Technology and Trends in Vehicle Automation

Pennsylvania Society of Professional Engineers

June 9, 2021

Traffic21

A transportation research institute of Carnegie Mellon University

Stan Caldwell

Executive Director

Traffic21

A transportation research institute of Carnegie Mellon University

Mobility21

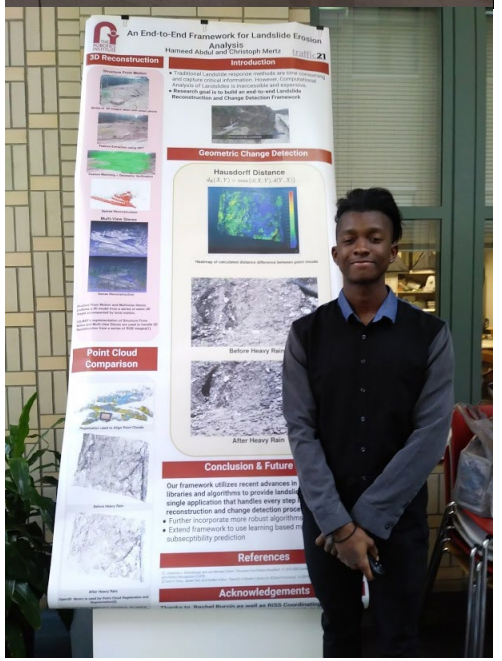
A USDOT NATIONAL UNIVERSITY TRANSPORTATION CENTER

Carnegie Mellon University

Penn
University of Pennsylvania

The Ohio State University

CCAC



Trends Driving Intelligent Transportation Systems

- Sensors
- Data Analytics (real time and predictive)
- Cyber Physical Systems
- Edge Computing
- Internet of Things
- 5G and Advanced Wireless

Technologies Disrupting Transportation

Automation

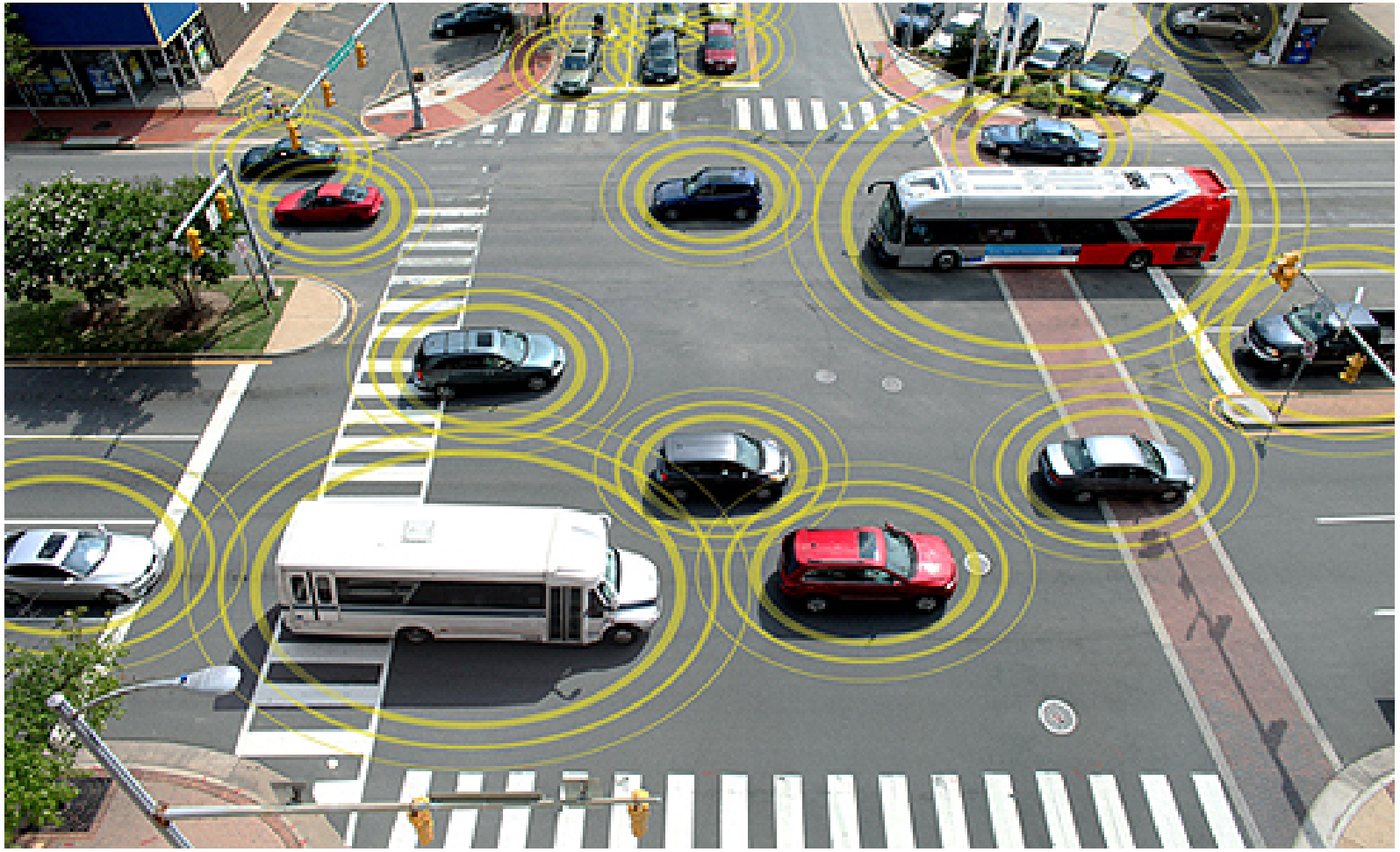
Connectivity

Shared Use

Electrification

Novel Modes, Drones, Hyperloop, etc.

