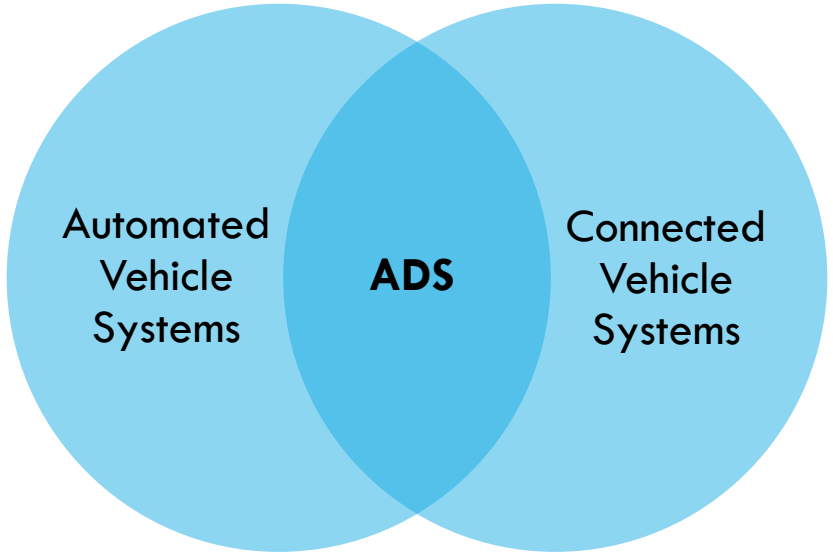
SAE INTERNATIONAL TAXONOMY

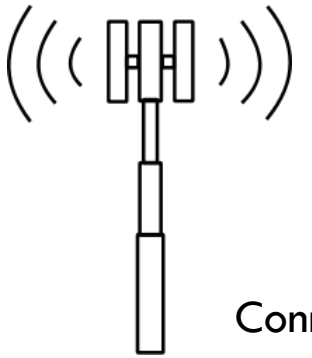


AUTOMATED DRIVING SYSTEMS (ADS)

CONNECTIVITY PRACTICALLY REQUIRED

- Cloud-based Digital Maps
- Fleet Telematics
- Vehicle Condition and Health Monitoring
- Realtime Traffic and Environmental Data
- Trip and Routing Instruction





Connectivity via cellular (4G LTE, 5G), encrypted Wi-Fi, or similar wireless network.

AUTOMATED DRIVING SYSTEMS (ADS)

PROMISES, PROMISES

Tesla
"Autopilot 2.0"
(Level 3 in 2017, with subsequent updates to higher levels)

Volvo
"DriveME" *Pilot*
(Level 3)

Audi
"Piloted Driving"
(Level 3)

Honda
"Automated HW Driving"
(Level 3?)

Nissan
"Autonomous Drive"
(Level 3?)

Lyft/GM
Automated Taxis
(Level 4)

Mercedes
"Autonomous Drive"
(Level 4)

Volvo
"DriveMe" Deployment
(Level 3? 4?)

Ford
Automated Ridesharing
(Level 4)

BMW
"Highly/Fully Autonomous"
(Level 4? 5?)

Uber
Autonomous Taxis
(Level 4)

AUTOMATED VEHICLE SYSTEMS

KEY POINTS

Driving automation systems are defined by SAE J3016.

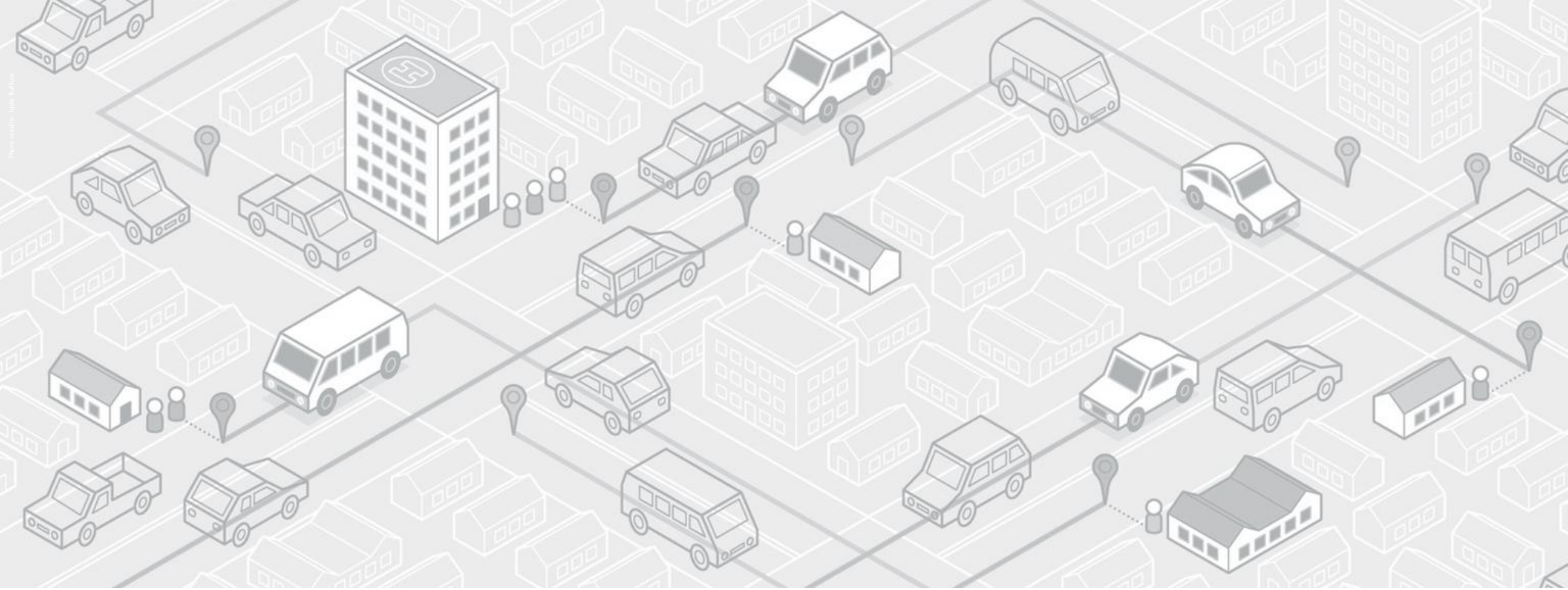
SAE levels 3-5, known as *automated driving systems (ADS)*, are systems that perform the entire driving task for sustained periods.

ADS practically requires connectivity.

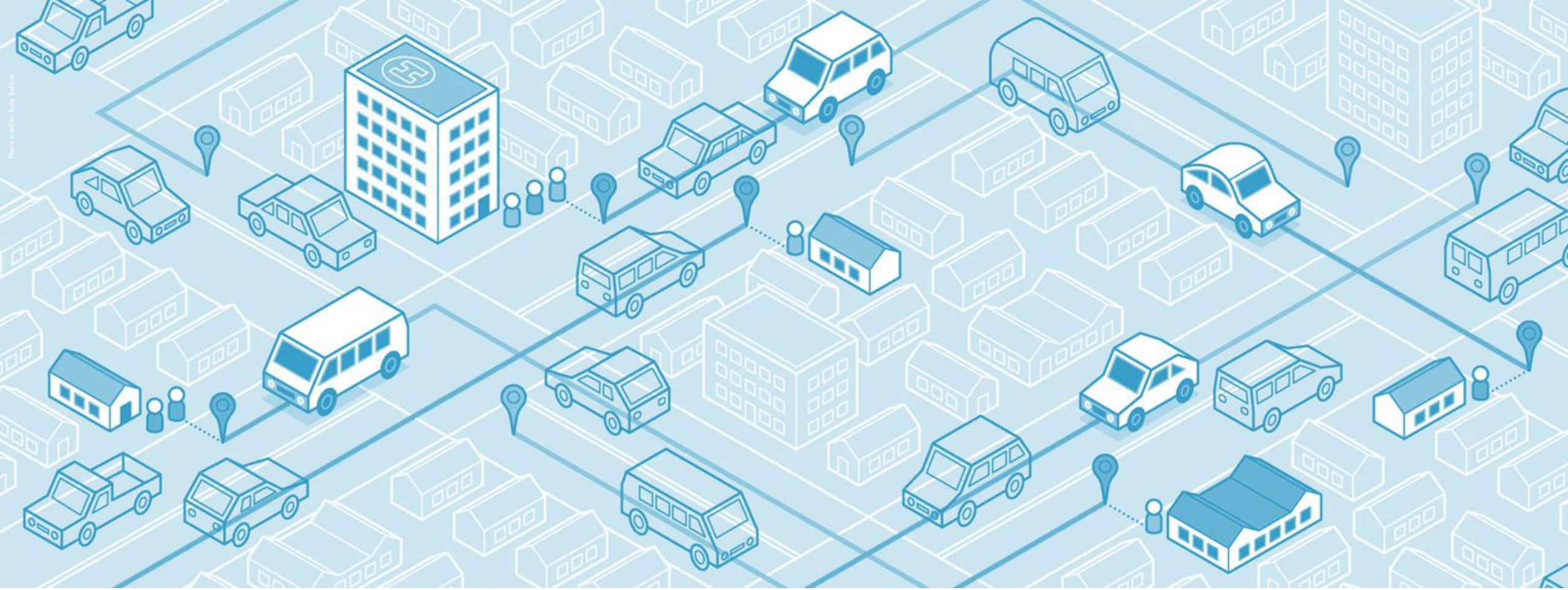
There are nearly zero ADS-equipped vehicles in public operation today. (Exceptions are low-speed shuttle pilot programs.)

