THE EASTERN TRANSPORTATION COALITION

CONNECTING FOR SOLUTIONS

Making Sense Of CAV Data:

How To Harness Today's Data For Tomorrow's CAV Deployments

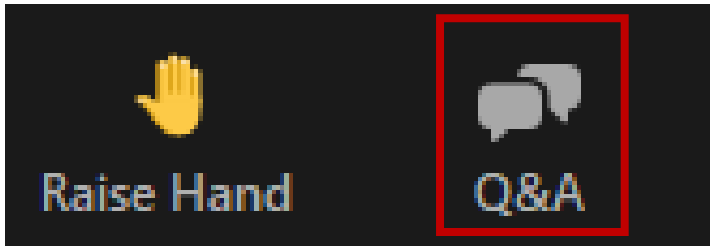
April 28, 2022

Welcome!

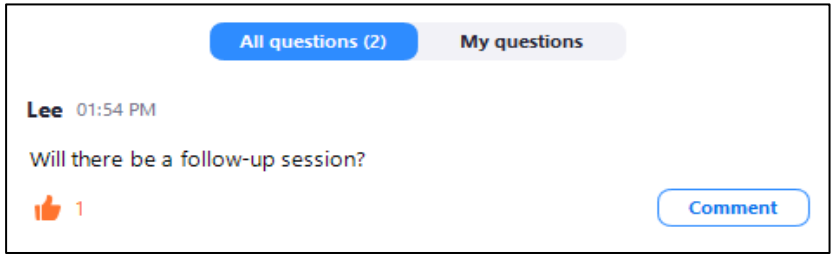
- We are using Zoom **Webinar**
- **AUDIO (Computer):** Use your computer speakers and microphone by clicking the “Join Audio” button at the bottom left of the screen. You will be muted.
- **Alternate Audio (Phone):** Call into the meeting by dialing the phone number based on your location (provided in the confirmation email) and enter the Meeting ID at the prompt. You will be muted.
- **This web meeting is being recorded.**
- **Questions** with the audio or web? Please contact Esther via email (ekleit@kmjinc.com)
- The **Chatbox** is not available to participants. Please use the **Q&A box** for questions to the presenters

Asking Questions in the Q&A Box

- Click on the Q&A icon at the bottom of your screen



- The questions in the Q&A box will be monitored and answered at the end of the meeting
- You can keep track of your questions in the “My Questions” tab in the Q&A box



Asking Questions Verbally

- Please raise your hand *(click on the hand icon at the bottom of the screen)*, and a host will unmute you.

- Please give your name and agency before asking your question
- **Please mute yourself when you are finished asking a question**

Welcome

Lisa Miller, Innovation Program Associate
The Eastern Transportation Coalition

17 States + D.C.

In the Corridor

For over 25 years, the Coalition has brought together public agencies across state lines and modes to work together to address pressing challenges.

Connecting for Solutions

More than I-95:

What We Do

In short, the Coalition helps agencies tackle the sticky issues and get solutions across the finish line.

1

PEOPLE

- Create a forum for public agencies to address transportation issues of common interest
- Establish a key network of transportation professionals
- Provide training (e.g., Freight Academy)

2

TOOLS & DATA

Support data acquisition and tool development

3

RESOURCES

- Compete for grants
- Extension of agency staff
- Partner with FHWA to explore policy implementation

THE COALITION STRUCTURE

EXECUTIVE BOARD
DOT CEOs

COALITION STAFF

STEERING COMMITTEE
& CO-CHAIRS

PROGRAM TRACK COMMITTEES

TRANSPORTATION SYSTEMS MANAGEMENT & OPERATIONS

VPP MARKETPLACE
DATA TOOLS & USER GROUPS
TRAVELER INFORMATION
TRAFFIC INCIDENT / EVENT MANAGEMENT
OPERATIONS ACADEMY

INTERMODAL FREIGHT

FREIGHT PLANNING
FREIGHT DATA & PERFROMANCE
TRUCK PARKING
FREIGHT ACADEMY

INNOVATION IN TRANSPORTATION

CONNECTED VEHICLES
MBUF
TOLLING RECIPROCITY
ELECTRIC VEHICLES

Coalition Update

RECENT

- **TIS Web Summit: Improving Safety - Implementing New Travel Information Services for Commercial Vehicles – March 17, 2022**
- **Building a Corridor Performance Summary Report: RITIS Workshop #1** - March 29, 2022
- **RITIS Product Enhancement Working Group Web Meeting** - April 6, 2022
- **New England HOGs – Using RWIS in Winter Operations** - April 7, 2022
- **Understanding Origin-Destination Data: RITIS Workshop #2** - April 8, 2022
- **Electric Vehicle Workshop** - April 12-13, 2022

ONGOING

- **FY2023 Strategic Planning** - April 2022 – June 2022 (Committee members only)

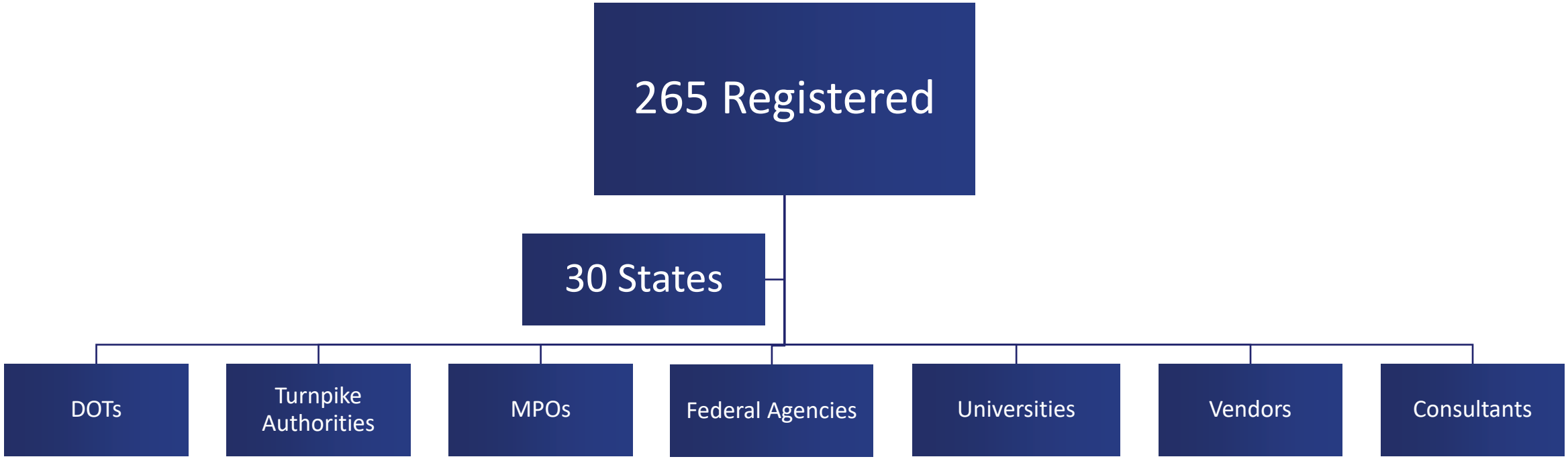
UPCOMING

- **RITIS User Group Meeting** - May 5, 2022
- **Potomac HOGs – Getting Better Information out to Travelers in Winter Operations** - May 11, 2022
- **TMC Operators Academy** – June 14-16, 2022 (Invite only)

Agenda

Topic	Speaker
Housekeeping Welcome & Update by the Eastern Transportation Coalition	Lisa Miller, Innovation Program Associate, The Eastern Transportation Coalition
Framing The Discussion About CAV Data	Lisa Miller
Speakers Introductions	Lisa Miller
VSI Labs AV Readiness Study Data	Peter Jager, CAV Engineer, Utah DOT
I-24 MOTION Test Bed	Lee Smith, Interim Director of Traffic Operations , Tennessee DOT Will Barbour, Project Manager, Vanderbilt University
Connected Vehicles: Privacy, Security, and Spectrum	Doug Gettman, Smart Cities and CAV Technology Solution Consultant, Kimley-Horn
Consumer Electronics Show – 2022 “An Engineers Tale – There and Back Again”	Stan Young, Chief Data Officer, The Eastern Transportation Coalition
Q&A/Discussion	Lisa Miller

The Eastern Transportation Coalition Sponsored Event



Framing The Discussion About CAV Data

Massive Amounts of Data

CAR AUTOMATION SENSORS		
Sensor type	**Quantity**	**Data generated per sensor**
Radar	4–6	0.1–15 Mbit/s
LIDAR	1–5	20–100 Mbit/s
Camera	6–12	500–3500 Mbit/s
Ultrasonic	8–16	<0.01 Mbit/s
Vehicle motion, GNSS, IMU	-	<0.1 Mbit/s

Fundamentals – State of the Industry

Data

The Coalition will sponsor one webinar or forum on a CAV data topic. Possible topics include:

- **CAV Data: What Is Out There and How Can State Agencies Use It?** This event would be designed to bring state transportation agencies together with data vendors and CAV technology providers to provide member agencies with an overview of what data are available and how they can be used and communicate to industry partners the use cases agencies would like to address.
- **Best practices in CAV data for transportation agencies.** This event would showcase leading efforts to use, store, access, and share CAV-related data acquired through vendors or generated through DOT infrastructure. The Coalition will wo working groups to generate a scan of existing data resourc

Infrastructure

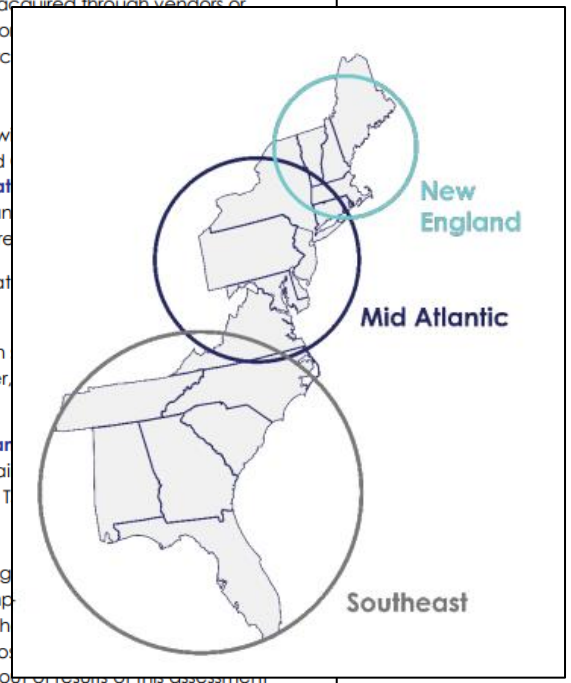
The Coalition will conduct a research project in partnership w Transportation, the University of Connecticut, and understand **lane striping requirements for automat** project is anticipated to develop an approach an adapted by other states or replicated in the future

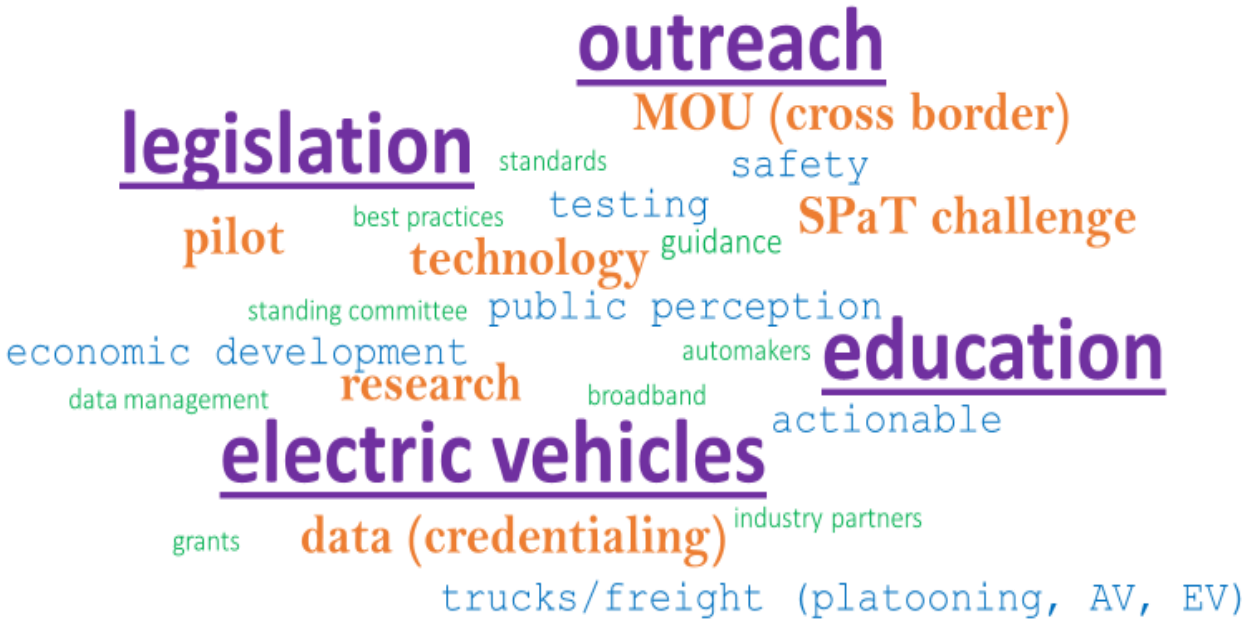
The Coalition also will conduct one webinar or workshop relat Possible topics include:

- **Communications infrastructure roles for DOTs**, focusing on partnerships around use of state DOT right-of-way for fiber, communications technology deployment.
- **Connected vehicle signals and maintenance practices ar** sharing strategies and agreements for managing and mai technologies. This event would be in partnership with the T

Legislation and Regulation

In FY21, the Coalition worked with New England CAV Working through the New England Transportation Consortium to comp **Policy Assessment for the New England Region**. Ph complete by the end of calendar year 2021; a po calendar year 2022. The Coalition will support rollou and explore opportunities to build off the approach and results for other regions.