Connected Vehicles

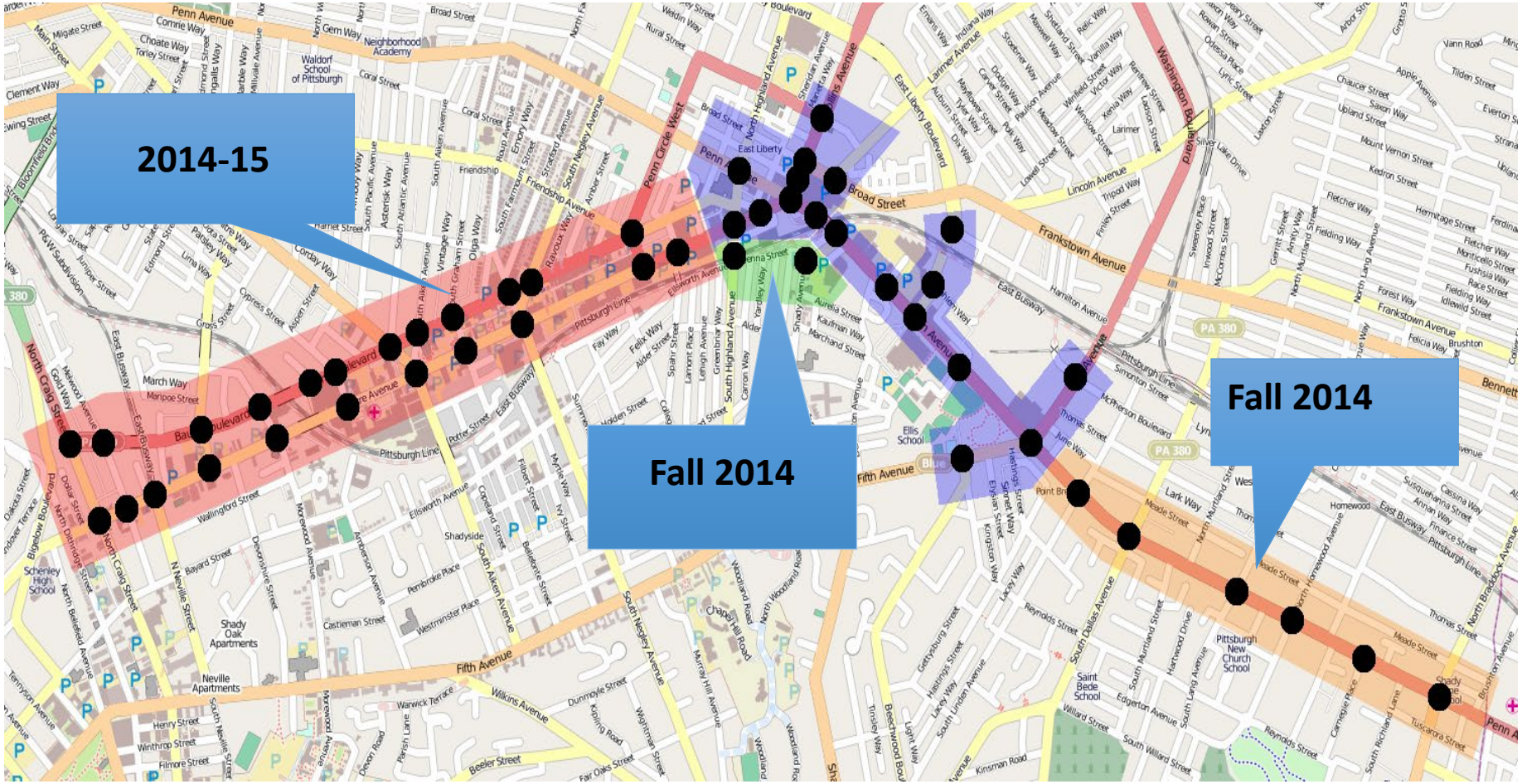


Dedicated Short Range Communication (DSRC)