First ADS-equipped light passenger vehicles promised by OEMs beginning in 2017.

We can only guess when ADS-equipped vehicles will be adopted or how they will affect the transportation system.



CONNECTED AND AUTOMATED VEHICLE SYSTEMS DISCUSSION



TRANSPORTATION SYSTEMS

TRAVEL DEMAND AND VEHICLE MILES TRAVELED (VMT)

Factors that could lead to an <u>increase</u> in VMT

- Increased travel demand
- Zero occupancy travel
- Parking located too far from points of interest
- Reduced trip chaining
- Mode shift away from mass transit
- Greater urban sprawl
- Significant share of privately owned cars
- Increased mobility of non-drivers
- Increased automated freight and delivery

Factors that could lead to a <u>decrease</u> in VMT

- Pay-per-use programs discourage unnecessary travel
- Lower car ownership
- Increased vehicle occupancy
- First-and-last-mile solution with transit
- Overall lower number of vehicles
- Less travel related to searching for parking
- Denser land development (less parking)
- Increased walking and biking

VEHICLE OWNERSHIP

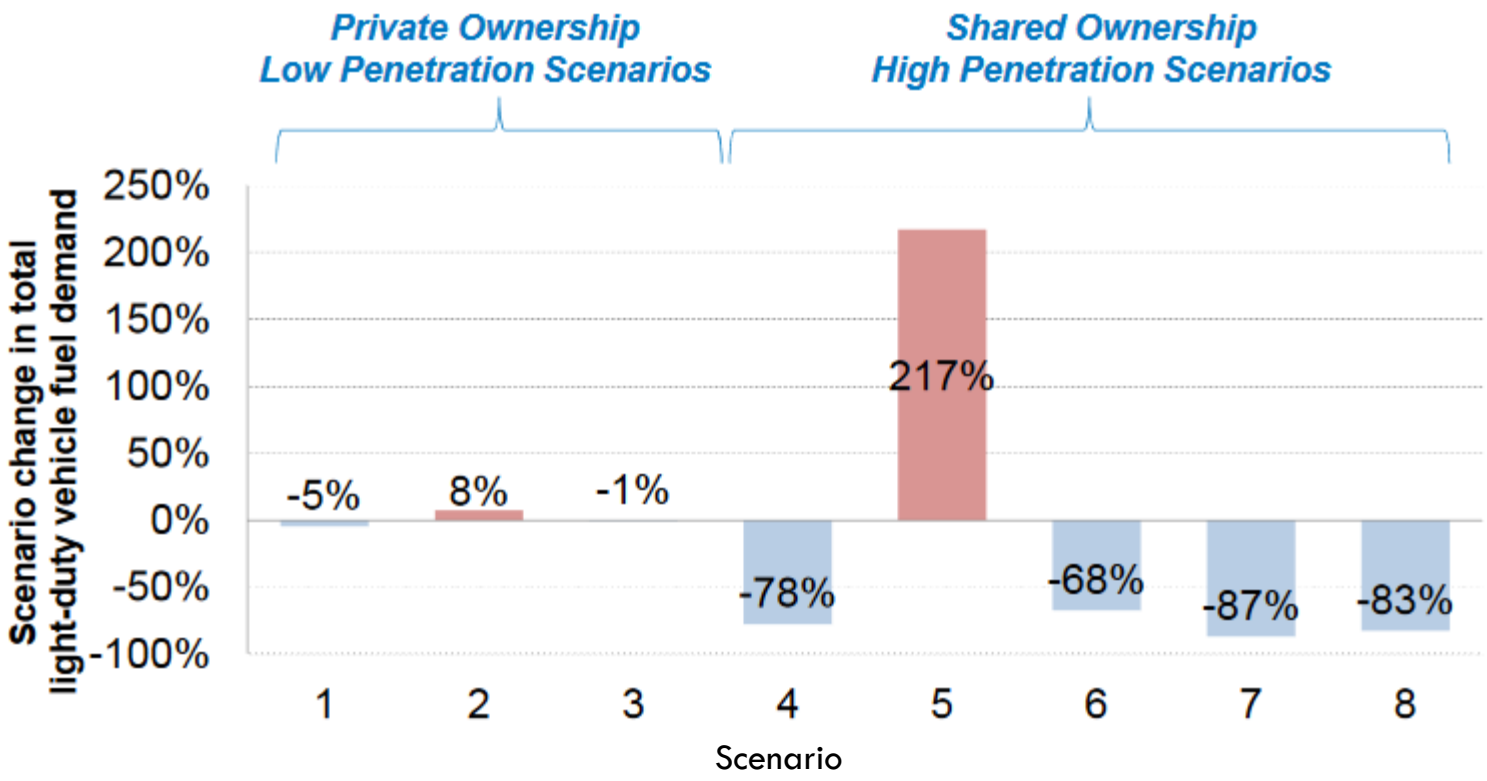
Private ownership scenario

- Private ownership to take full advantage of added convenience
- Cars as a symbol of status and freedom
- Primarily for higher income households
- Mostly for exurban and rural areas

Shared-use/On-demand scenario

- Access to CAVs as a service
- CAVs owned by fleet operators
- Lower transportation costs for users with average or shorter commutes
- Mostly for denser urban areas

POSSIBLE ENERGY IMPACTS OF AUTOMATED VEHICLES



Scenario Number	Name
1	Private Ownership, Fuel Savings Only
2	Private Ownership, Fuel Use Increase Only
3	Private Ownership, Combined Effects
4	Shared Vehicles, Fuel Savings Only
5	All Identified Potential Fuel Use Increases
6	Vehicle Electrification
7	All Identified Potential Fuel Savings
8	All Effects

Source: NREL, 2013

TRANSFORMATION OF PARKING

V2I will enable more efficient use of existing parking supply.

Potential changes:

- Less parking demand (with shared CAVs)
- Smaller parking spots, less on-site and on-street parking
- Parking relocated on the back of lots or outside prime locations

Opportunities ✅

- Lower or no parking requirements
- Reduced need for new municipal parking
- Reconversion in drop-off/pick-up areas
- Road diets

Threats ⚠️

- Possible decline of municipal revenues
- Relocation of CAV parking impacts both VMT and congestion

TRANSFORMATION OF PARKING

TRANSITION PERIOD

Transition period

One parking level for CAVs

Four parking levels for conventional cars

Floor heights compatible with use change.

Concept: Arrowstreet Architecture

TRANSFORMATION OF PARKING

CONNECTED AND AUTOMATED VEHICLES ONLY

CAVs only

One parking level for CAVs.

Ground floor converted to access area.

Top floors converted to other uses.

Concept: Arrowstreet Architecture

INTERACTION WITH NON-MOTORIZED TRAFFIC

- Automated driving promises increased safety for pedestrians and cyclists.
- CAVs can free up space for pedestrian areas and bike lanes (through road diets).

- Non-motorized transportation networks could become even more fragmented, especially in urban settings.
- Planning and design will need to consider non-motorized modes and CAVs equally to avoid unintendedly discouraging biking and walking.

IMPLICATIONS FOR MASS TRANSIT

- Passenger CAVs may reduce public transit demand.
- Equity issues and digital divide might be exacerbated.

Automated public transit could:

- be more affordable
- improve service in low-density areas
- act as feeder service to rail or BRT
- decrease wait times
- lead to job loss among public transit employees.

Pilot projects for automated transit already exist, mostly in Europe.