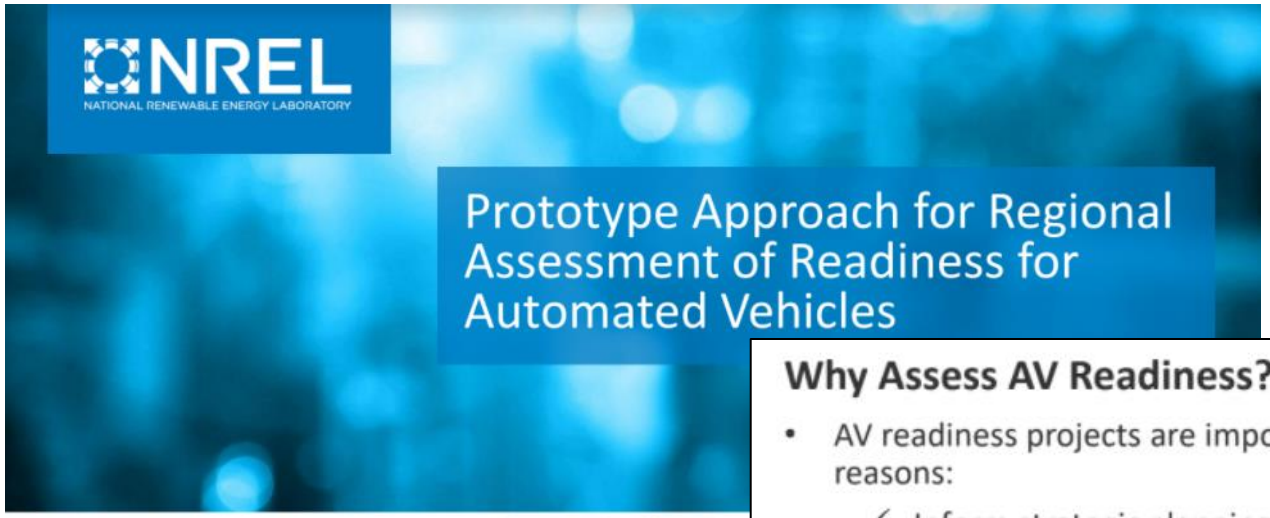
Labor Changes and Shortages

Mobility XX


MOBILITYXX
Empowering Women in Transportation
Empowers All Women
www.mobilityXX.org

Readiness Studies

Regional Assessment of Readiness



Views expressed in remarks or prepared materials by FHWA, US DOT-Volpe, NREL, Gannett Fleming, or The Eastern Transportation Coalition and its members do not constitute official policy of the USDOT.

THE EASTERN TRANSPORTATION COALITION

Why Assess AV Readiness?

- AV readiness projects are important for the following reasons:
  - ✓ Inform strategic planning and resource allocation.
  - ✓ Identify high value AV readiness projects.
  - ✓ Inform project development of currently planned projects to ensure inclusion of best practices.
- AV readiness projects also help inform other regional and national level projects:
  - ✓ Regional and multi-state corridor efforts.
  - ✓ AASHTO National Strategy for Transportation Automation.
  - ✓ FHWA National Roadway Automation Concept of Operations.

AV Readiness is not…

- Unnecessary.
- A crutch to make up for the technology shortcoming of AVs.
- Just V2I and pavement markings.

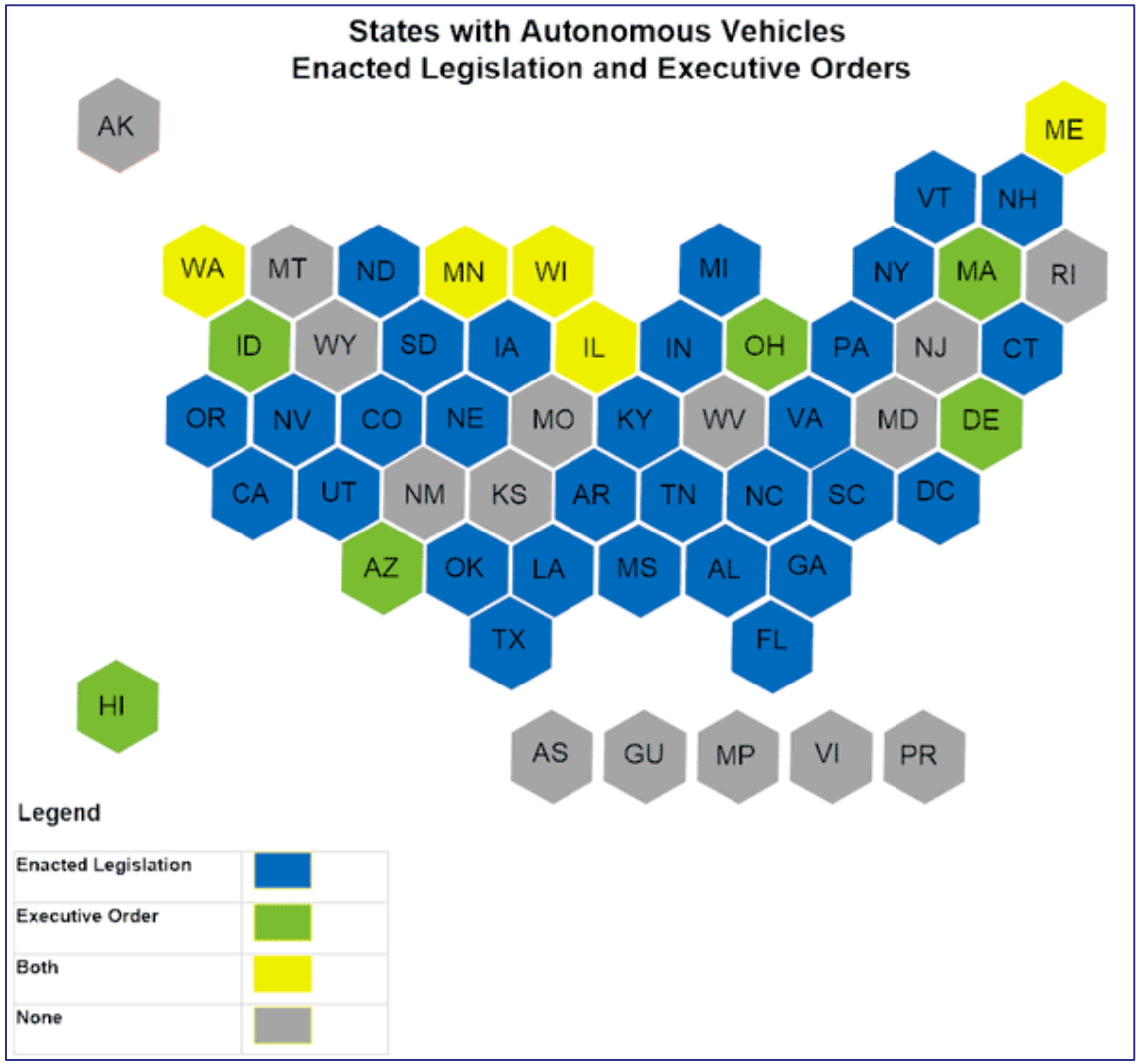
AV Readiness is about…

- Integrating AVs successfully into the transportation system to realize significant societal benefits.
- Leveraging their unique capabilities to better operate the system.
- Ensuring consistency and interoperability across jurisdictions.

Policy & Legislation

TOPICS

- [ ] All Topics
- [ ] Commercial
- [ ] Cybersecurity of Vehicle
- [ ] Definitions
- [ ] Infrastructure and Connected Vehicles
- [ ] Insurance and Liability
- [ ] Licensing and Registration
- [ ] Operation on Public Roads
- [ ] Insurance and Liability
- [ ] Licensing and Registration
- [ ] Operation on Public Roads
- [ ] Operator Requirements
- [ ] Other
- [ ] Privacy of Collected Vehicle Data
- [ ] Request for Study
- [ ] Vehicle Inspection Requirements
- [ ] Vehicle Testing



Outreach for CAV

"How do we know when a vehicle is safe enough to deploy? Driving is inherently risky. The important question is what is an acceptable level of safety? From the engineering standpoint, we've been calculating the level of risk for our entire profession by setting speed limits, etc. it would be incredible for safety if all roads had a posted speed limit of 5mph. There's logic behind every transportation decision we've ever made."
– Presenter, NIST webinar 03/2022

Goals

To further the agency's mission to plan, build and operate a safe, accessible, efficient and reliable multimodal system, the MnDOT CAV Strategic Plan developed goals for MnDOT's CAV program.

The action plan that follows in this document links each strategy to one or more of these goals.

SAFETY – Support deployment of CAV technology to improve safety and achieve Toward Zero Death (TZD) goals to eliminate traffic-related deaths

EFFICIENCY – Harness CAV technology to improve the efficiency of the transportation system for the movement of people, goods, and services

EQUITY AND ACCESSIBILITY – Use CAV technology to improve transportation equity and accessibility for all Minnesotans

ECONOMIC BENEFITS – Position Minnesota as a place to safely test and deploy CAV in order to advance public benefits and encourage workforce and economic development

TRUST AND UNDERSTANDING – Engage the public and other stakeholders to build trust and develop understanding of CAV

READINESS – Support MnDOT in preparing the organization to proactively address changes in transportation technology

SUSTAINABILITY – Emphasize CAV technologies that have the potential to promote environmental and fiscal sustainability

PUBLIC OUTREACH

Several public demonstrations were held allowing Minnesotans to see, touch and better understand CAV technology. Pilot projects were conducted to help Minnesotans, policymakers and industry understand how AVs adapt to Minnesota's cold weather climate, because a vast majority of the nation's testing is currently done in warm weather climates.

Automated vehicle exhibit at 2018 Minnesota State fair

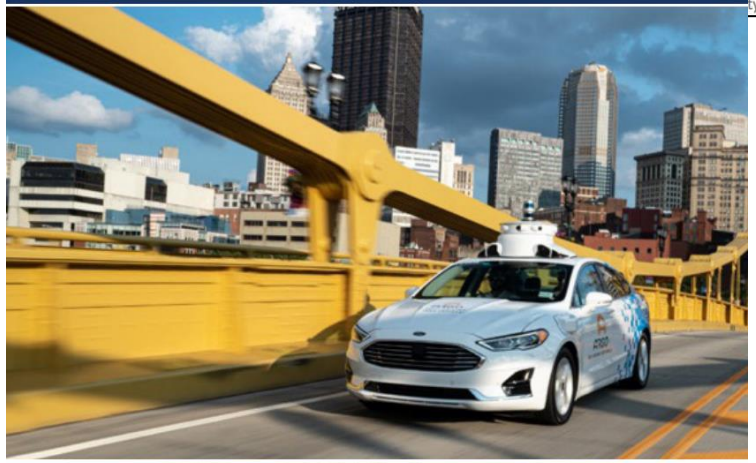
State Fair – In partnership with Polaris and AutonomouStuff, MnDOT debuted the first CAV exhibit at the Minnesota State Fair in August 2018. The exhibit included a level 4 automated shuttle to help the public learn about the technology and share feedback.

Governor's Advisory Council on Connected and Automated Vehicles – Alongside the CAV Strategic Planning process, MnDOT worked with the Governor's Advisory Council on Connected and Automated Vehicles (Advisory Council). In March 2018, Minnesota's Governor issued Executive Order 18-04 that established a 15-seat Advisory Council represented by members of business, labor, tribes, mobility advocates, public safety and others. The Council was required to draft a report by December 2018 recommending changes to state law, rule and policy ted to CAV. An Interagency CAV Team was also ted representing the state's executive agencies to aborate on CAV programs.

subcommittees were created focusing on policy s including equity, accessibility, infrastructure, enue, cyber security, insurance, land use, traffic y, driver's licensing and registration and others. More

FOREFRONT:

Securing Pittsburgh's Break-out Position in Autonomous Mobile Systems.