CV2X vs DSRC

CV2X Enabled by 5G Cellular Network

Surtrac Adaptive Signal Control Expansion



ACCESSIBLE TRANSPORTATION TECHNOLOGIES
RESEARCH INITIATIVE

Safe Intersection Crossing for Pedestrians with Disabilities

Stephen F. Smith

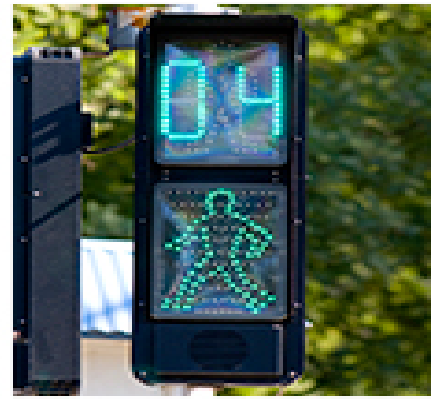
The Robotics Institute

Carnegie Mellon

U.S. Department of Transportation
Federal Transit Administration

U.S. Department of Transportation
Federal Highway Administration

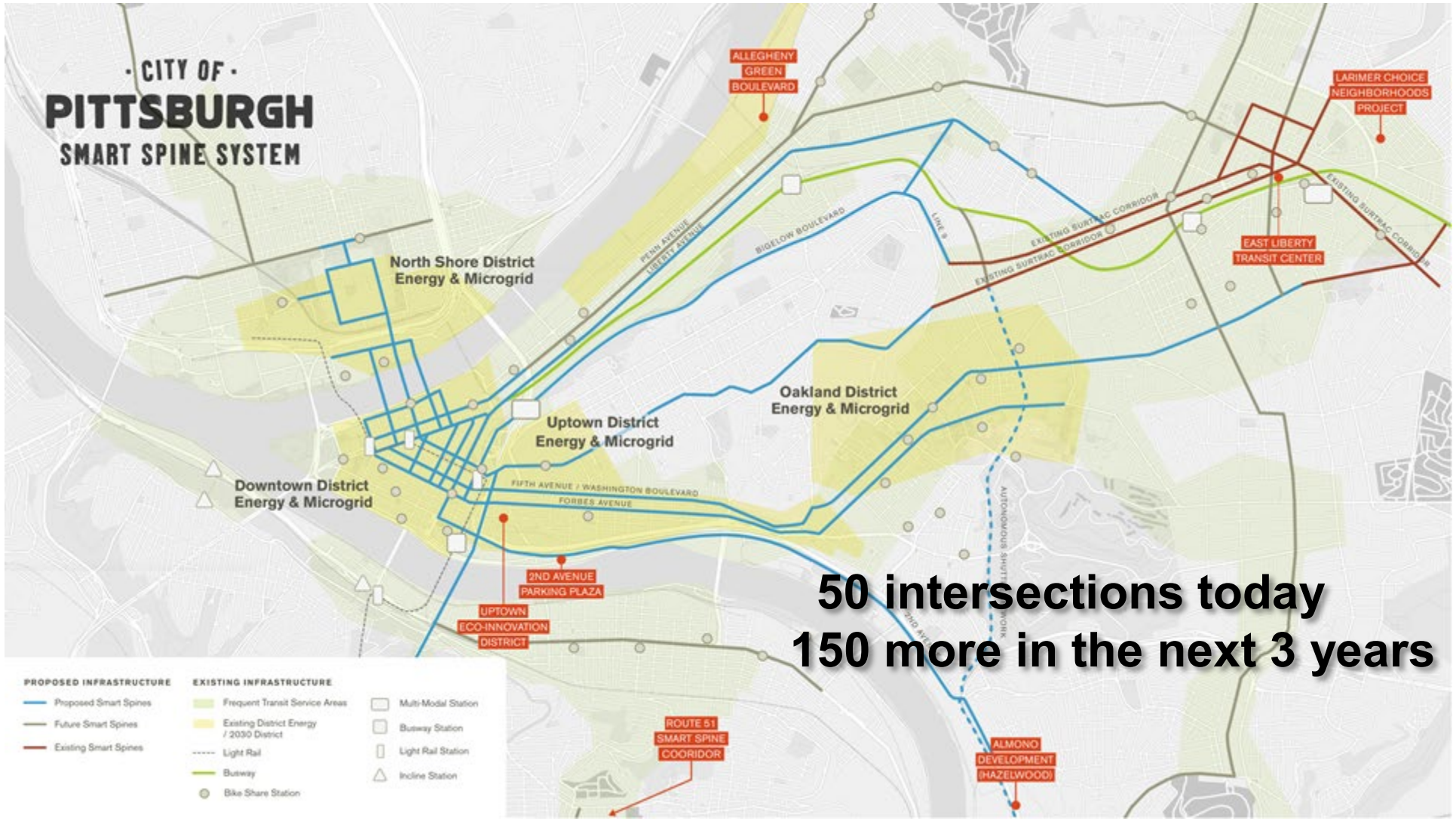
U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology



Safe Intersection Crossing

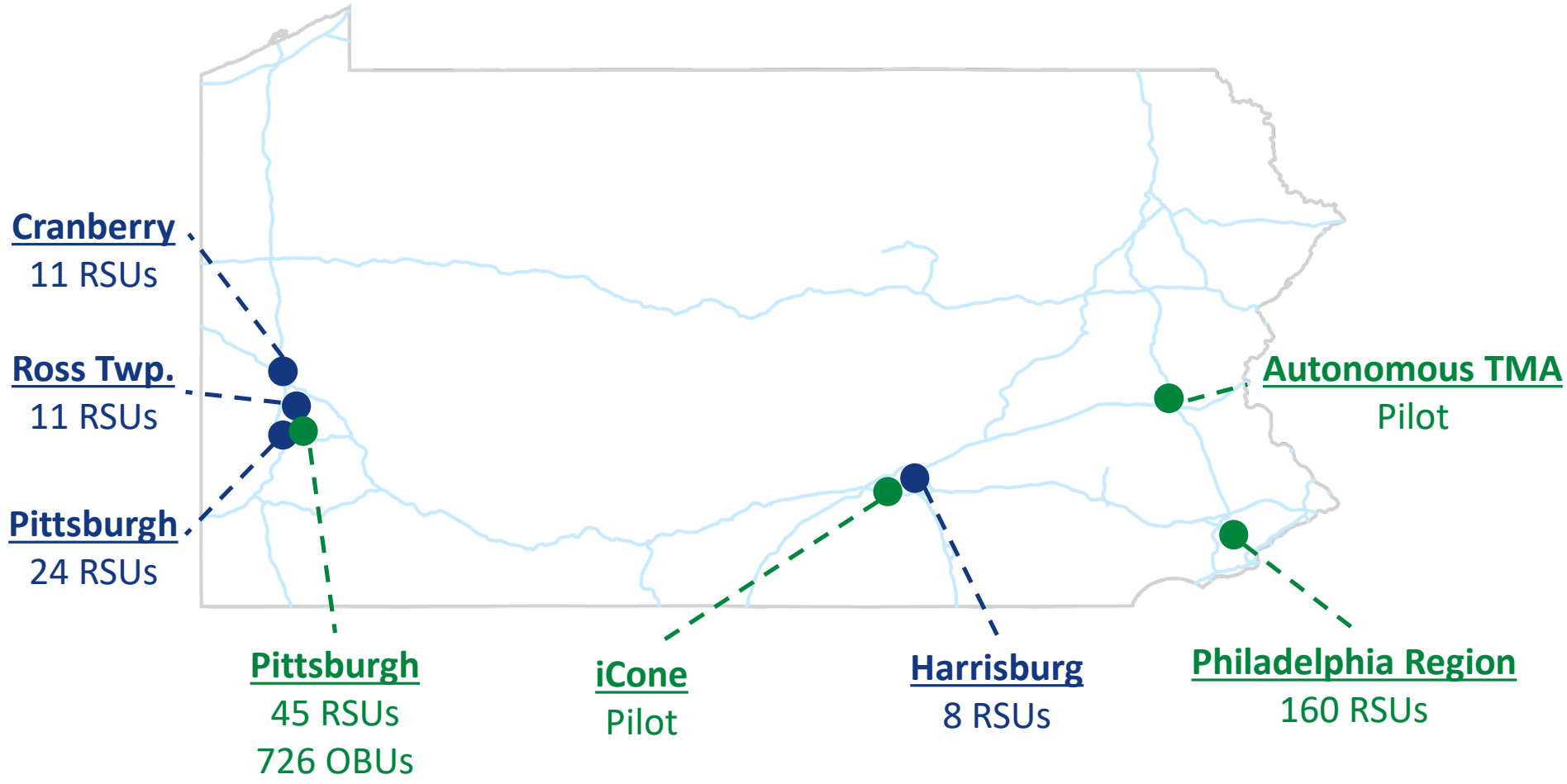
- **Project Objective:** Develop a smartphone application that allows pedestrians to
  - *interact directly* with the intersection and
  - *actively influence* traffic signals for safe and efficient crossing