IMPLICATIONS FOR MASS TRANSIT

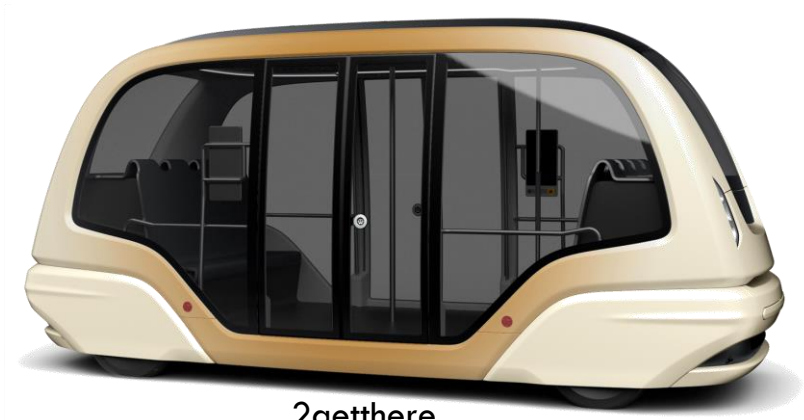
AUTOMATED SHUTTLES

Level 4 Automation, available today: low speed, fixed route, limited conflicts

Navya Arma

Easymile EZ10

Local Motors Olli



2getthere

Auro

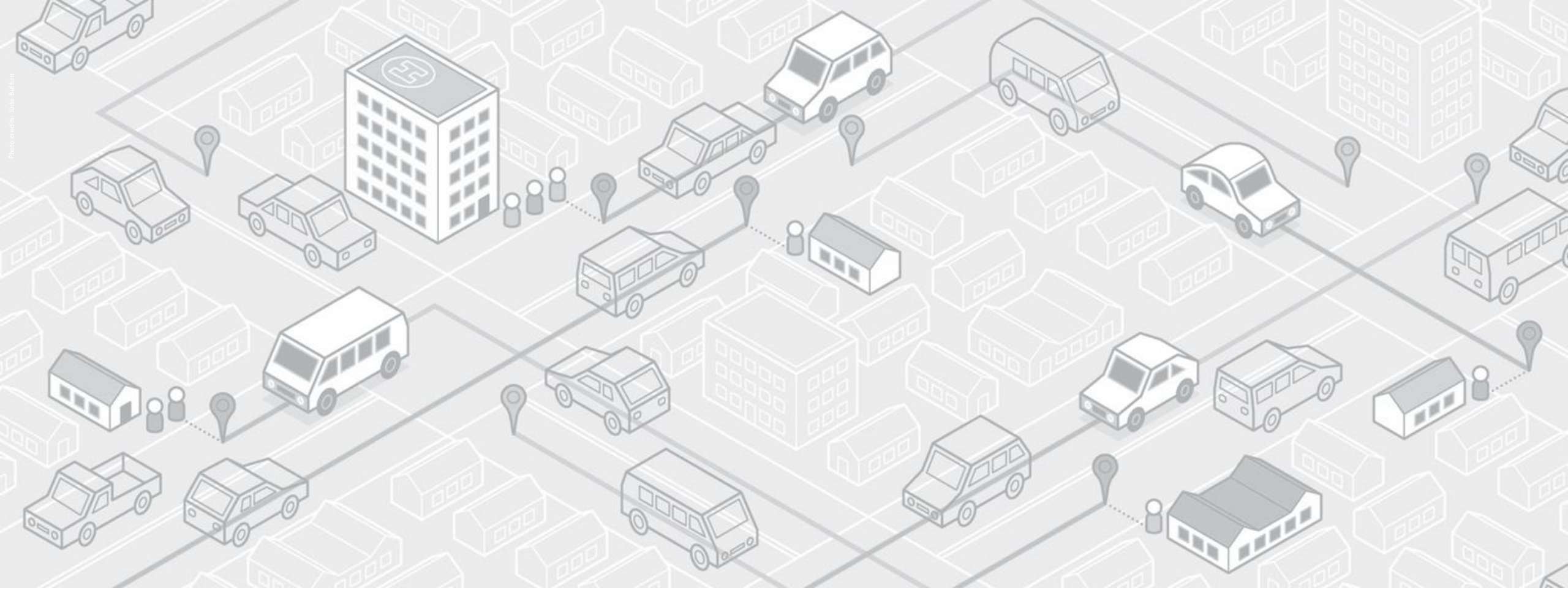
USDOT TRANSIT V2I RESEARCH PROGRAM

Application of the connected vehicle concept to transit.

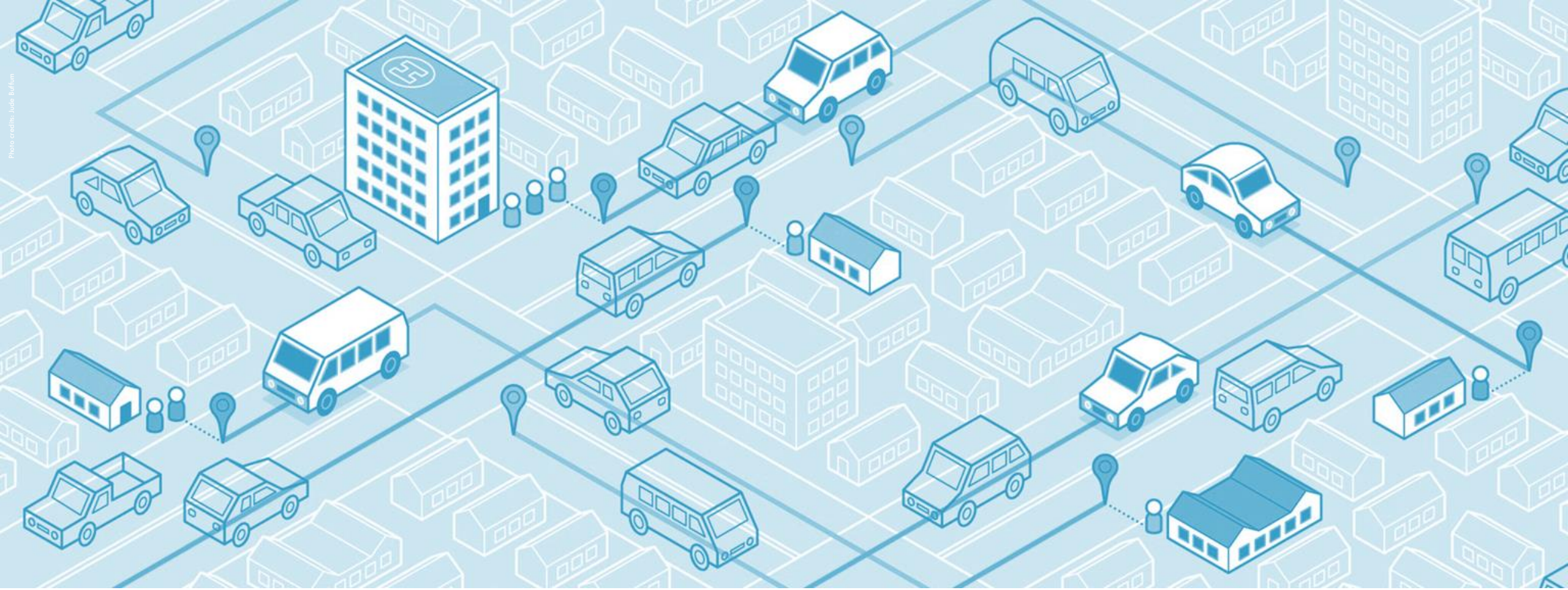
Goal: develop safety, mobility, and environmental applications.

Example: 3 University of Michigan transit buses retrofitted with connected vehicle technologies.

Transit V2I Applications (Source: USDOT, 2015)



TRANSPORTATION SYSTEMS DISCUSSION



INFRASTRUCTURE INVESTMENTS

CROSS-CUTTING ISSUES

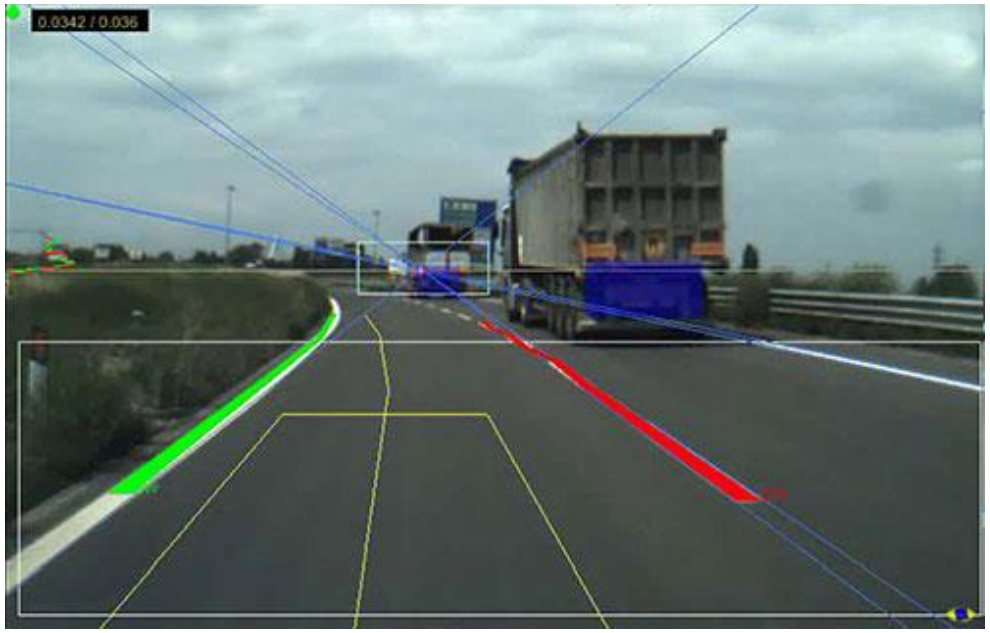
- Companies are developing automated vehicles that can function in today's (imperfect) roads.
- Automated vehicles may not require significant infrastructure investment before they can be used.
- In the long term, gradual infrastructure changes could maximize the benefits of automated vehicles.
- V2I applications may require significant public investment.

- Ultimately, it is a matter of public policy choice.

MODIFICATIONS TO EXISTING INFRASTRUCTURE

ROAD MARKINGS

- Clear lane markings are beneficial for CAV operation, but are not necessary.
- Lane marking improvements are useful for non-CAVs too.
- AASHTO and SAE are working on a guideline for CAV-oriented lane markings specifications.



Source: Point Grey

MODIFICATIONS TO EXISTING INFRASTRUCTURE

SIGNAGE AND SIGNALIZATION

- Traffic signal updates are necessary to enable V2I.
- V2I communication may replace some functions of signs and signals.
- Pedestrians, cyclists, or vehicles without V2I/V2V still need signs and signals.