Performed for: Regional Industrial Development Corporation and the Greater Pittsburgh Chamber of Commerce, with funding support provided by the Richard King Mellon Foundation

Prepared by: TEConomy Partners, LLC

September 2021

RIDC

Greater Pittsburgh Chamber of Commerce

Introductions

Peter Jager
CAV Engineer
Utah DOT

Lee Smith
Interim Director of Traffic Operations
Tennessee DOT

Will Barbour
Project Manager
Vanderbilt University

Doug Gettman
Smart Cities and CAV Technology Solutions Consultant
Kimley-Horn

Stan Young
Chief Data Officer
The Eastern Transportation Coalition

VSI Labs AV Readiness Study Data

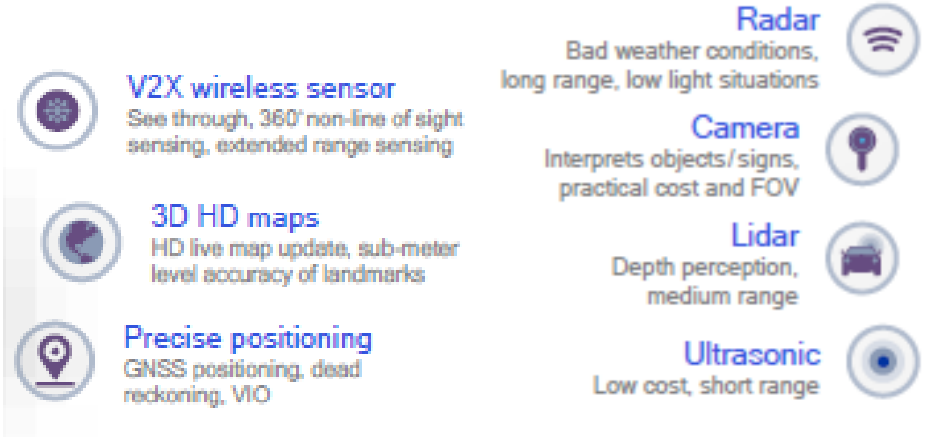
Peter Jager, CAV Engineer
Utah DOT

VSI Labs AV Readiness Study

Peter Jager, P.E., PTOE

UDOT Transportation Technology

April 28, 2022

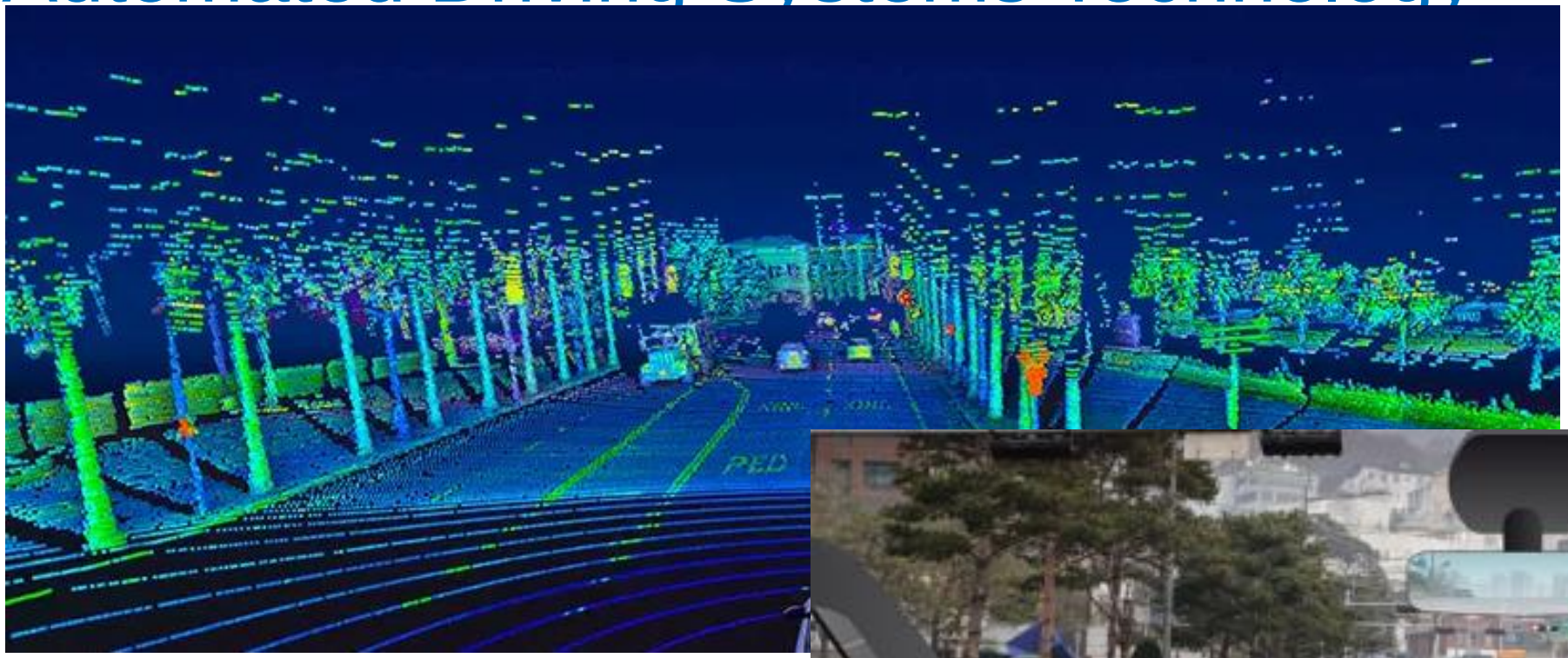


Automated Vehicles use various sensor technologies:

- GPS
- Radar Sensors
- LiDAR
- Digital Imagery (cameras)

. . . to sense their surroundings and take some (or all) driving functions from the human driver

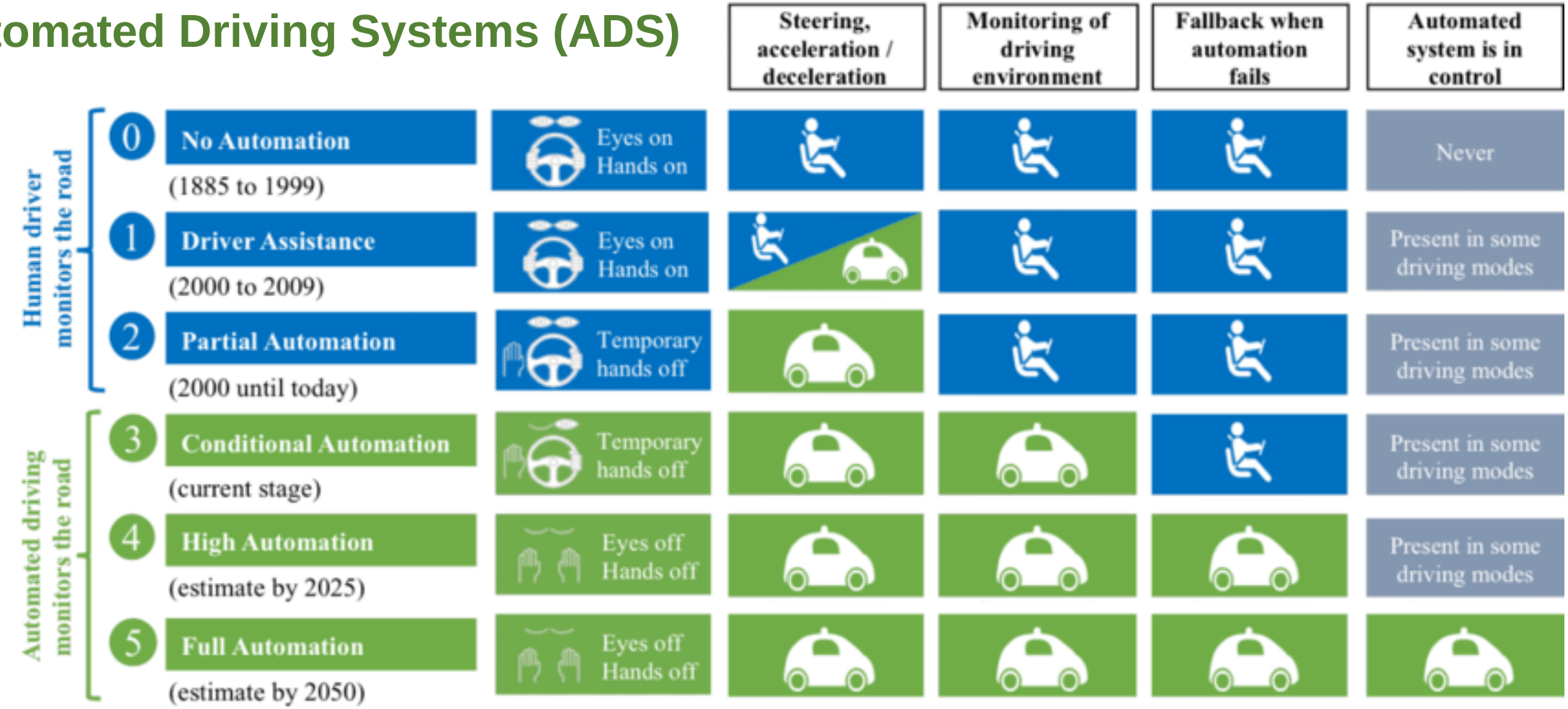
Automated Driving Systems Technology



Courtesy Velodyne LiDAR

Levels of Driving Automation

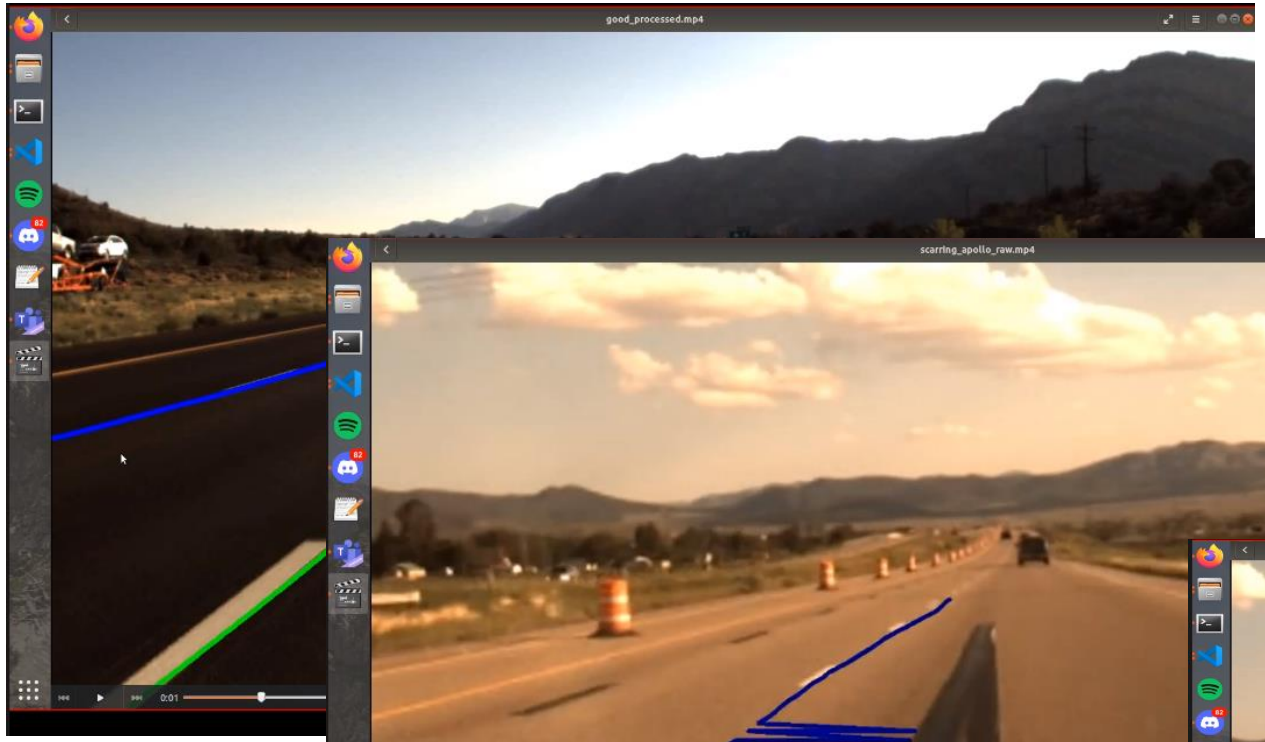
Automated Driving Systems (ADS)



Automated Vehicle Road Readiness

- Are UDOT's Roads Ready?
- What Will it Take to Be Ready?
- Issues to Consider:
  - Lane Markings
  - Signage
  - Lane Closure / Work Zone Information
  - Roadside Connectivity
  - Overhangs / Shadows

Automated Vehicle Road Readiness – Lane Markings



VSI Labs Evaluation

Contracted to evaluate three corridors for AV Readiness:

- I-15 from SLC to St. George
- US-89 from Salina to Spanish Fork
- SR-210 – Little Cottonwood Canyon

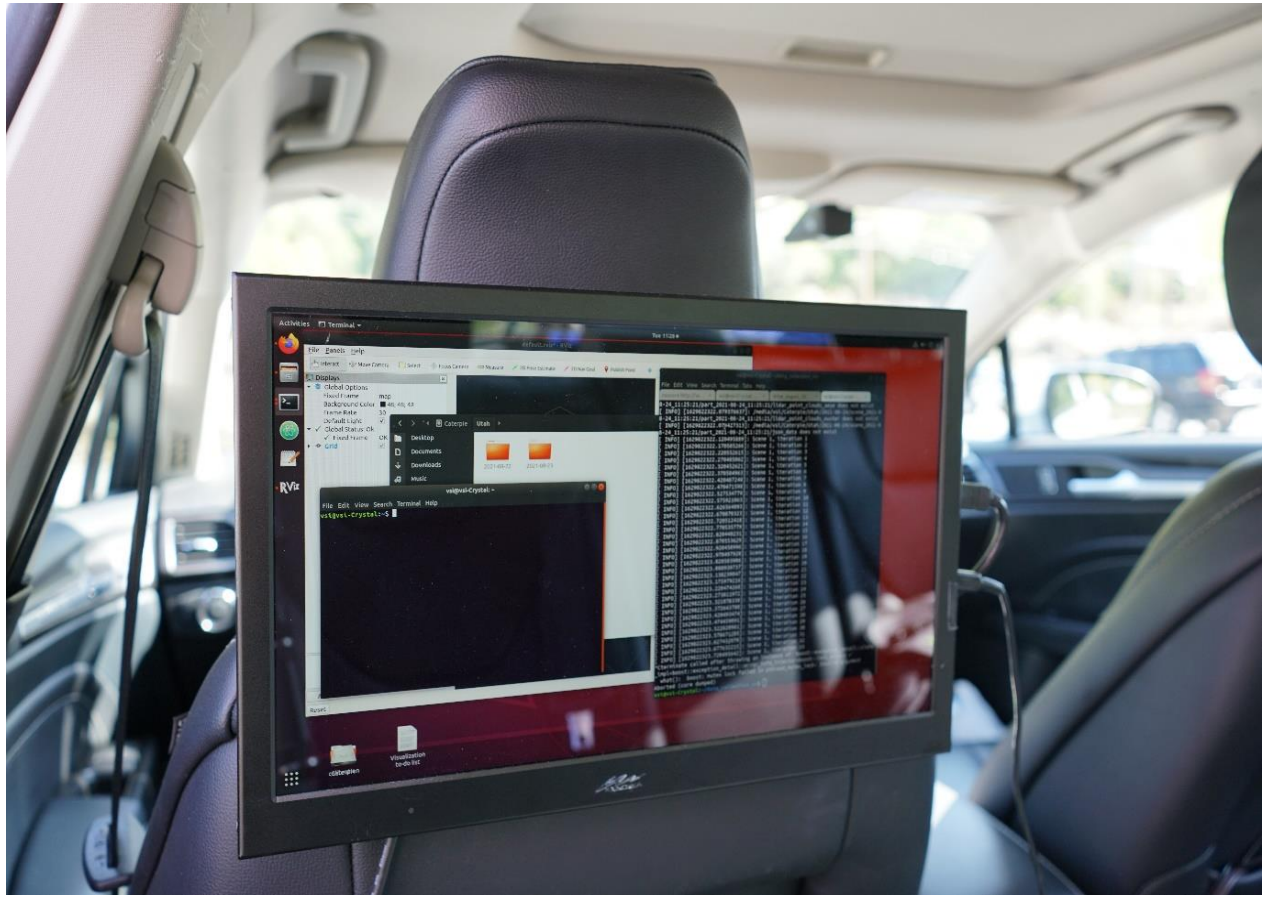
Survey Vehicles-August 2021

Methodology

Detailed survey of the routes with radar, lidar, multiple cameras and positioning systems