Carnegie Mellon


· CITY OF ·
PITTSBURGH
SMART SPINE SYSTEM
North Shore District
Energy & Microgrid
Downtown District
Energy & Microgrid
Uptown District
Energy & Microgrid
Oakland District
Energy & Microgrid
ALLEGHENY
GREEN
BOULEVARD
LARIMER CHOICE
NEIGHBORHOODS
PROJECT
EAST LIBERTY
TRANSIT CENTER
PENN AVENUE
LIBERTY AVENUE
BIGELOW BOULEVARD
LINE B
EXISTING SURTRAC CORRIDOR
FIFTH AVENUE / WASHINGTON BOULEVARD
FORBES AVENUE
2ND AVENUE
PARKING PLAZA
UPTOWN
ECO-INNOVATION
DISTRICT
ROUTE 51
SMART SPINE
COORIDOR
ALMONO
DEVELOPMENT
(HAZELWOOD)
AUTONOMOUS SHUTTLE NETWORK
PROPOSED INFRASTRUCTURE
Proposed Smart Spines
Future Smart Spines
Existing Smart Spines
EXISTING INFRASTRUCTURE
Frequent Transit Service Areas
Existing District Energy / 2030 District
Light Rail
Busway
Bike Share Station
Multi-Modal Station
Busway Station
Light Rail Station
Incline Station
50 intersections today
150 more in the next 3 years

V2I Deployments

CURRENT **PLANNED**



pennsylvania
DEPARTMENT OF TRANSPORTATION

Connected and Autonomous Vehicles

Connectivity

- Includes all types of communication with vehicles and infrastructure (Wi-Fi, DSRC, Cellular, etc.)

Connected Vehicle

Communicates with nearby vehicles and infrastructure

Connected and Autonomous Vehicles

Connectivity

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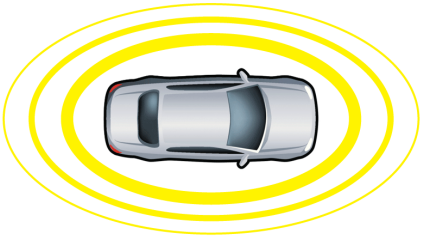
Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors

Connected Vehicle



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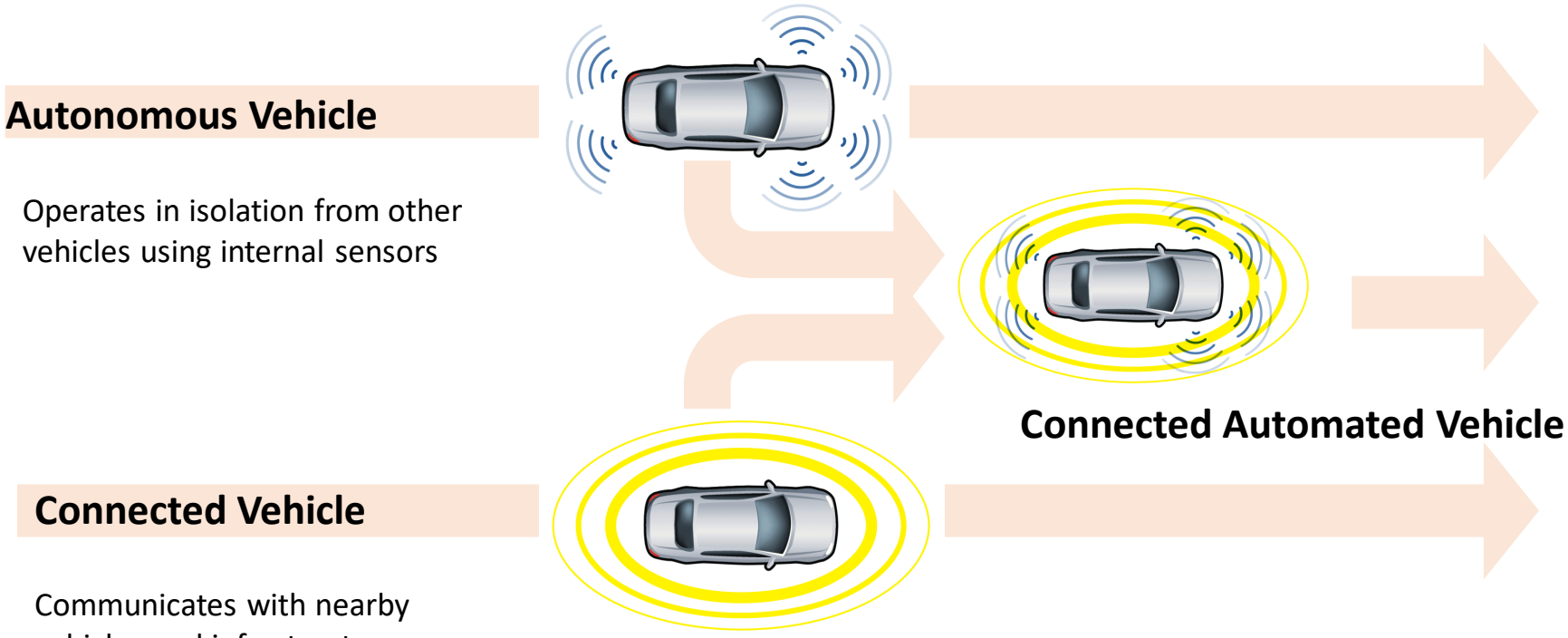