Concept of Autonomous Intersection Management (AIM) – Massachusetts Institute of Technology (MIT), Swiss Institute of Technology (ETHZ), Italian National Research Council (CNR)
https://www.youtube.com/watch?v=4CZc3erc_I4

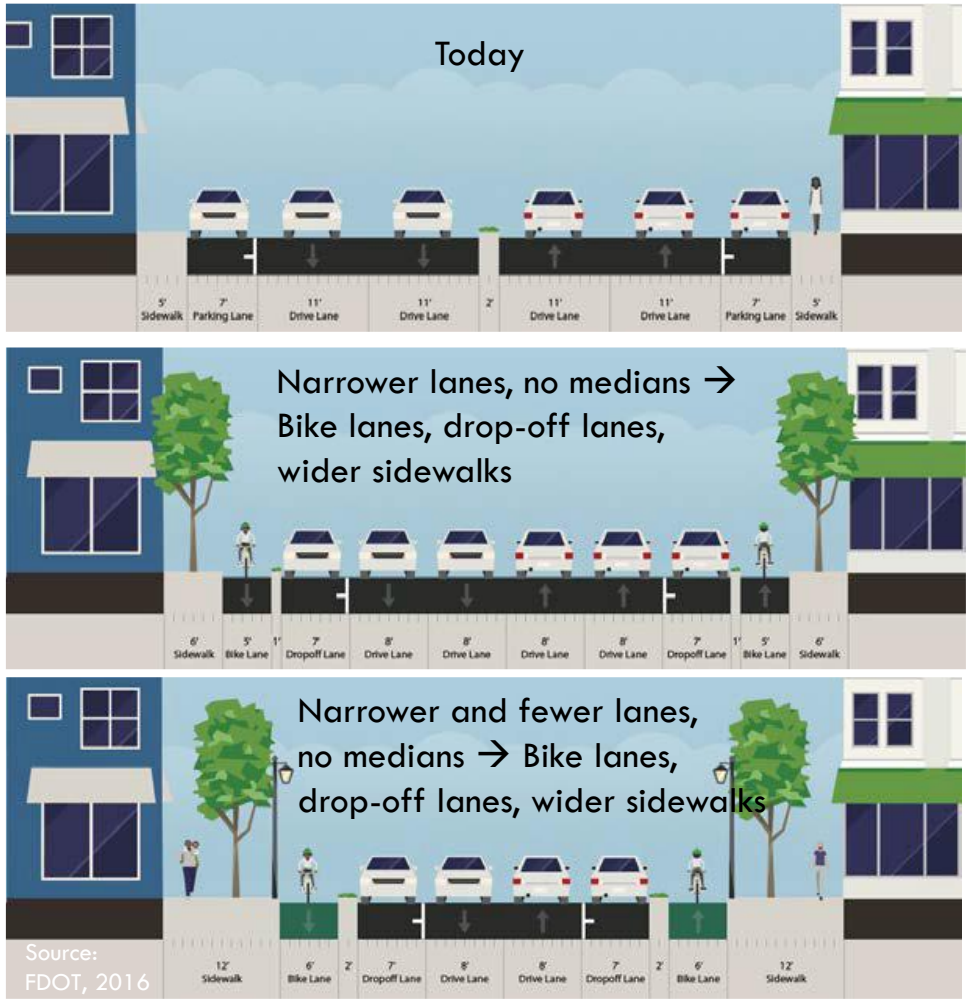
⚠️ Concepts of free-flow intersections would make access of pedestrians, cyclists, human-driven cars more difficult unless other modifications also are made.

MODIFICATIONS TO EXISTING INFRASTRUCTURE

LANE WIDTH AND ROAD CAPACITY

- CAVs could allow for:
  - Reduced lane width requirements
  - Reduced number of lanes
  - Increased road throughput and efficiency
  - Medians to be removed or narrowed
- Space saved could be repurposed: sidewalks, bike lanes, green space.
- Road expansions might become unnecessary.

⚠ Congestion relief effect could be cancelled out if VMT increases.



Source: FDOT, 2016

MODIFICATIONS TO EXISTING INFRASTRUCTURE

ACCESS MANAGEMENT

- Self-parking vehicles increase need for drop-off/pick-up points.
- Retrofit: curbside and on-site parking, bus stops, turn lanes, frontage and service roads
- Entirely new designs for drop-off/pick-up points
- New forms, location, and design of curb cuts
- Need for design standards for drop-off/pick-up areas

Potential conflict with non-motorized traffic on sidewalks and bike lanes.

Typical suburban strip-mall design

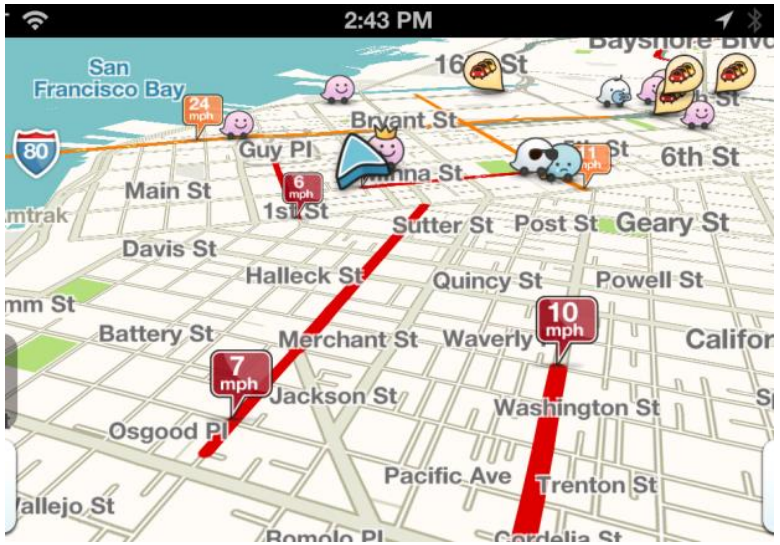
Concept for a CAV-oriented commercial site design

Source: FDOT, 2016

DIGITAL INFRASTRUCTURE

Potential roles of the public sector

- Creation, maintenance, and distribution of maps for automated driving:
  - Create open-sourced maps
  - Develop open standards
  - Collect and publish pertinent data
- Data exchange partnerships: Waze, Here, INRIX
- Support deployment of broadband: “dig-once” policies

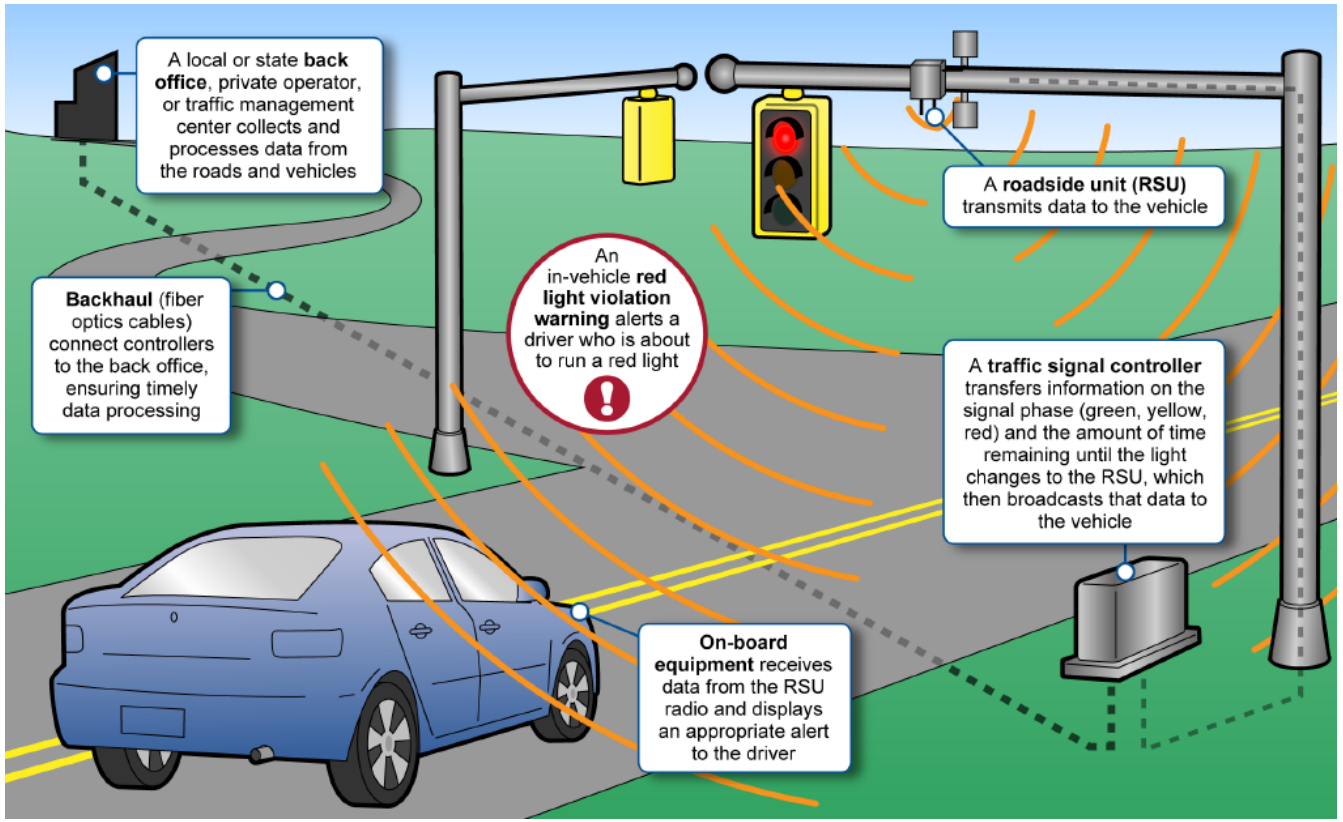


Source: Waze

NEW INFRASTRUCTURE FOR V2I

Example of roadside equipment:

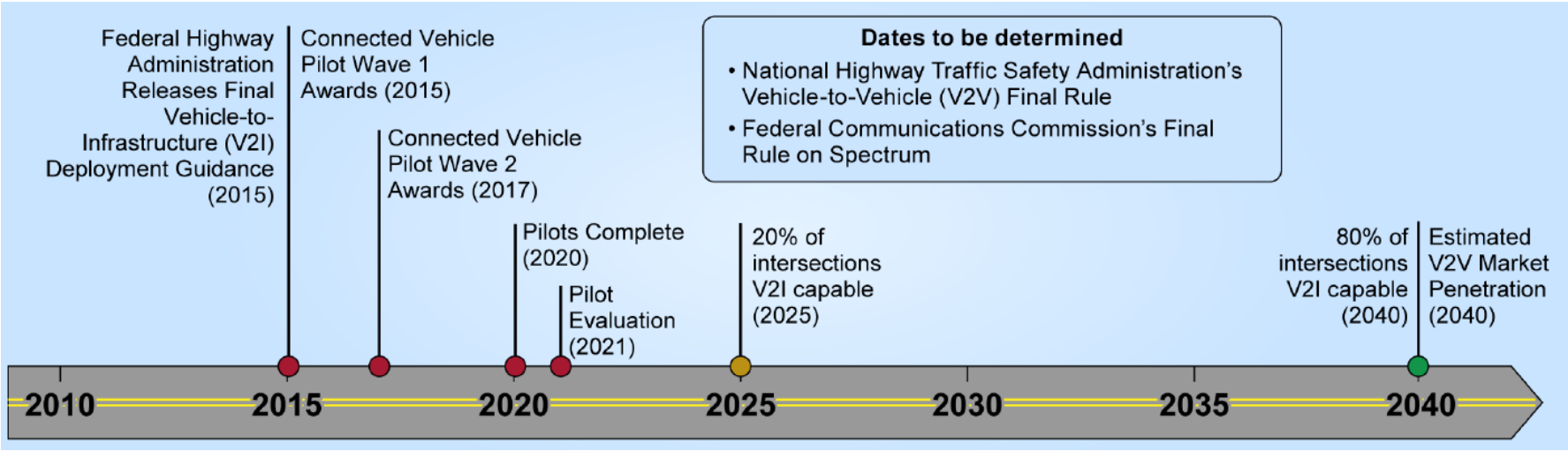
- **Roadside units (RSUs):** Devices that transmit data to, or receive data from, nearby vehicles.
- **Traffic signal controller:** Generates the Signal Phase and Timing (SPaT) message.
- **Traffic Management Center.** Collects and processes aggregated data from the infrastructure and vehicles.
- **Communication links.** Connect roadside equipment to the back office.
- **Support functions.**



Example of V2I application and roadside equipment (Source: GAO Report 15-775)

NEW INFRASTRUCTURE FOR V2I

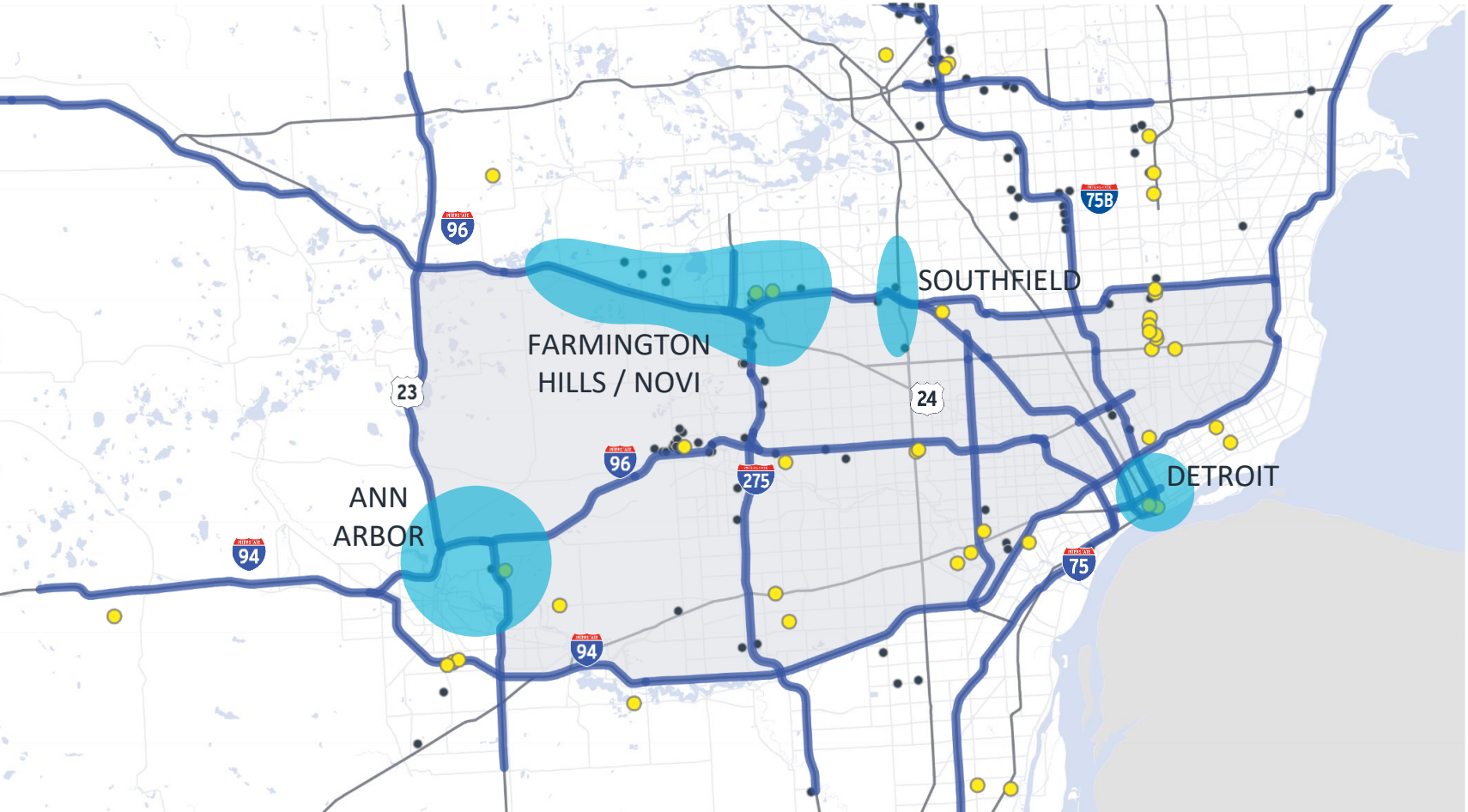
- Voluntary deployment over the next decades.
- Costs borne by local and state authorities, eligible for federal aid highway funding.
- AASHTO V2I Deployment Coalition



USDOT's Planned Connected Vehicle Path to Deployment (Source: GAO Report 15-775)

SE MICHIGAN CONNECTED VEHICLE ASSETS

MDOT PILOT APPLICATIONS



Vehicle-to-Infrastructure (V2I)

- Red light violation warning
- Work zone warning/management
- Road weather management
- Pavement condition monitoring

- Connected Vehicle Environment
- Connected Vehicle Test Beds
- Tier 1 Automotive Suppliers
- Major OEM Facilities
- MDOT Roadway ITS Coverage

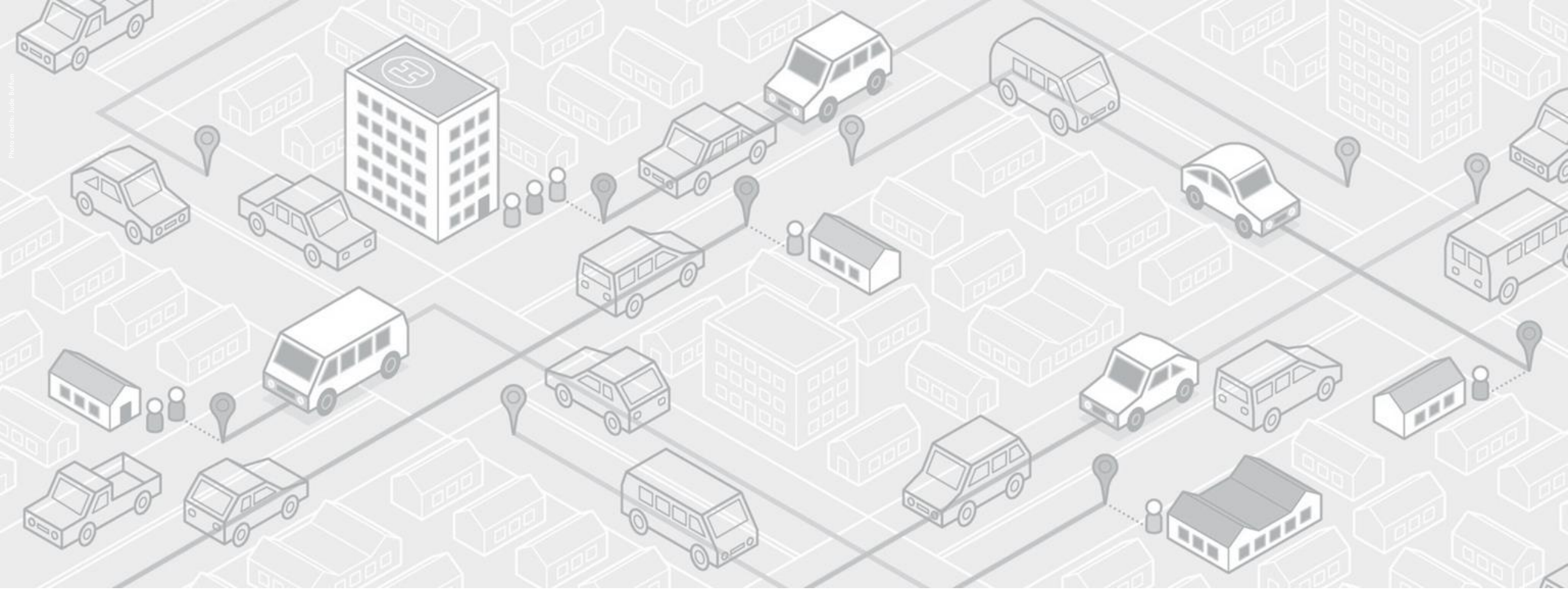
NEW INFRASTRUCTURE FOR AUTOMATED DRIVING