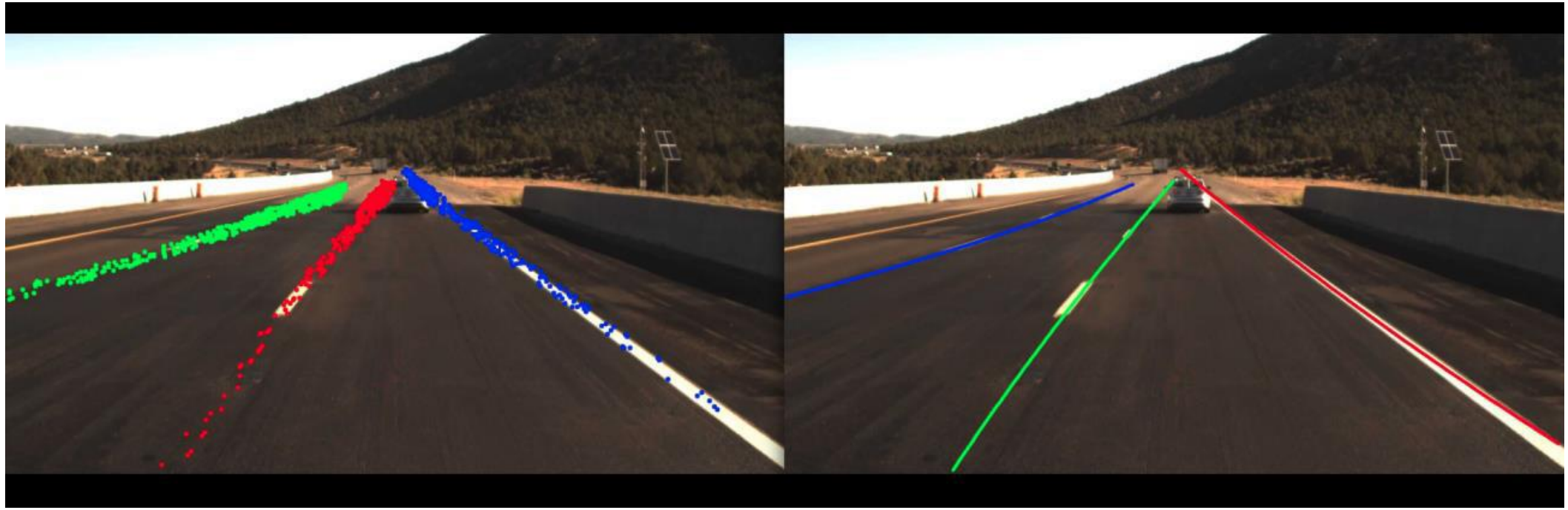
Tested against various automated driving algorithms.

Post processing examines the performance of LKA on the corridor.



Post Processing

- Lane detection based on AI using multiple points
- Polyfit and linear fit methods used to connect points to create lane lines



Step 1 -- Raw Points Detected

Step 2 -- Line Fitment

Data Samples

Pavement Change and Gap in Striping – SR-210

Location:

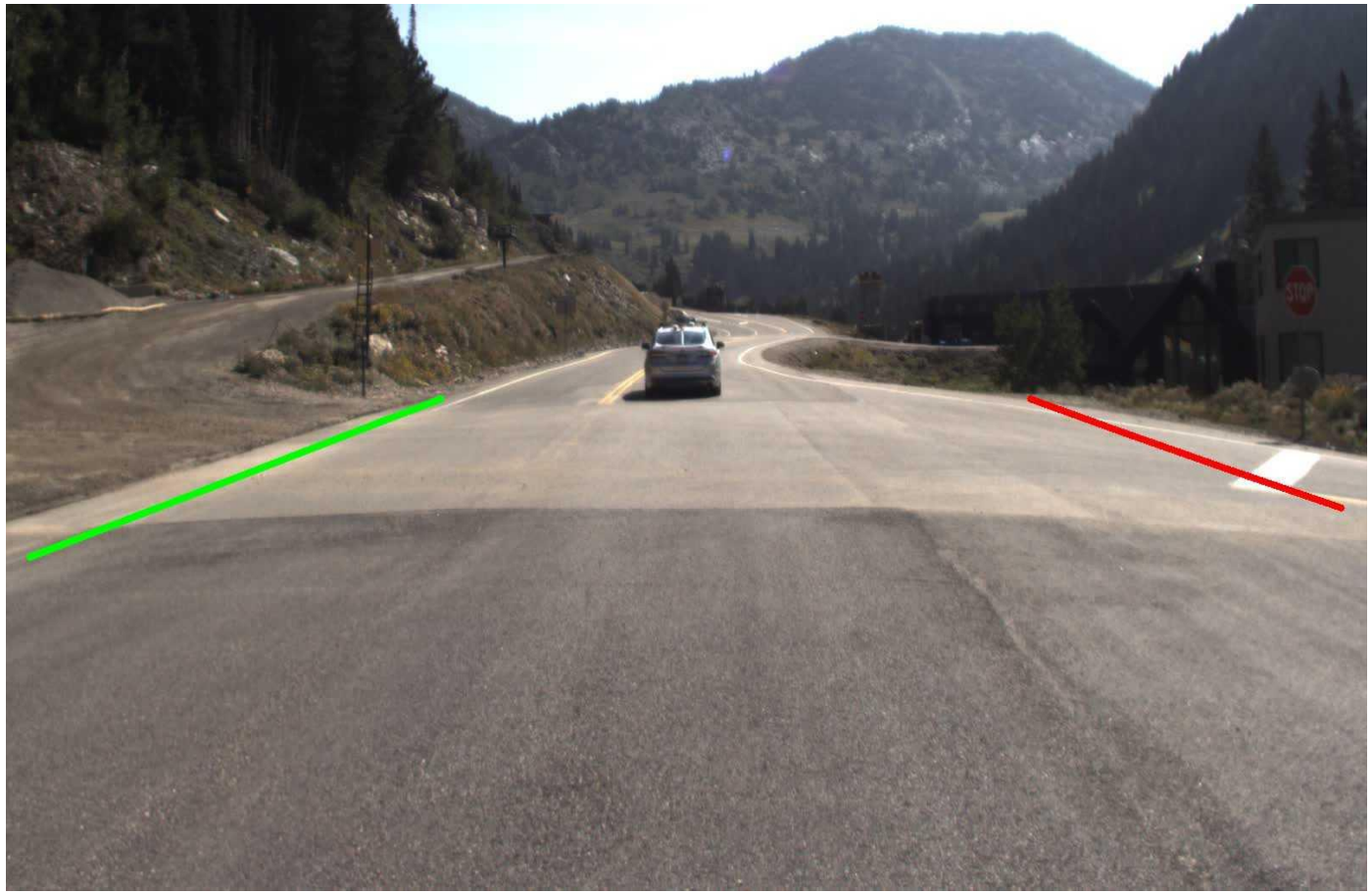
Alta

Situation:

Long gap for Bypass Road may lead to inadvertent move.

Recommend:

Dashed marker



Surface Change Issue – US-89

Location:
Entering Salina

Situation:
Surface change –tough contrast

Recommend:
Enhanced markers
LKA or automated driving not advised in this area

Tree Shadows – Urban Area US-89

Location:

Manti

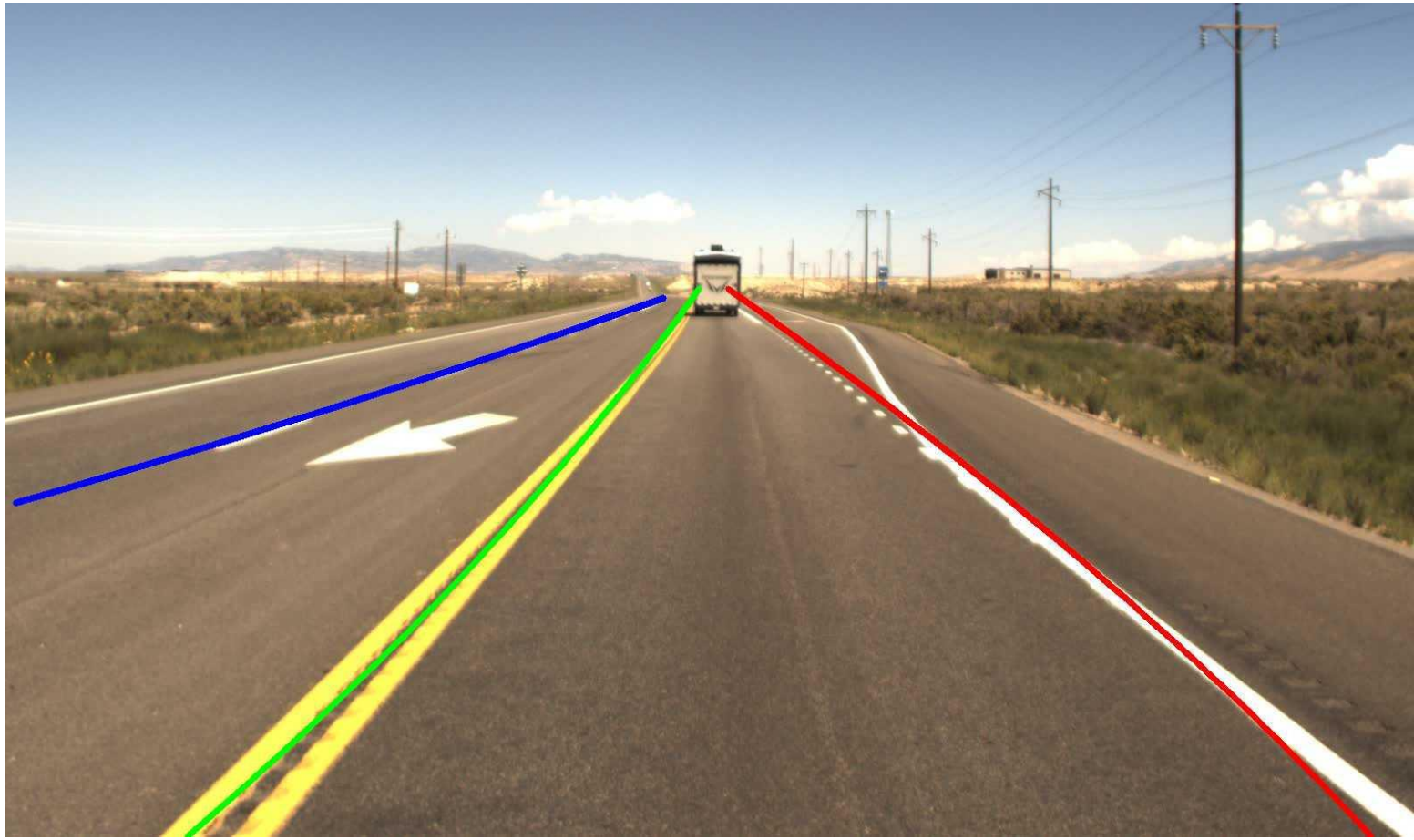
Situation:

Heavy shade cause LKA trouble due to contrast change

Effective Turn Lane Marking - Skip Line US-89

Location:
Redmond

Situation:
Perfect marking and proper dashed line for exit/right turn lane



I-15 – Faded Center stripe

Location:
Kanarraville

Situation:
Poor centerline – cannot detect for some frames

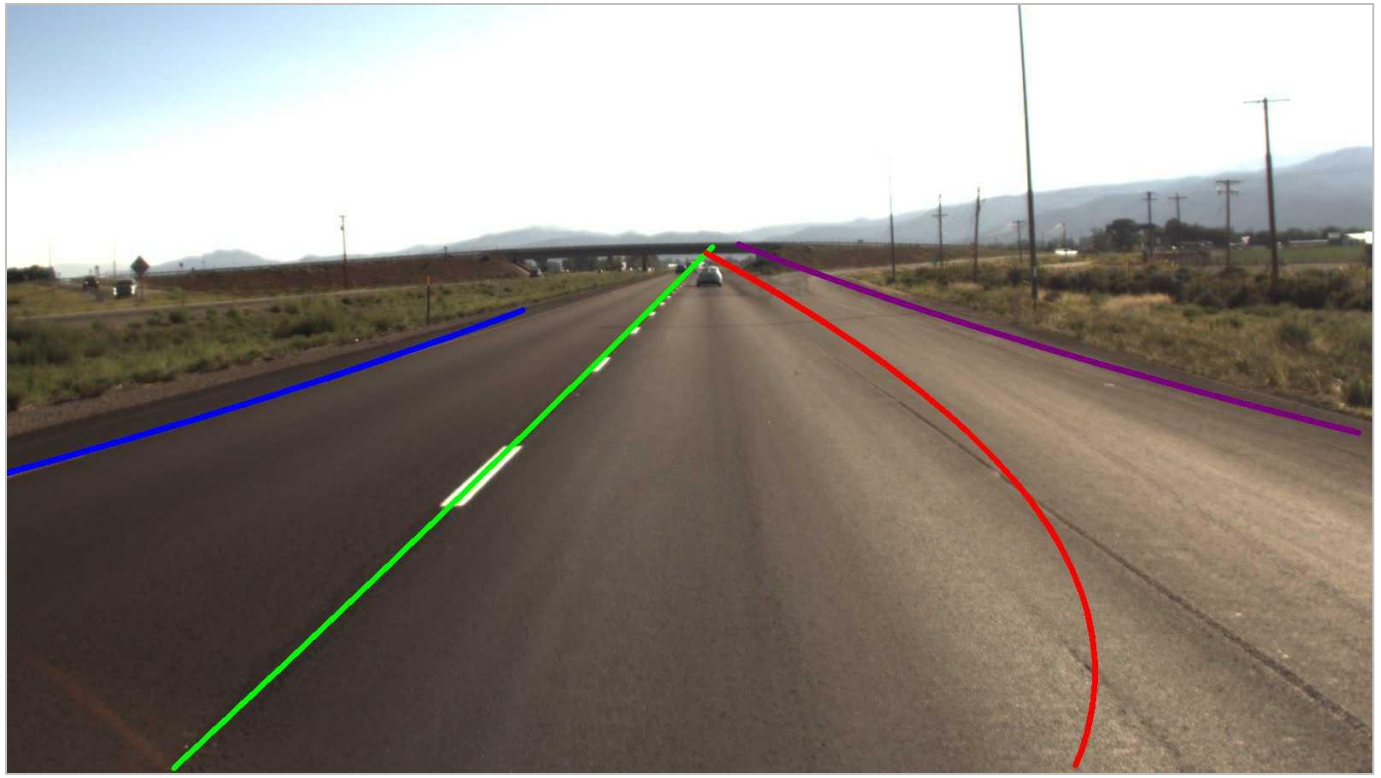
Recommend:
New centerline

I-15 Exit 75-Wide diverge point confusion

Location:
Iron County

Situation:
Exit 75 off ramp -- No dashed line

Recommend:
Add dashed line



I-15 Resurface – No markings yet

Location:
Paragonah

Situation:
Exit #82 No markings

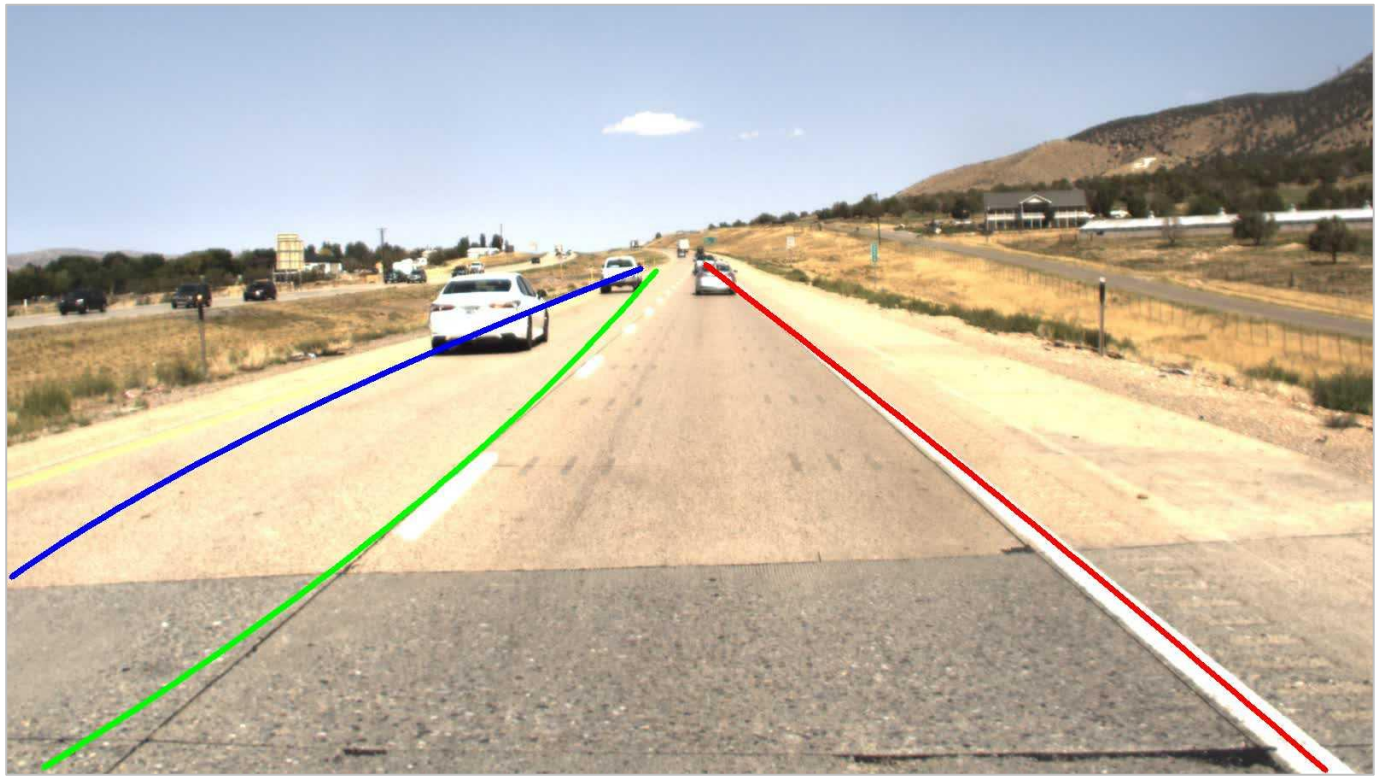
Recommend:
Add markings

I-15 – Surface Change- Low Contrast

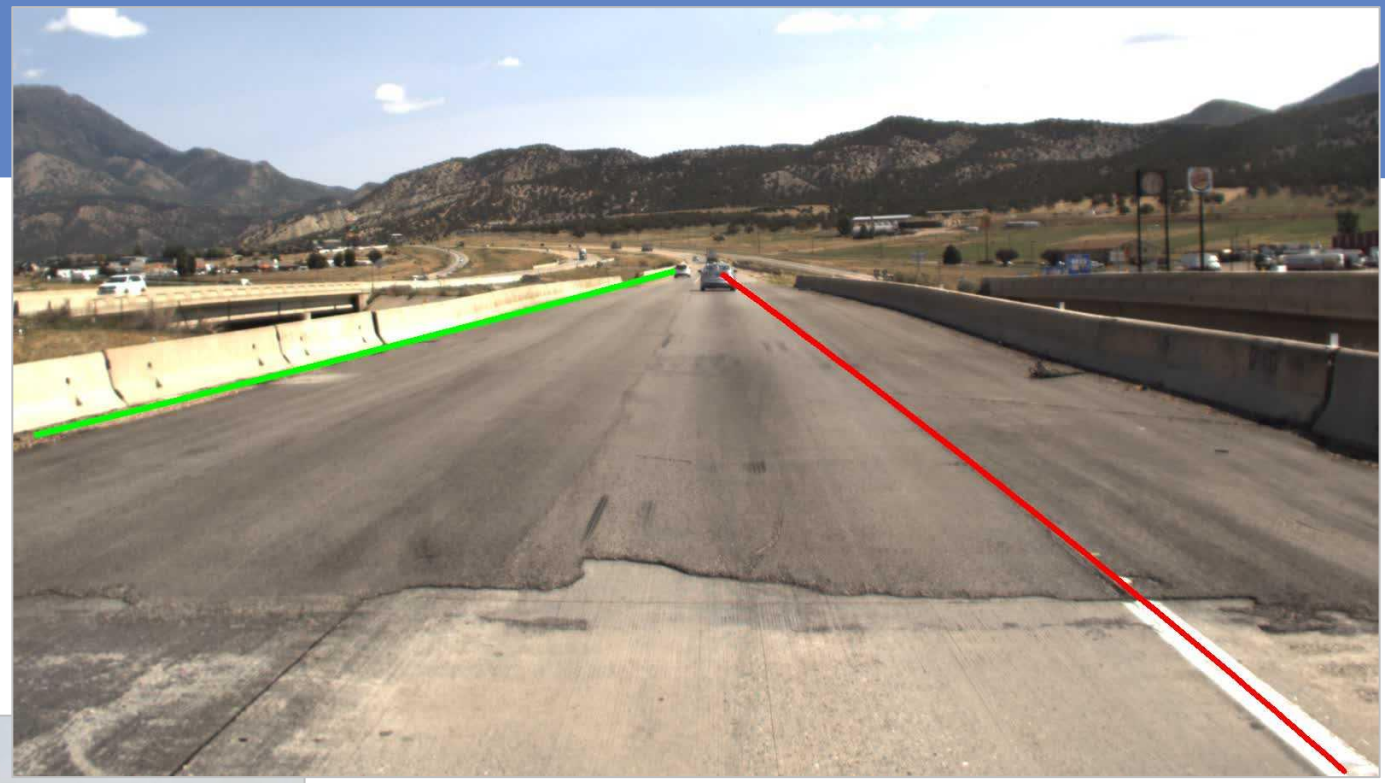
NB - Nephi Area

Situation:
Surface change, declining contrast leads to some misdetection

Recommend:
High contrast markers



I-15 Bridge Deck Resurface



Location:
I-15 Near Nephi (RT) Spanish Fork (Below)
Situation:
Bridge Deck - Surface change and faded markings
Recommend:
Short gaps like these are short enough for the system to stay straight to the next striping.

Concrete Pavement – Lack of Contrast

Location:
American Fork

Situation:
Poor markings

Recommend:
High contrast markers

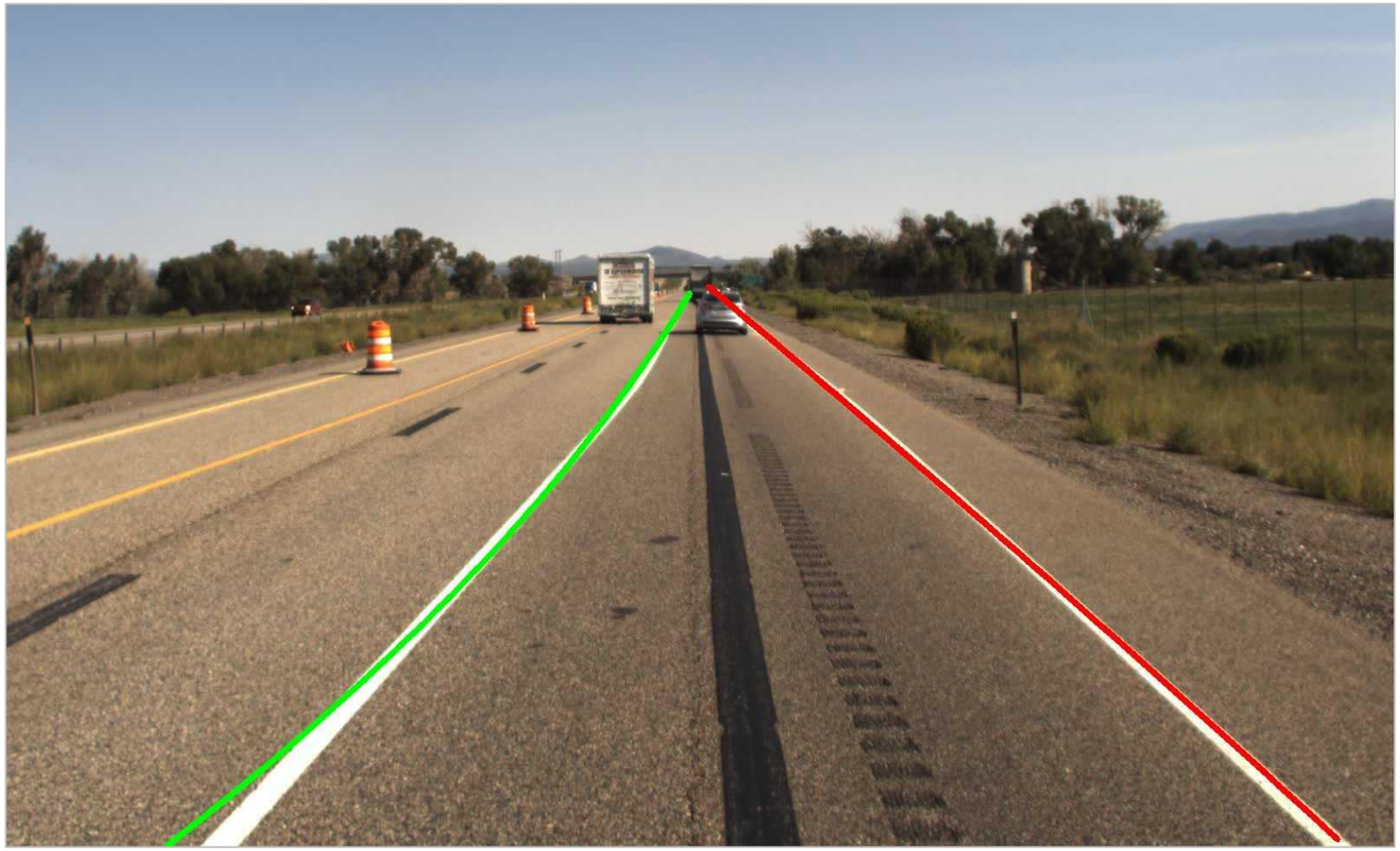
Temporary Striping I-15

Segment:

I-15 NB near Beaver

Situation:

Construction zone -- Temporary markers performed well, blacked out markings were ignored.