SAE J3016™ LEVELS OF DRIVING AUTOMATION™

Learn more here: sae.org/standards/content/j3016_202104

	SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?	**You are driving** whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			**You are not driving** when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			**These are automated driving features**		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering **OR** brake/ acceleration support to the driver	These features provide steering **AND** brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering **OR** • adaptive cruise control	• lane centering **AND** • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

Carnegie Mellon University
30 Years of Self-Driving Car Research

1984
- The Terregator's top speed was a few centimeters per second; it could avoid obstacles.
- NavLab launched. Its goal: apply computer vision, sensors and high-speed processors to create vehicles that drive themselves.

1986
Humans or computers controlled NavLab1, a Chevy van. Top speed: 20 mph.

1990
NavLab 2, a US Army HMMWV, wrangled rough terrain at 6 mph. Highway speed: 70 mph.

1995
NavLab 5, a Pontiac Trans Sport, traveled from Pittsburgh to San Diego in the "No Hands Across America Tour."

2000
NavLab 11, a Jeep, was equipped with Virtual Valet.

2005
Sandstorm and Highlander placed 2nd and 3rd in the DARPA Grand Challenge.

2007
Carnegie Mellon's "Boss" won the DARPA Grand Urban Challenge by outmaneuvering other vehicles along the 55-mile course.

2014
Carnegie Mellon's **14th self-driving vehicle** is a Cadillac SRX that:
- avoids pedestrians and cyclists
- takes ramps and merges
- recognizes and obeys traffic lights
- looks like other Cadillac SRXs

www.engineering.cmu.edu

Autonomous Vehicles

2007 GM Lab

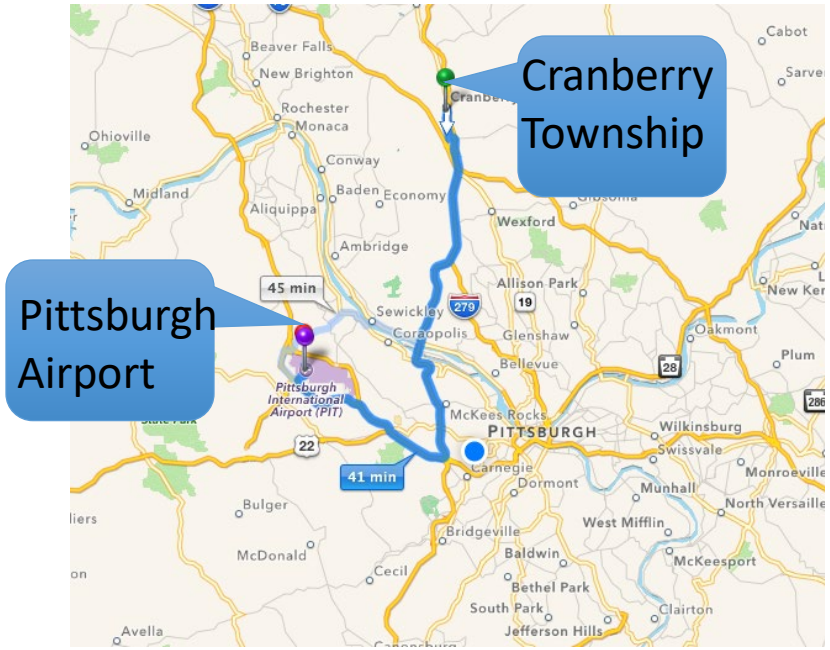
2012 GM Lab

Carnegie Mellon

Trunk Space

Pittsburgh Demonstration

9-4-14



33 miles along Route 19 in multi-lane, dense traffic with lights and two interstate highways

Connected and Autonomous Vehicles 2040 Vision

2014

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DEPARTMENT OF TRANSPORTATION

Report to the Citizens of Pennsylvania

Vehicle Automation in Pennsylvania

February 1, 2018

pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

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DEPARTMENT OF TRANSPORTATION

PREPARING for the FUTURE

- Stay Informed
- Understand the Implications
- Start Small & Work With Partners
- Develop a Plan

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DEPARTMENT OF TRANSPORTATION