Localization beacons

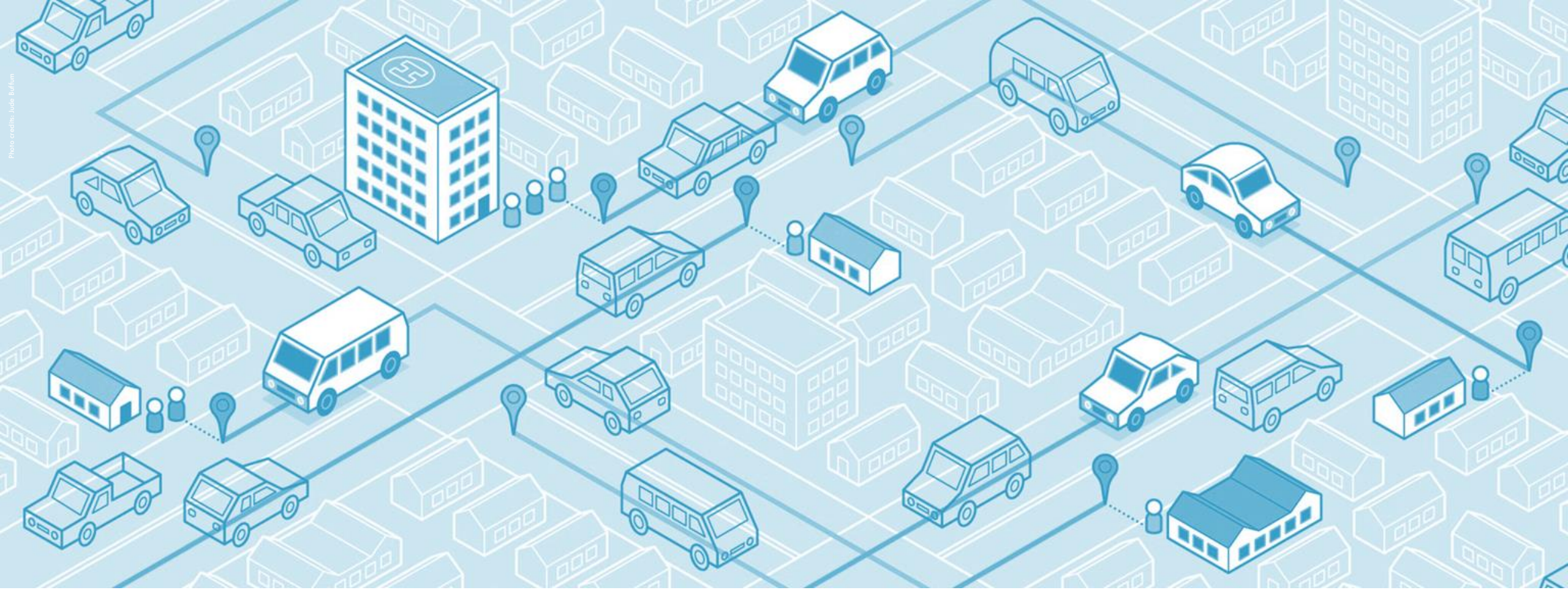
- Might be needed in tunnels and under bridges to improve accuracy of vehicle localization (GPS not adequate in such locations)

Minimal risk condition/fall back

- Might require wide road shoulders or pullout areas where CAVs can safely stop in case of a malfunction.



INFRASTRUCTURE INVESTMENTS DISCUSSION



LAND USE

LAND FORM

MORE SPRAWL SCENARIO

If CAVs lower transportation costs…

- Commuter willingness to travel longer distances to and from work could increase;
- Household and businesses might locate farther from urban cores;
- Low-density land-use patterns, more urban sprawl, and greater infrastructure costs could develop.

LAND FORM
MORE DENSITY SCENARIO

If CAVs contribute to reduced on-site parking needs…

- Valuable, urban-core space could be freed up for redevelopment;
- More space could be dedicated to human occupancy and other non-parking uses;
- Denser, more walkable developments could be created.

"Shuffle City," a matrix of compact urban cells, on-demand shared workspaces, and a shared mobility network of autonomous vehicles. (Source: Alloybuild)

REGIONAL AND LOCAL PLANNING

Near term

Develop policies for data collection and sharing

Incorporate CAVs in city goals for safety, GHG emissions, congestion

Start considering policies to manage the VMT and sprawl impact

Medium to long term

Update travel demand models and roadway design manuals

Reevaluate road capacity needs and road expansion projects

Reevaluate transit fleet management plans and service delivery plans

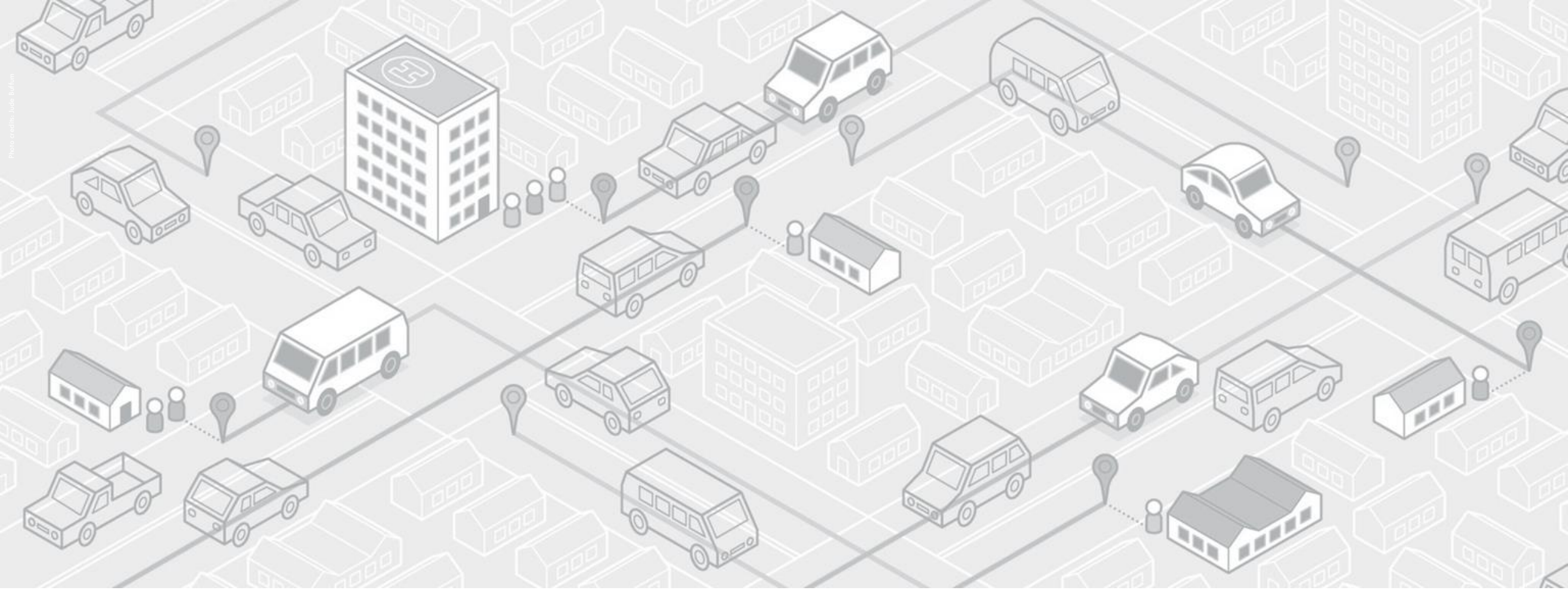
Plan infrastructure investments

Take impact of CAVs into account in long range transportation plans

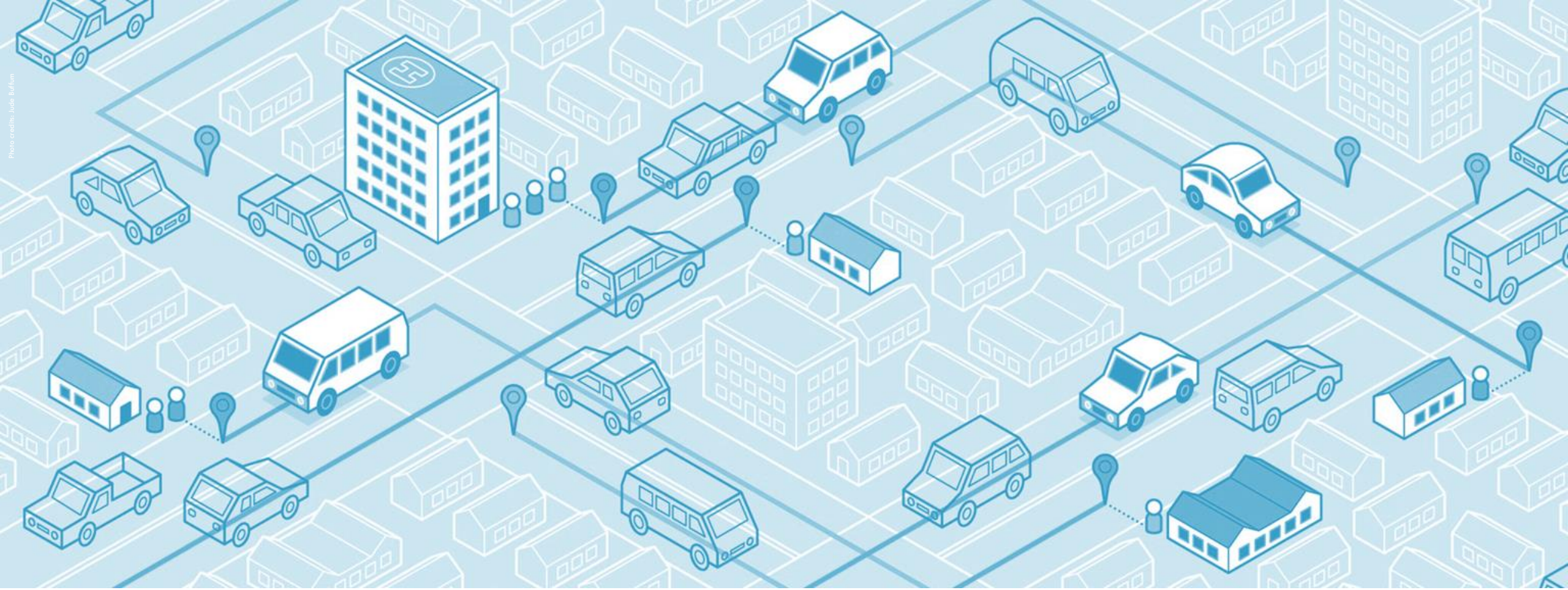
ZONING

Potential changes to zoning ordinances:

- Eliminate or reduce minimum parking requirements
- Develop specifications for parking design for CAVs
- Develop specifications for the design of drop-off/pick-up areas
- Evaluate the opportunity for minimum requirements for drop-off/pick-up areas

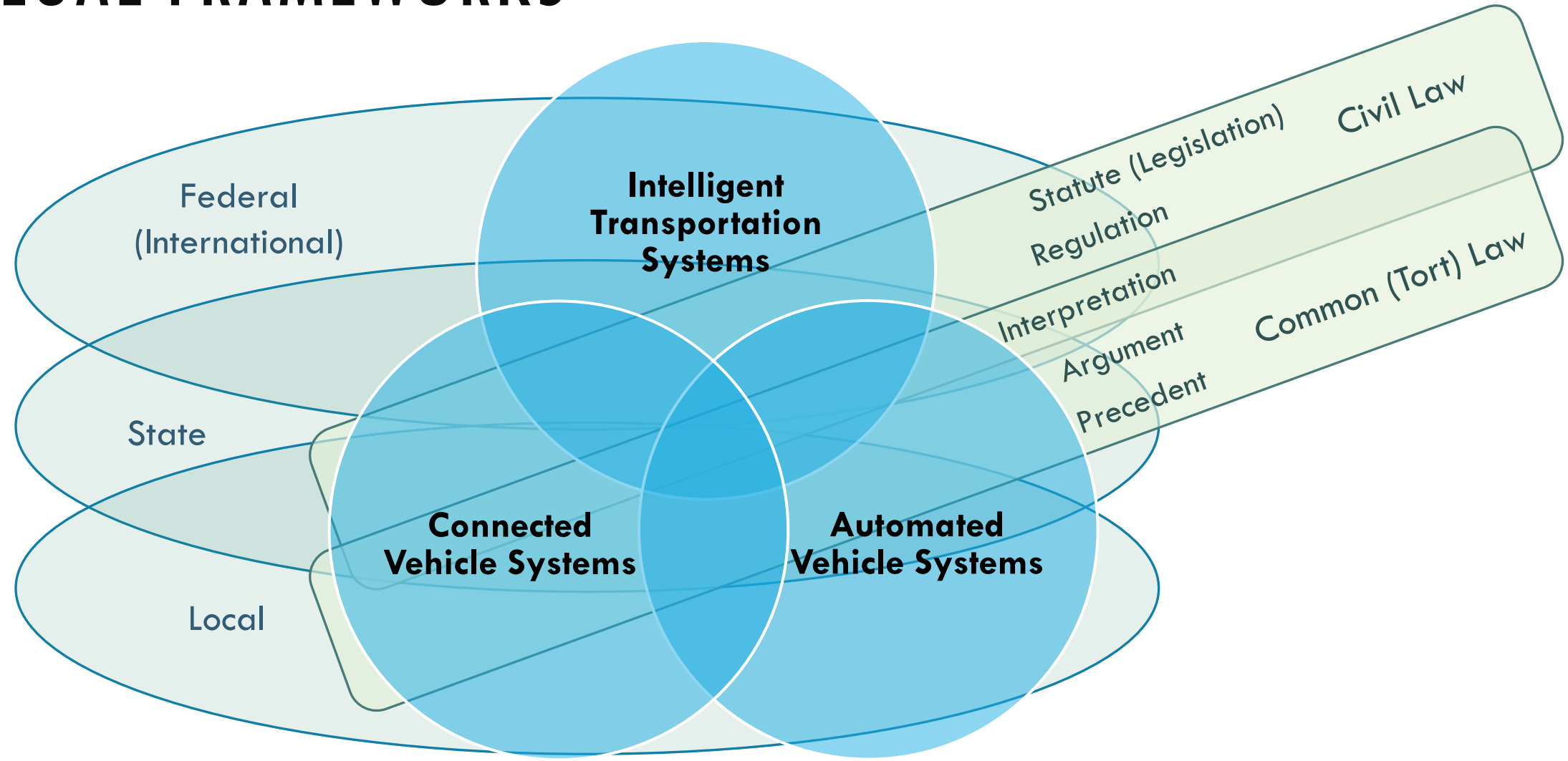


LAND USE DISCUSSION

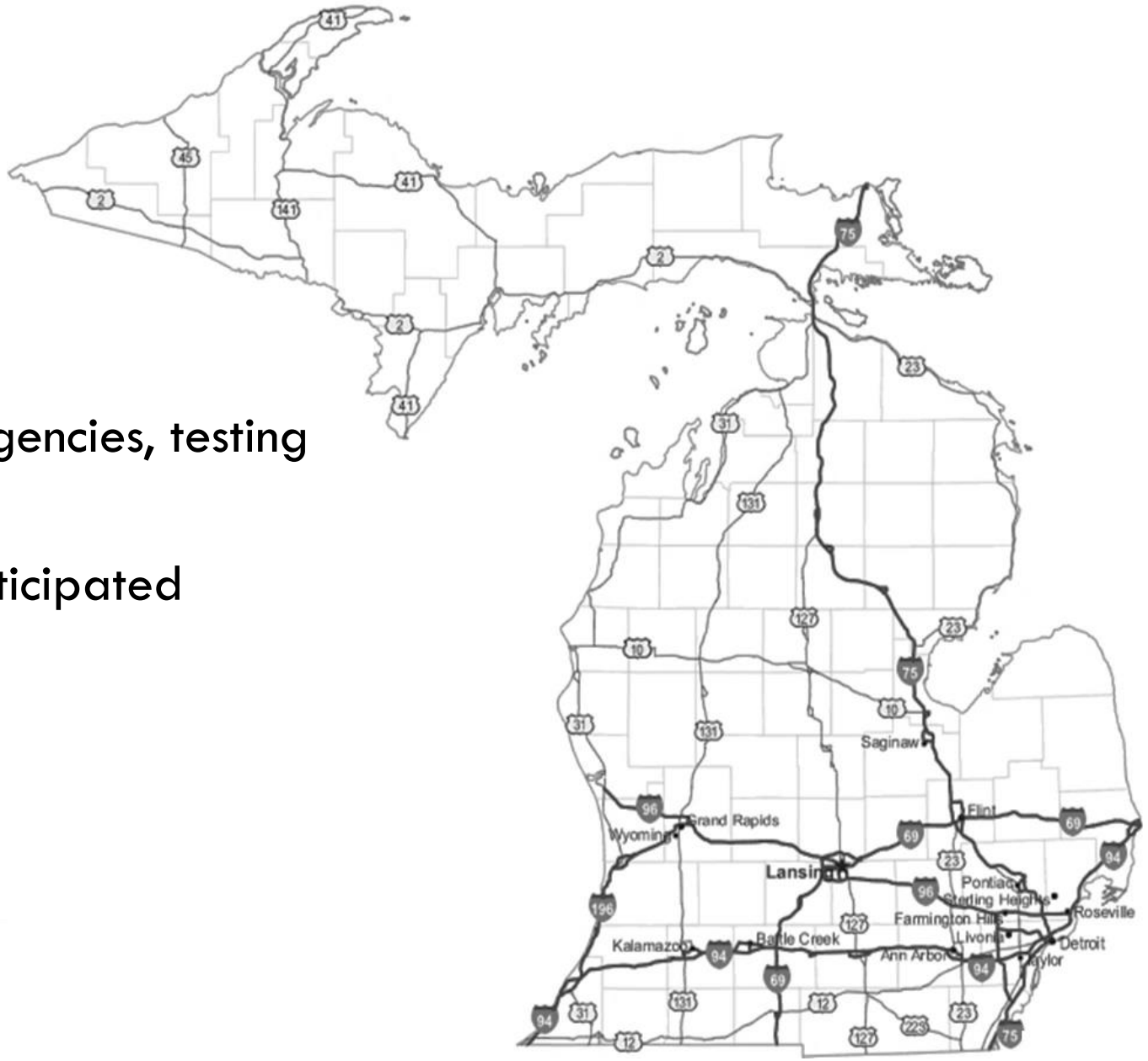


LEGAL AND REGULATORY CONSIDERATIONS

LEGAL FRAMEWORKS



MICHIGAN



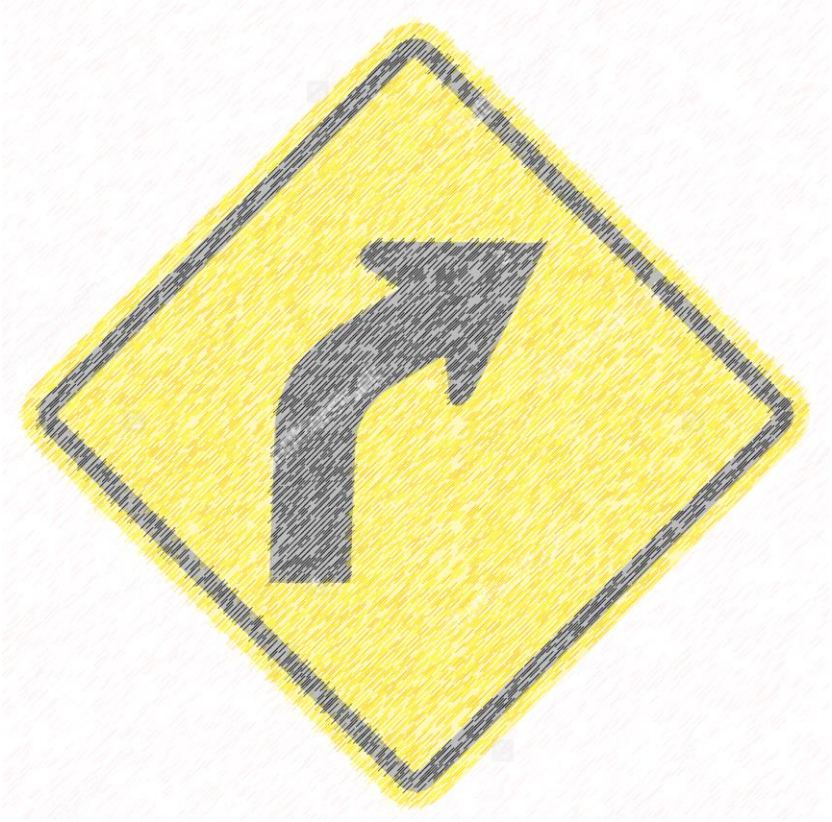
Current policy affects mainly state agencies, testing organizations, and manufacturers