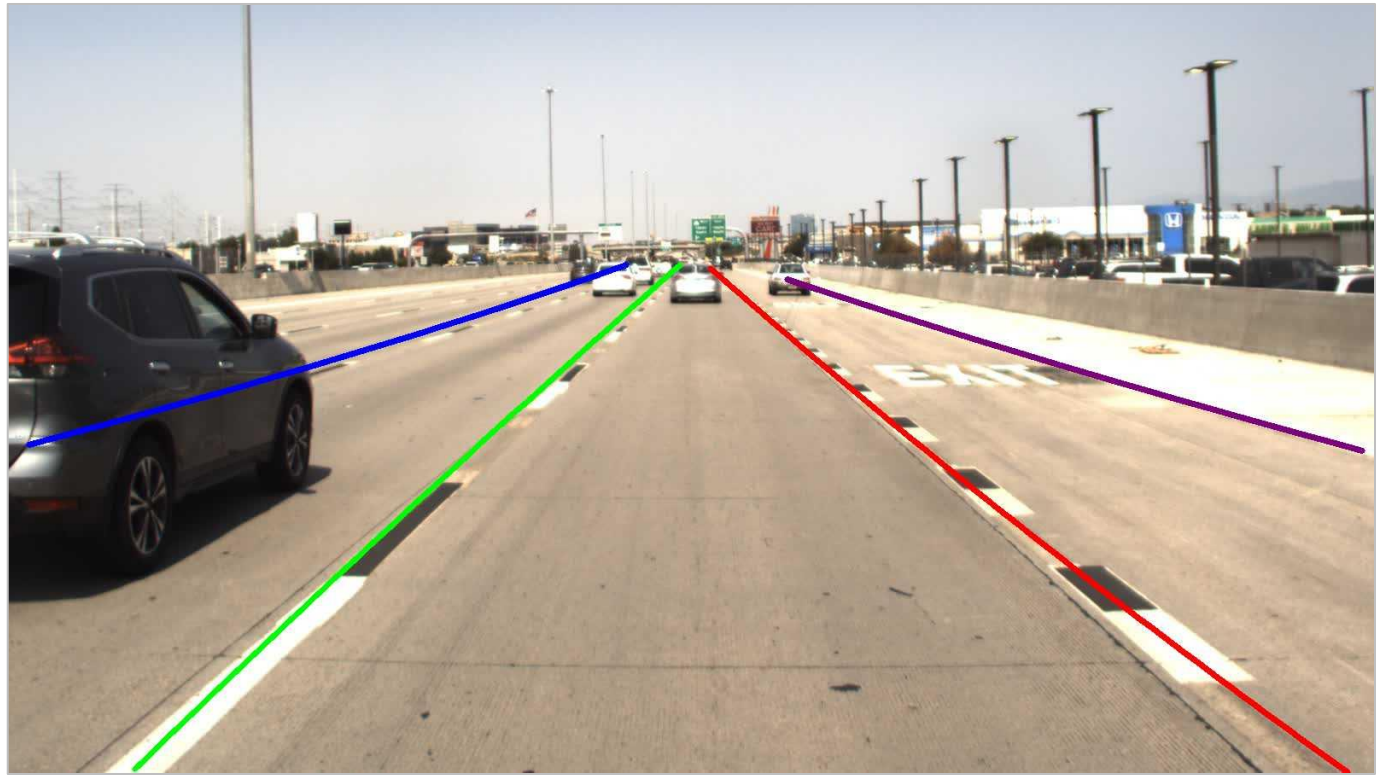


I-15 Tiger Tail

Location:
Sandy

Situation:
High contrast markers
Tiger tail

Recommend:
Very effective

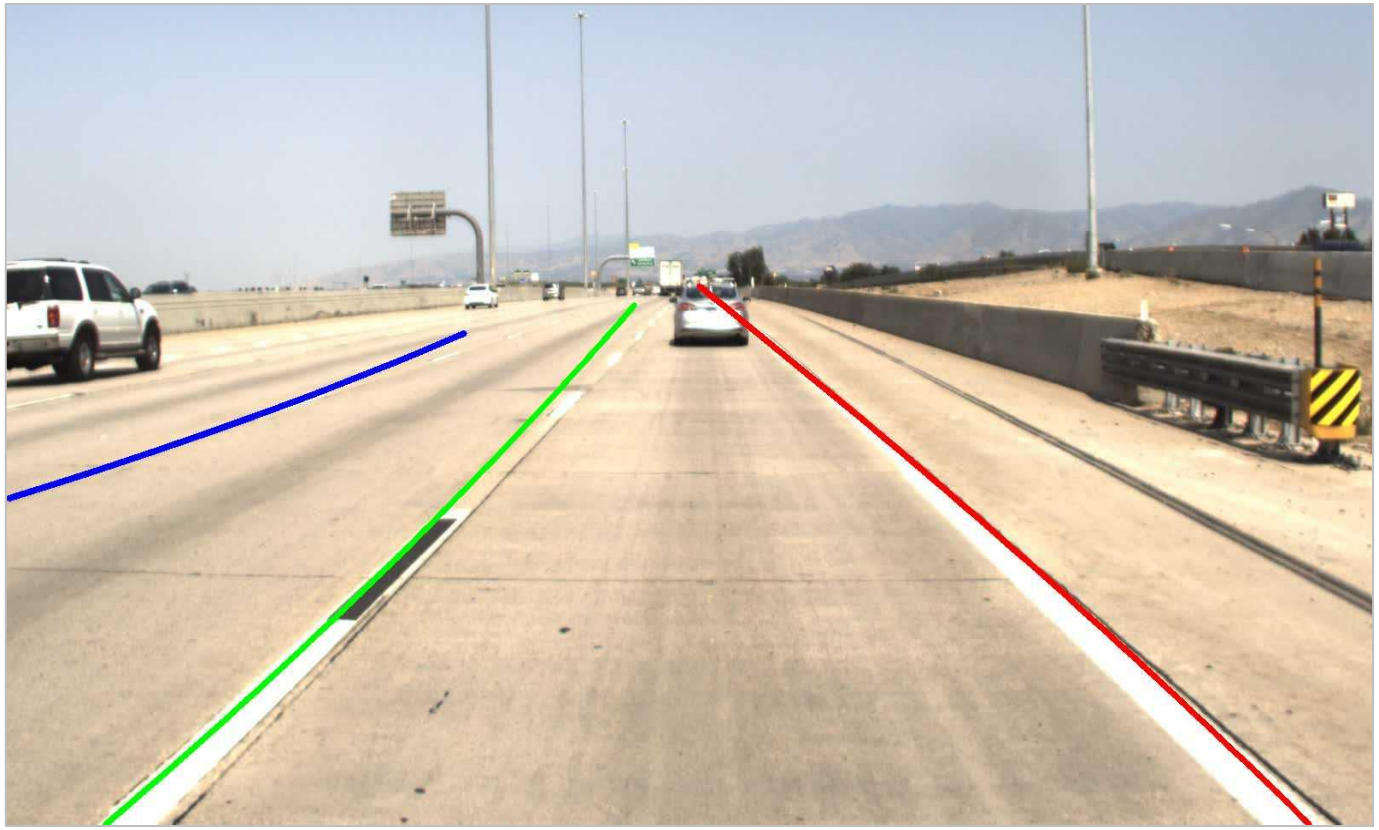


I-15 – End of Tiger Tail

Location:
Midvale

Situation:
Contrast Markings end and machine vision loses sight.

Recommend:
High contrast markers

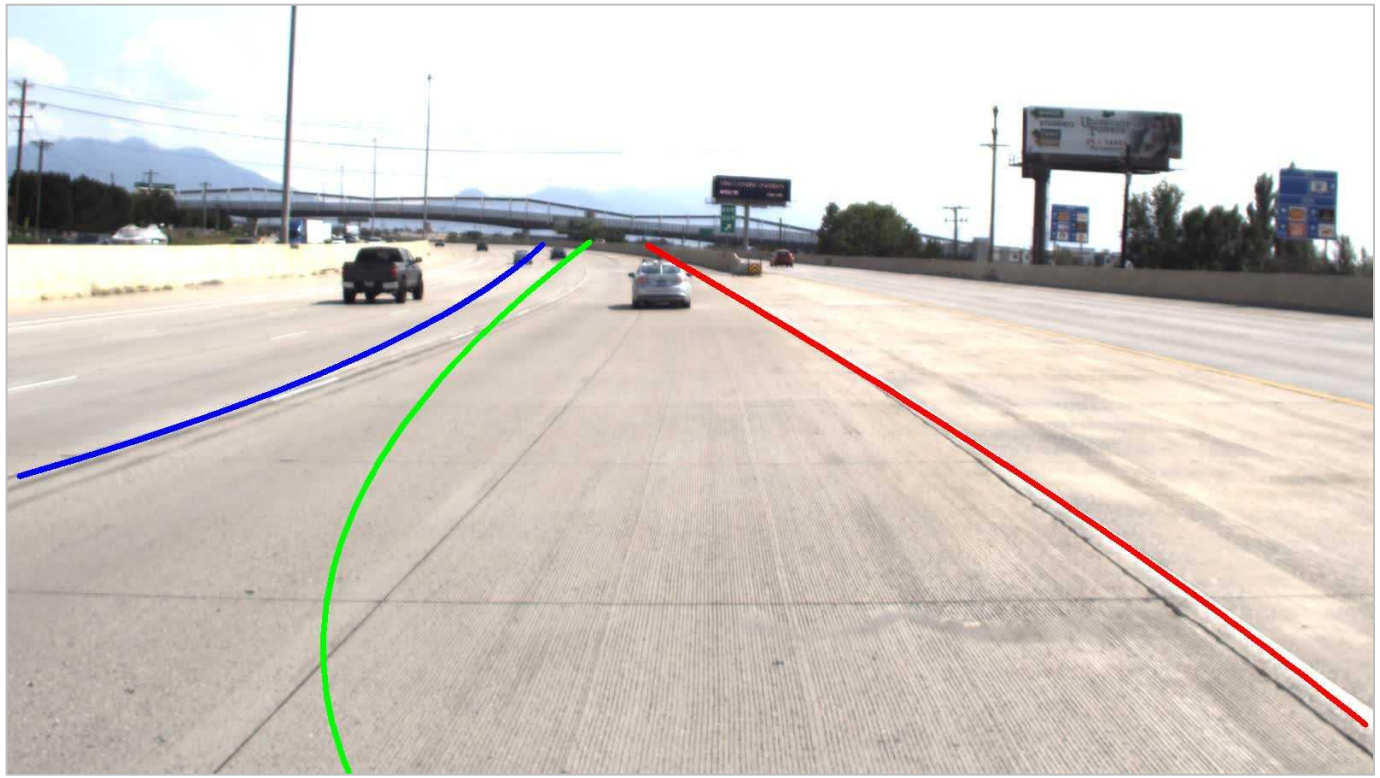


I-15 Diverge Area - Wide Gore offramp

Location:
I-15 SB Orem,
University Pkwy exit

Situation:
Double-lane offramp leaves a wide gap, machine loses sight.