AV Policy Task Force

- Government -

- PennDOT
- DCED
- Insurance
- City of Pittsburgh
- PTC
- PSP
- FHWA

- Advocacy -

- AAA
- ATA
- PMTA

- Academia -

- CMU
- U Penn
- Penn State

- Industry -

- Uber
- SAE
- GM
- Global Automakers

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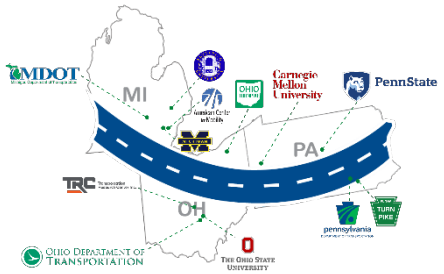
State Policy

- PennDOT Automated Vehicle Testing Guidance
- PennSTART Test Track
- Truck Platooning
- Regulations on Personal Delivery Devices
- Automated Vehicles Equipped with Truck Mounted Crash Attenuators

Local AV Policy

- The Pittsburgh Principles include (Pittsburgh 2019):
- Instituting transparent lines of communication between the City and partners testing autonomous vehicles, and annual reports on the implementation of AV policies
- Promoting automated driving systems that encourage high vehicle occupancy with lower or no emissions, and lower cost and equitable transportation options
- Engaging industry leaders and community stakeholders to collaboratively facilitate the further development and deployment of self-driving technology



Smart Belt Coalition

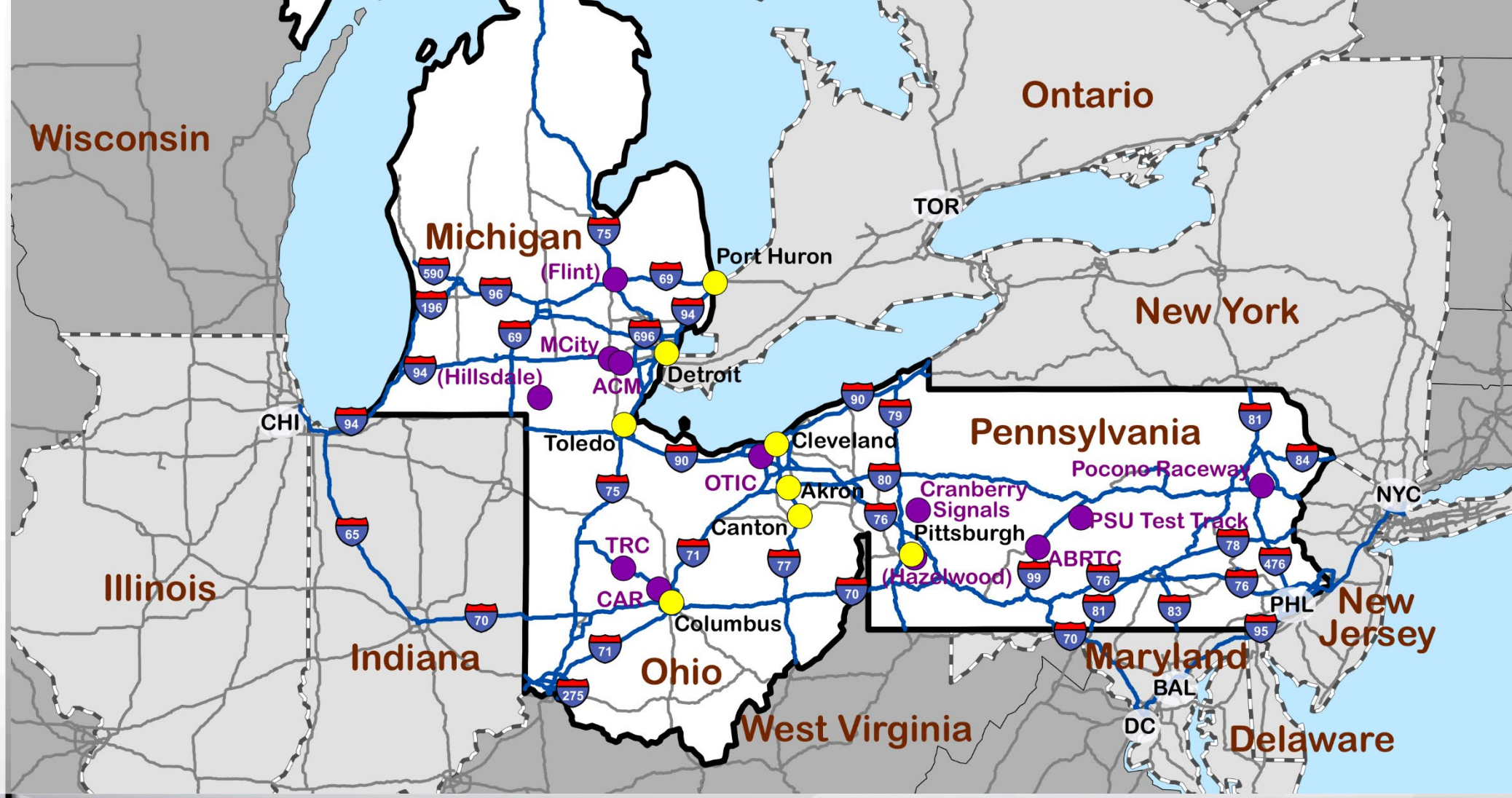
MDOT
Michigan Department of Transportation

OHIO DEPARTMENT OF TRANSPORTATION

OHIO TURNPIKE

pennsylvania
DEPARTMENT OF TRANSPORTATION

PENNA TURN PIKE



Smart Belt Coalition (SBC)

A Regional Connected and Automated Vehicle Collaborative

Purpose, Vision and Mission

Purpose

- The Smart Belt Coalition will organize for the economic benefit, safety, and welfare of the partner states.