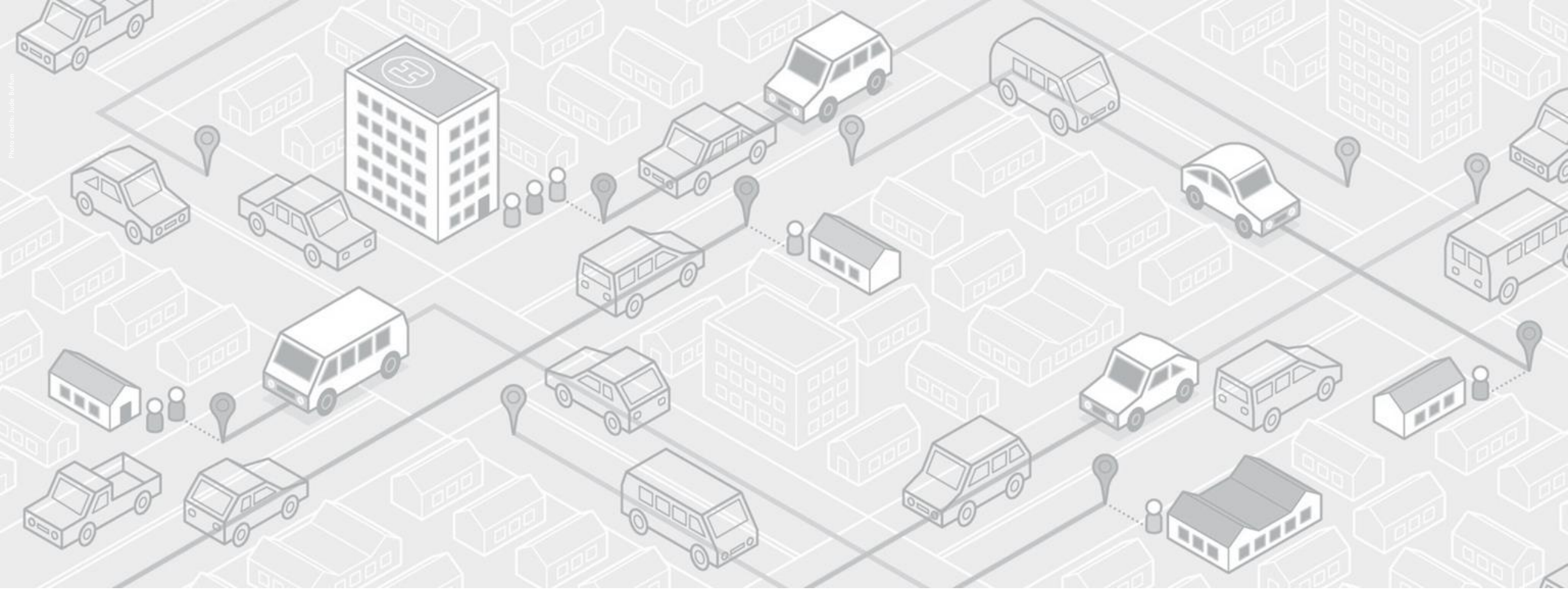
No local requirements pending or anticipated

Opportunities for engagement

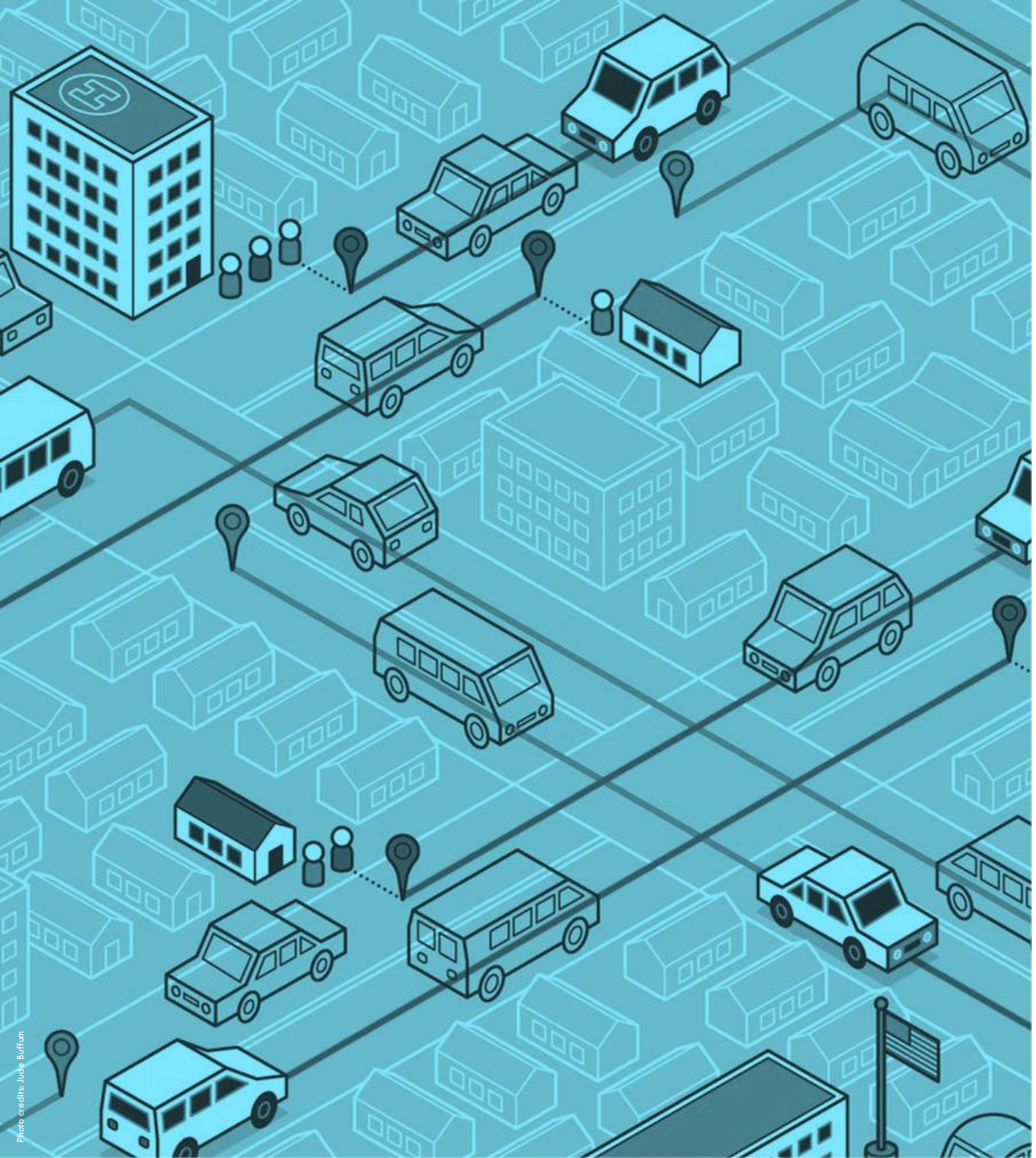
THINGS THAT COULD CHANGE LEGAL LANDSCAPE

- Automated vehicle deployment
- Connected vehicle mandate
- Federal legislation, regulation, and policy
- State legislation, regulation, and policy
- Local statute and policy
- Divergent case law rulings





LEGAL AND REGULATORY CONSIDERATIONS DISCUSSION



THANK YOU! QUESTIONS?

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