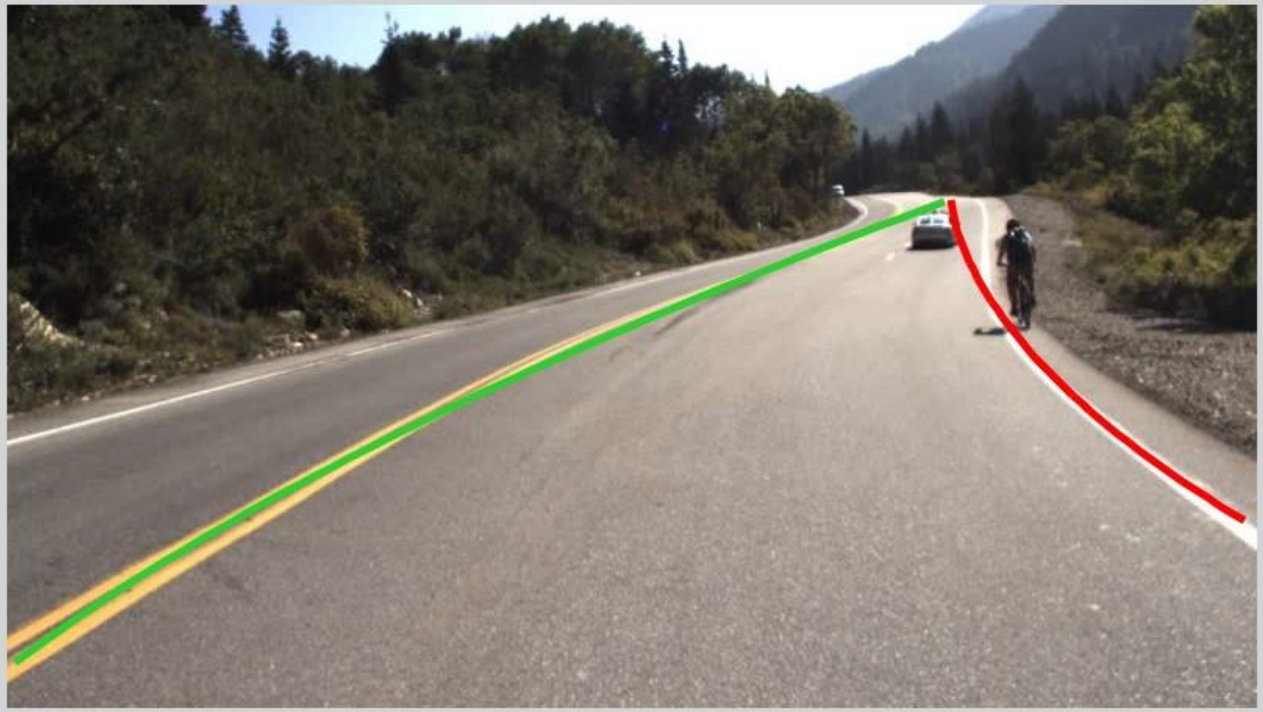
Recommend:
Markers

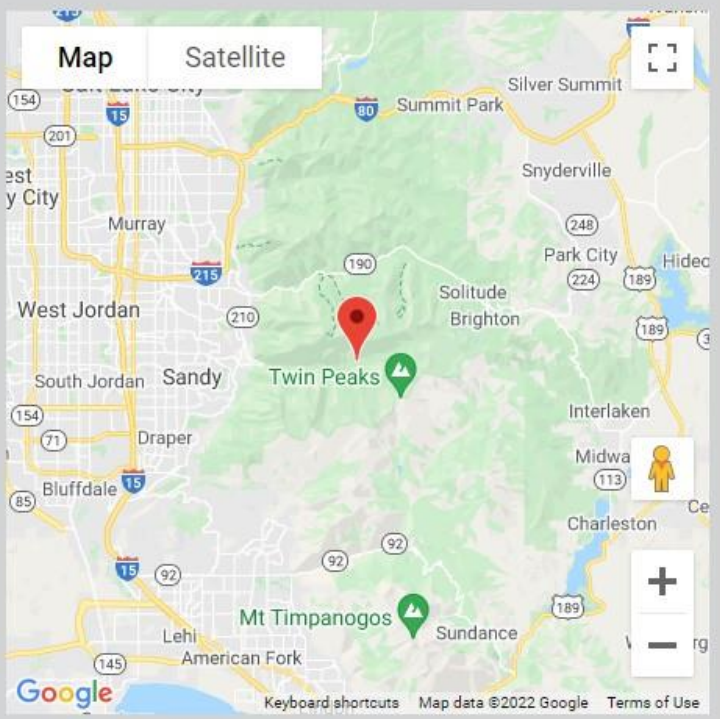


Data Tool Demo

VRU – Online Tool Demonstration

Use Keyboard Arrow Keys, Buttons, and Slider on Screen to Navigate Images





Jump Back 10

Tuesday, August 24, 2021 at 6:47:52 PM UTC

Jump Forward 10

Conclusions: I-15 Suitability

- I-15 is well suited for Lane Keeping Assistance (LKA).
- The route is generally suitable for an AV to travel, but there will still be disengagements at times.
- There are still gaps in detection of striping, but some are short enough not to disrupt the system.
- An updated HD map may correct deficiencies.

Conclusions – US-89 Suitability

- The system worked well overall, rural highways with good markings are well suited to LKA.
- The system disengaged frequently upon entering urban areas, so continuous use should not be expected.
- Tree shadows, varying pavement, and intersection controls were noted issues and could cause system disengagement.

What's Next?

Future Evaluations may include night driving or wet weather visibility

UDOT

Keeping Utah Moving

TRANSPORTATION TECHNOLOGY

https://transportationtechnology.utah.gov/

I-24 MOTION Test Bed

Lee Smith, Operations Engineer
Tennessee DOT

Will Barbour, Project Manager
Vanderbilt University

I-24 MOTION Test Bed

Lee Smith
Interim Traffic Operations Division Director
Tennessee Department of Transportation

Will Barbour
Research Scientist
Institute for Software Integrated Systems
Vanderbilt University
https://barbourww.github.io

1

1

Motivation and background

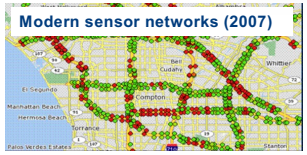
4/27/22

2

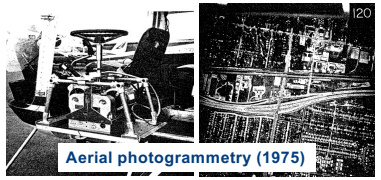
Transportation is driven by and validated by experimentation and sensing

Traffic via video camera (1935)

First sensor network for estimation & control (1969)



Modern sensor networks (2007)



Aerial photogrammetry (1975)

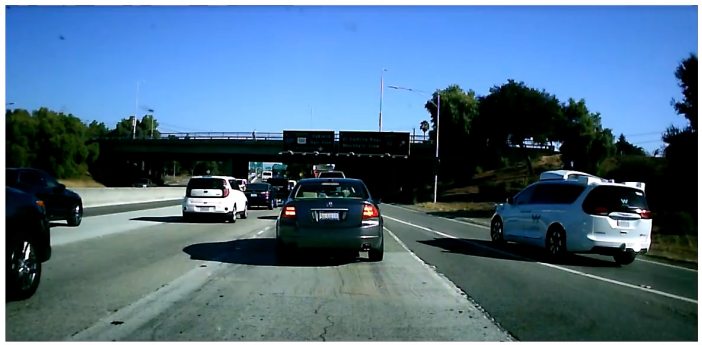
Mobile phone based monitoring (2008)

[Greenshields 1935; Treiterer 1975; Gazis et al. 1970; PeMS 2007; Herrera et al. 2010]

3

3

Connected and automated vehicles – new needs for understanding traffic



[https://www.youtube.com/watch?v=HjtiiGCe1pE]

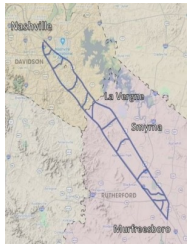
4

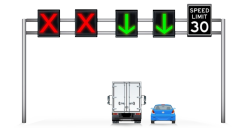
4

How do drivers respond to active traffic management?

I-24 SMART Corridor project

- Integrated corridor management across 28 miles of I-24 and 29 miles of SR-1, using 30 miles of connector routes.
- Physical improvements consisting of:
  - Extended ramp lengths
  - Emergency pull-offs
  - Ramp meters
  - Variable speed limits
  - Lane control system
  - Signal optimization and control
  - Additional digital messaging
- Coordination powered by an AI-based decision support system





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6

I-24 MOTION

Traffic instrumentation and testbed facility

7

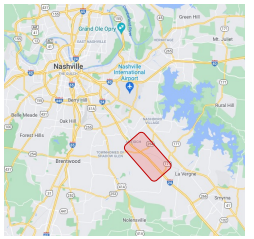
I-24 MOTION (Mobility Technology Interstate Observation Network)

Vision: Create the premier, globally-recognized on-road testbed for:

- Ultra-high-resolution traffic observation.
  - Driver behavior, safety studies, traffic waves.
- Integrated corridor management.
- Real world *connected and autonomous vehicle* (CAV) deployments.
  - Vehicle interactions, truck platooning, etc.

Innovation:

- Dense installation of 4K resolution video cameras and modern computer vision algorithms on I-24.
- Four miles of continuous camera coverage observing all vehicles.



8

8

Experimentation and demonstration capabilities

Testbed collects anonymous vehicle trajectory data from daily conditions useful for traffic science, but also allows for targeted experimentation and demonstration.

TDOT envisions opportunities to pursue mutually beneficial uses of the testbed with industries such as:

- Automotive Original Equipment Manufacturers and Suppliers
- Researchers
- Traffic Simulation Software Developers
- Freight and Logistics Operators
- Infrastructure Owners
- Intelligent Transportation Systems (ITS) Product Manufacturers
- Enterprise Networking and Data Solution Providers

Source: FHWA

9

9

What's coming online for I24 MOTION

2006 NGSIM (California)

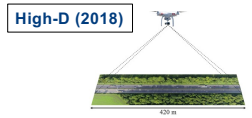
- 1,800 vehicle miles traveled (I-80)
- Backbone of the traffic simulation community.

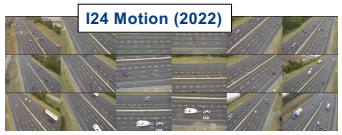
2018 High-D (Germany)

- 25,000 vehicle miles traveled.

2022+ I-24 MOTION

- 200,000,000 vehicle miles traveled/year.
- Ongoing year after year.
- Persistent sensing captures full spectrum of traffic, plus rare events.
- **Trajectory data feed publicly available.**





10

10

I-24 MOTION: Milestones in 2020-2021

- System Engineering Analysis Report (SEAR)
  - Completed and approved by FHWA.
  - Project eligible for federal funds.
- 3-Pole Validation System
  - Prototype and testing of 6-camera pole system.
  - Constructed completed August 2020 and operational September 2020.
  - Data sample generated.
- CMAQ Grant (awarded March, 2021: $11M)
- Began business plan development
  - Researched funding and ongoing partnerships.
  - Interviews with existing testbed owners and operators.
- Data model and management plan

11

I-24 MOTION Validation system construction

https://youtu.be/k8ADU8uZIz8

12

The “Beetle”: enabling 6 cameras per pole

- Height of poles necessitates camera lowering device.
- Effectively need to pass through power and ethernet for six cameras = 1+ Gbps CLD from MG^2.
- CLD + Beetle uses redundant connections for power and ethernet to bottom of pole, and PoE-injecting ethernet switch between cameras.

Beetle designed by Jeffrey Watson and the team at MG Squared. See their booth at ITSA for more information.

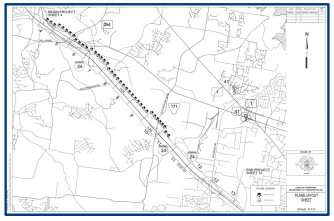
13

13

I-24 MOTION: Progress in 2022

Construction of 4-mile section is underway.

- Site selection and design completed.
- Equipment selection and procurement complete.
- **40 new poles (110-135’ tall), 276 new cameras.**
- 6x dual-CLD/Beetle poles (=12 cameras/pole) at interchanges to collect data on highway and interchange ramps simultaneously.

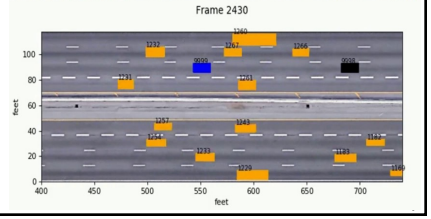


14

14

Trajectory processing algorithms

- Generate high-precision 3D bounding boxes for all vehicles within view on each video frame (30 fps).
  - 3D boxes give footprint and height of vehicles.
- Vehicles tracked between frames to generate time-space trajectories.
- Coordinate transform from image to roadway reference.



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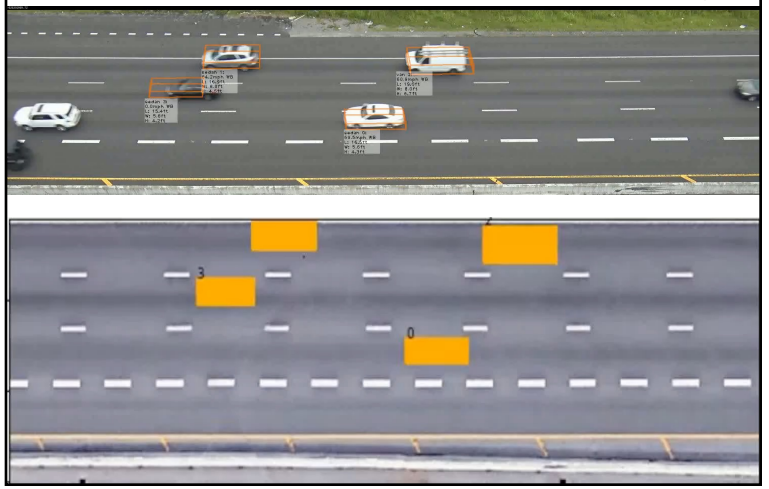
Trajectory processing algorithms



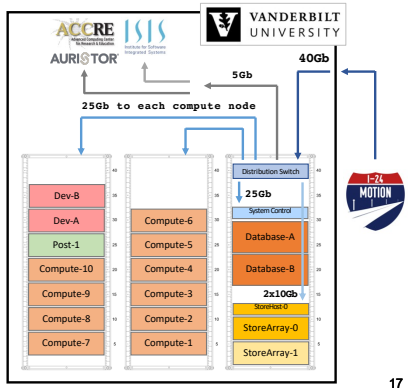
16

16

Computing architecture to support I-24 MOTION

- A centralized compute cluster is responsible for processing video from 300 cameras into complete, anonymized vehicle trajectories.
- Video processing algorithms are deep-learning based, requiring GPU computation and communication between parallel processes.