Vision

- The Coalition's **Vision** is to be a multi-jurisdictional network that fosters the advancement of connected and automated vehicle technology.

Mission

- The Coalition's **Mission** is to create a mechanism for transportation agencies, academic institutions, and others to collaborate on connected and automated vehicle initiatives.

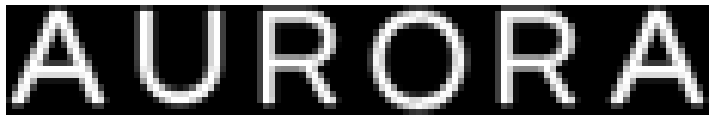
Members			Partners
State	Agencies	Research Affiliates	
Pennsylvania 	pennsylvania DEPARTMENT OF TRANSPORTATION; PENNA TURN PIKE	Carnegie Mellon University; PennState	Federal Highway Administration
Ohio 	OHIO TURNPIKE; OHIO DEPARTMENT OF TRANSPORTATION	THE OHIO STATE UNIVERSITY; TRC	
Michigan 	MDOT	Kettering University; MICHIGAN; American Center for Mobility	

Priority Applications

- Work Zones: Reservation and Traveler Information System
- Freight: Truck Platooning
- TIM: CV Applications
- Work Zones: Intelligent/Connected WZ Detection
- Freight: Truck Parking

Autonomous Vehicle Companies Testing in Pittsburgh

- Uber
- Argo AI
- Aurora
- Aptiv (Motional)
- Locomation



Early Levels of Automation Improving Safety

- According to a study by the Insurance Institute for Highway Safety, the crash involvement rate for vehicles with blind-spot monitoring was **14% lower** than the same models without the equipment.
- Corey Harper, a researcher at Carnegie Mellon University, says his analysis suggests the combination of vehicle crash avoidance technologies **reduces crash frequency by about 3.5%.**

“If vehicle crash avoidance technologies were deployed throughout the light-duty vehicle fleet, we could see **crash prevention cost savings of up to $264 billion**, assuming all relevant crashes are prevented,” he says.

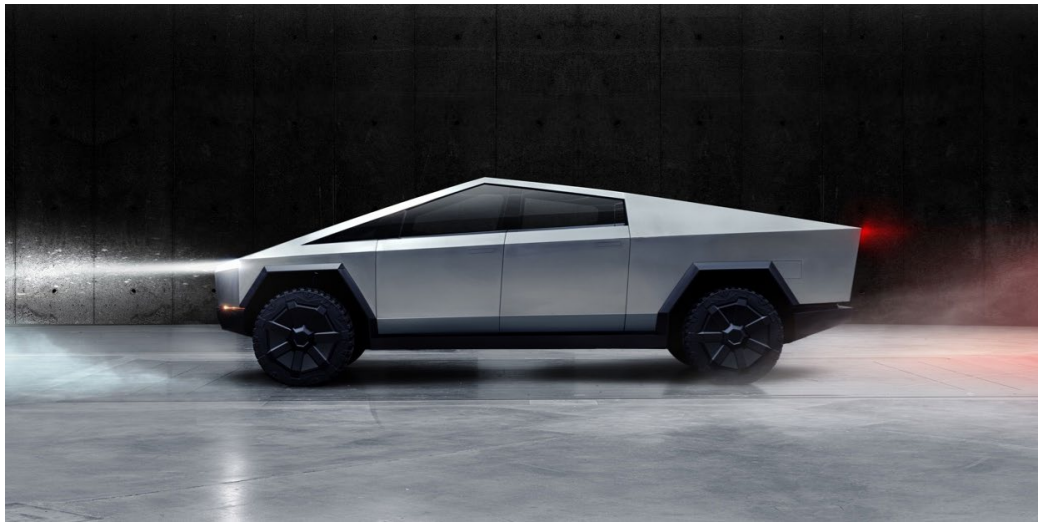
Race for Level 3 AV Commercial Deployment

Mercedes Benz Announces Plans for Industry First Level 3 Deployment, Pending Legal Approval

Tesla Auto Pilot Classified Between Level 2 and 3 But

“Very Close to Level 5”

Per Elon Musk



Industry Collaboration

- UL 4600 “Standard for Safety for the Evaluation of Autonomous Products”
- SAE Automated Vehicle Safety Consortium
- 5G Automotive Association
- PAVE – Partners for Automated Vehicle Education
- ADAS Standard Terminology AAA, Society of Automotive Engineers, Consumer Reports, JD Power and the National Safety Council

Continued Industry Shuffling

- *Mercedes Benz and BMW dissolve AV partnership*
- *Mercedes Benz partners with NVIDIA on AV platform*
- *Hyundai and Aptiv form Motional*
- *Yandex and Uber spin off AV unit*
- *VW breaks with Aurora*
- *Ford and VW partner on AV technology with ArgoAI*
- *Toyota invests in PonyAI*

Federal Government Initiatives

FHWA

Cooperative driving automation (CDA) enables automated vehicles (AVs) to communicate between vehicles, infrastructure devices, and road users such as pedestrians and cyclists.

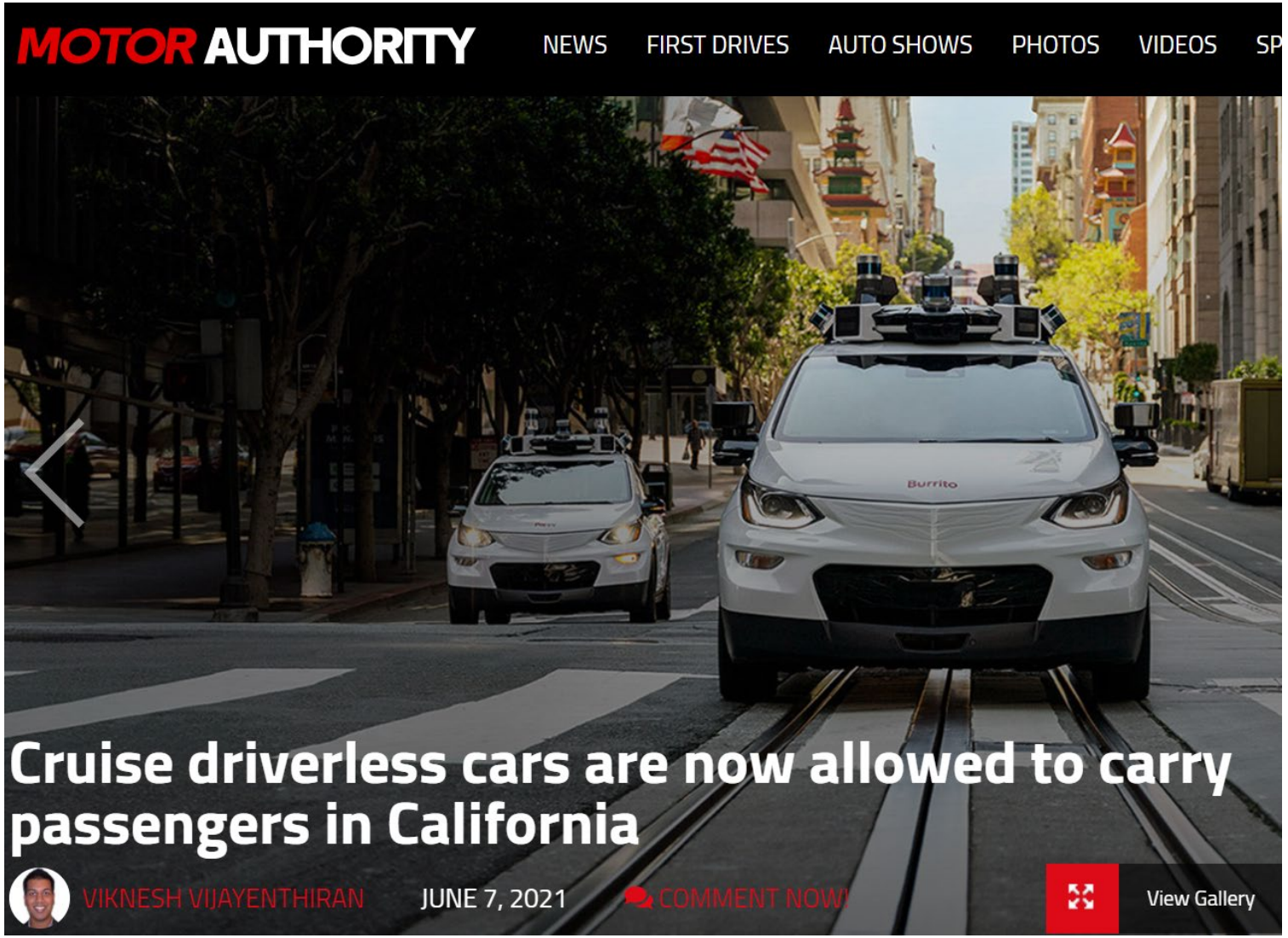
NHTSA AV TEST Initiative – Interactive web tool to track AV testing

US DOT Inclusive Design Challenge

US DOT AV 4.0 Assuring American Leadership in Automated Vehicle Technologies

FCC Reallocating 5.9 GHz Spectrum Reserved for Connected Vehicles

Business Model of Driverless Taxis



Shift from AV Taxis to Freight Delivery Via Cute Sidewalk Vehicles and Large Trucks

- UPS and Waymo Autonomous Van Package Delivery Testing
- Amazon Acquires AV Company Zooks for over $1 Billion

Autonomous Trucking

- **Daimler Trucks AV Testing Group partnering Torc Robotics** with developing Level 4 AV Truck with new facility in New Mexico
- **Waymo** testing heavy duty trucks in Texas
- **TuSimple** teaming with delivery and trucking companies to develop the first AV freight network. fleet of 41 autonomous-capable trucks are pulling 13 loads per day between Arizona and Texas.
- **FORU Trucking**, a technology logistics company, and **Trunk**, a service provider of autonomous driving technology for trucks
- **Locomation** On Road Testing Autonomous Relay Convoy Technology

Automated Vehicles Respond to COVID-19

- Columbus Re-launches EasyMile Leap Shuttle for Food Delivery
- GM Cruise Makes Food Bank Deliveries in San Francisco
- Nuro Delivering Medical Supplies in California
- Beep and Navya Delivering COVID-19 Tests at Mayo Clinic in Florida
- Neolix Delivers Medical Supplies in Wuhan and Disinfects Roadways

Infrastructure

- AV companies generally require quality line painting and legible signage.
- Connected traffic signals are an early CAV infrastructure.
- Dedicated Road Lanes from Detroit to Ann Arbor for Autonomous Vehicles
- Audi AG and Ericsson announced success upon wrapping up a three-year cellular vehicle-to-everything (C-V2X) real-world trial that first began in December 2016 in Germany.
- Qualcomm Partners with Hawaii DOT and the University of Hawaii to Extend the Deployment C-V2X Infrastructure Across Entire State

Why Now? – Enabling Information and Communications Technologies

Why Pennsylvania?- Research, Development and Deployment of Innovative Technology and Policy

Learning Assessment Questions:

- In addition to vehicle automation, provide an example of another technology disrupting transportation.
- Give an example of an automated vehicle industry trend.
- Identify a how state or local governments are addressing automated vehicle technology through policy.

Questions

stancaldwell@cmu.edu

http://mobility21.cmu.edu/

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