Estimated data quantities:
- 31 PB/year video processed (not stored)
- 11 TB/year trajectories shared



17

17

Congestion Impacts Reduction via CAV-in-the-loop Lagrangian Energy Smoothing (CIRCLES) UC Berkeley Prime, funded by U.S. DOE

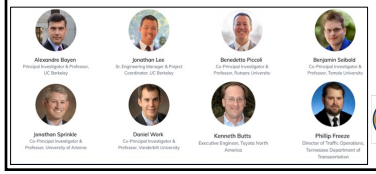
Measurement methodology:
- **On-board data gathering** for a few immersed sensing vehicles (1%-4% of all);
- 4k multi-camera data of the entire traffic flow.

Metrics:
- **Instantaneous fuel usage** (direct or model-based) translated into energy
- Additionally: acceleration, velocity, vehicle spacing, position behind control vehicle translated into other traffic flow characteristics

Validation:
- Correlate immersed sensing data to camera data for **vehicle dynamics and energy** (via fuel models).

Without control: more stop-and-go, more fuel used. Some cars directly measured, all vehicles estimated

With control: more uniform flow, less fuel used. Only some cars controlled/measured, all vehicles estimated



45+ researchers
5 universities, TDOT, and 3 OEMs

18

18

I-24 MOTION Test Bed

Lee Smith
Interim Traffic Operations Division Director
Tennessee Department of Transportation

Will Barbour
Research Scientist
Institute for Software Integrated Systems
Vanderbilt University
https://barbourww.github.io

19

19

Connected Vehicles: Privacy, Security, and Spectrum

Doug Gettman, Smart Cities and CAV Technology Solutions Consultant
Kimley-Horn

LEARN. COLLABORATE. SHARE. ENERGIZE.

Kimley»Horn

SMART CITIES TECHNOLOGY FORUM

Connected Vehicles
Privacy, Security, and Spectrum

April 2022

Douglas Gettman, Ph.D.

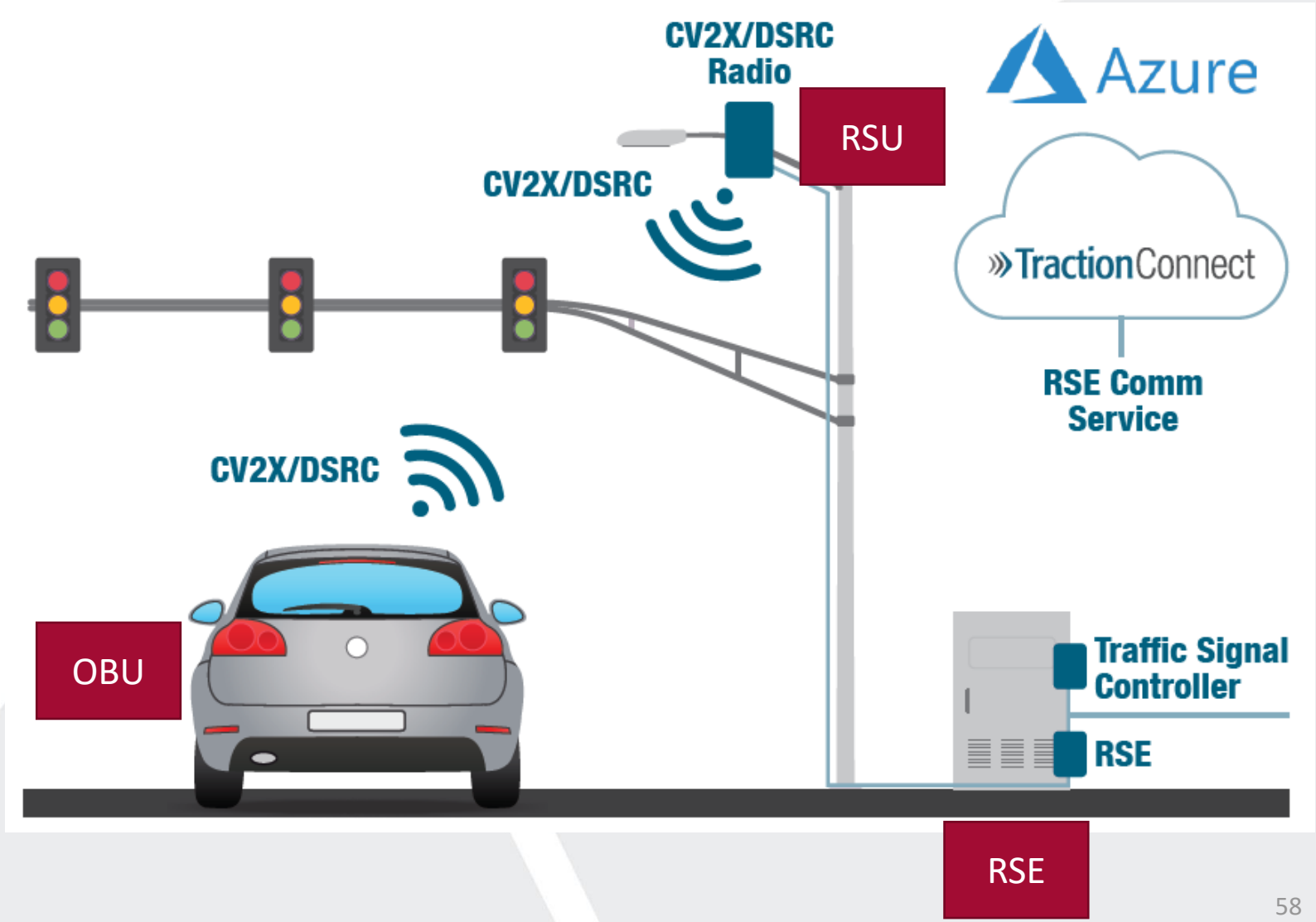
»KITS
A Kimley-Horn Software Solution

»Traction
A Kimley-Horn Software Solution

»Kadence
A Kimley-Horn Software Solution

Connected Vehicles 101

- On Board Unit – OBU – processor and DSRC/CV2X in the vehicle
  - Without a driver interface/apps: “Vehicle Awareness Device”
- Roadside Unit – RSU – the DSRC radio at the traffic signal
- Roadside Equipment – RSE – the processor that runs CV applications



Connected Vehicles 101

- Vehicles broadcast Basic Safety Messages (BSMs) and can relay Probe Data Messages (PDMs) if/when configured
- RSE/RSU broadcast Signal Phase and Timing (SPaT), a map of the intersection geometry (MAP), and traveler information messages (TIM)
- DSRC/CV2X radios within range and line of sight hear the broadcast
- There is no “connection” from V2V or V2I/I2V, kind of like **tweeting** instead of **instant messaging**

ITS Standards in a Connected World

* API SW not req but advised
** ATC Cabinet not required

Jan 2018

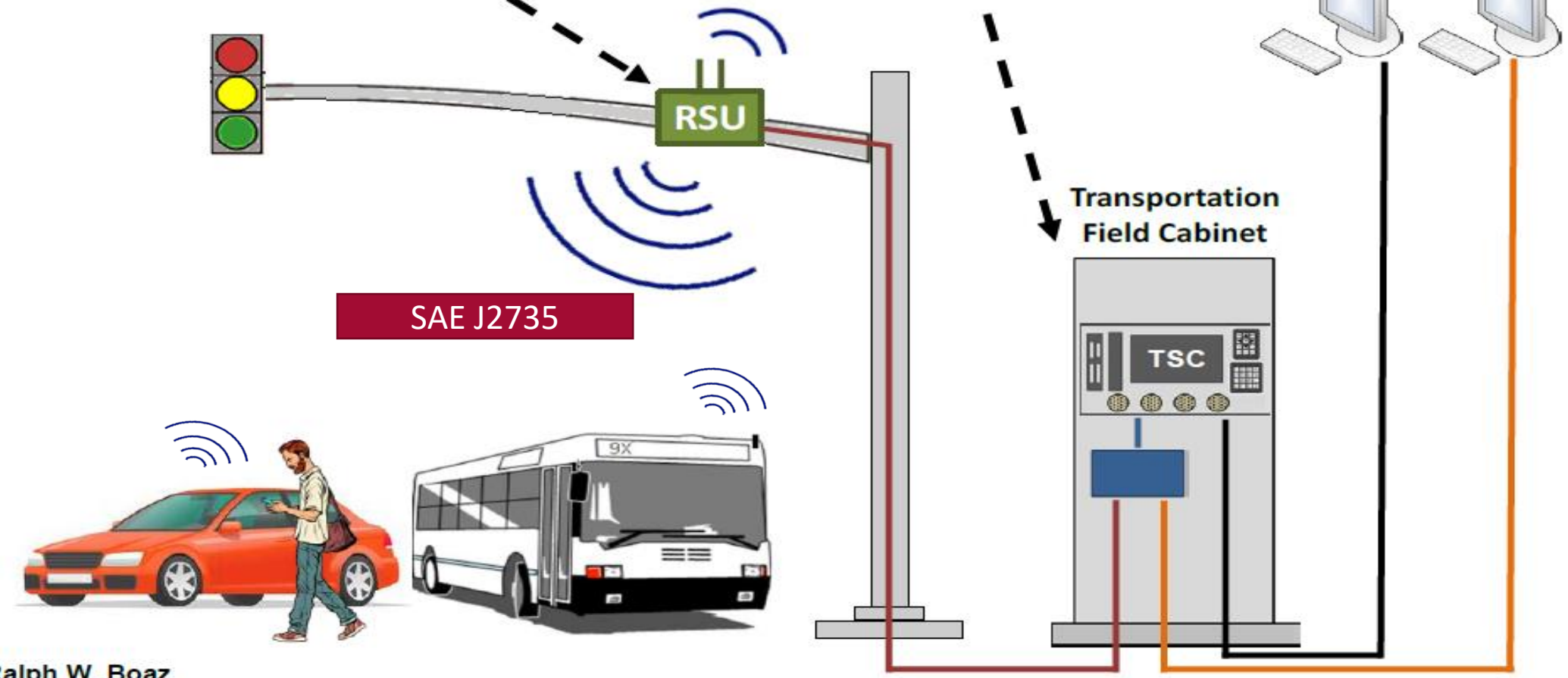
ATC 5201 v06A
ATC 5401 v02A *
NTCIP 1202 v03A
ATC 5301 v02 **

NTCIP 1202
NTCIP 1218

Nov 2021
Sept 2020
May 2019

RSU v01
NTCIP 1218 v01
NTCIP 1202 v03A (part)

CTI 4001 v01

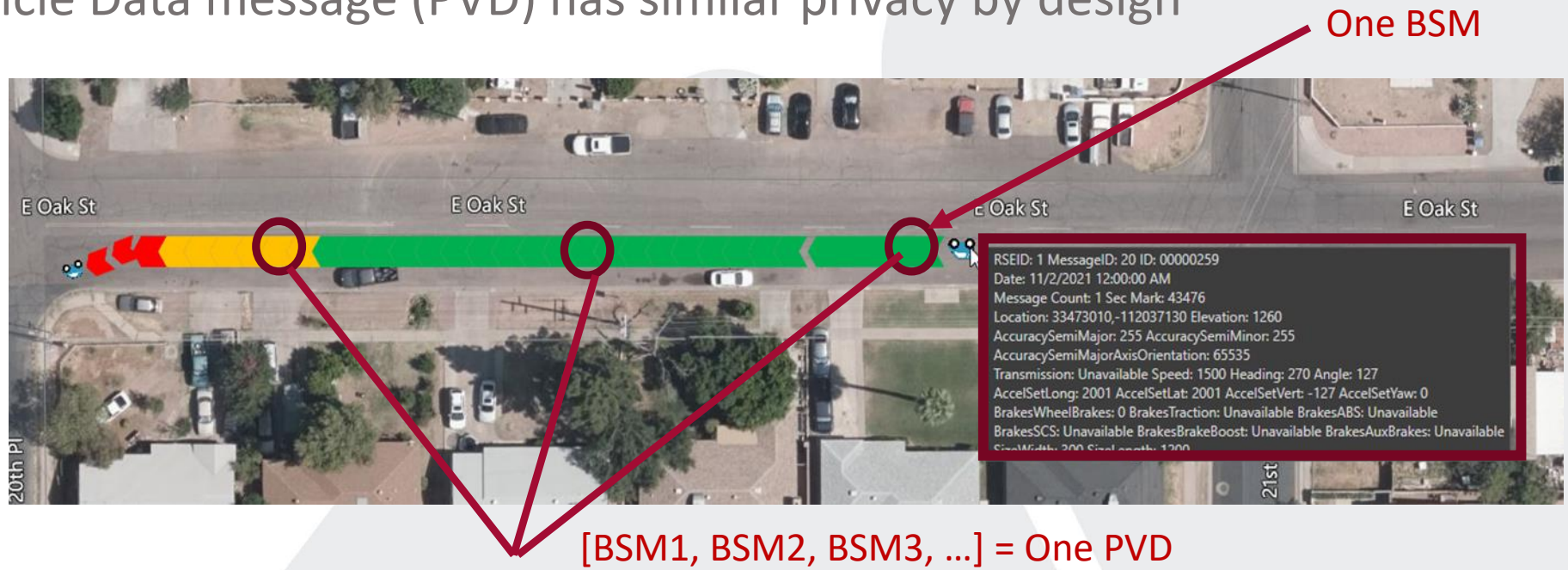


SAE J2735

Graphics: Ralph W. Boaz

Connected Vehicles 202 – Privacy

- BSMs do not start broadcasting until the vehicle is ~100m from the engine start location
- A randomized ID number assigned to vehicle at start and changed each ~5 minutes
- BSMs only include this randomized ID number
- NO information about license plate, make/model, VIN, registered owner, insurance, MAC address, etc.
- Probe Vehicle Data message (PVD) has similar privacy by design



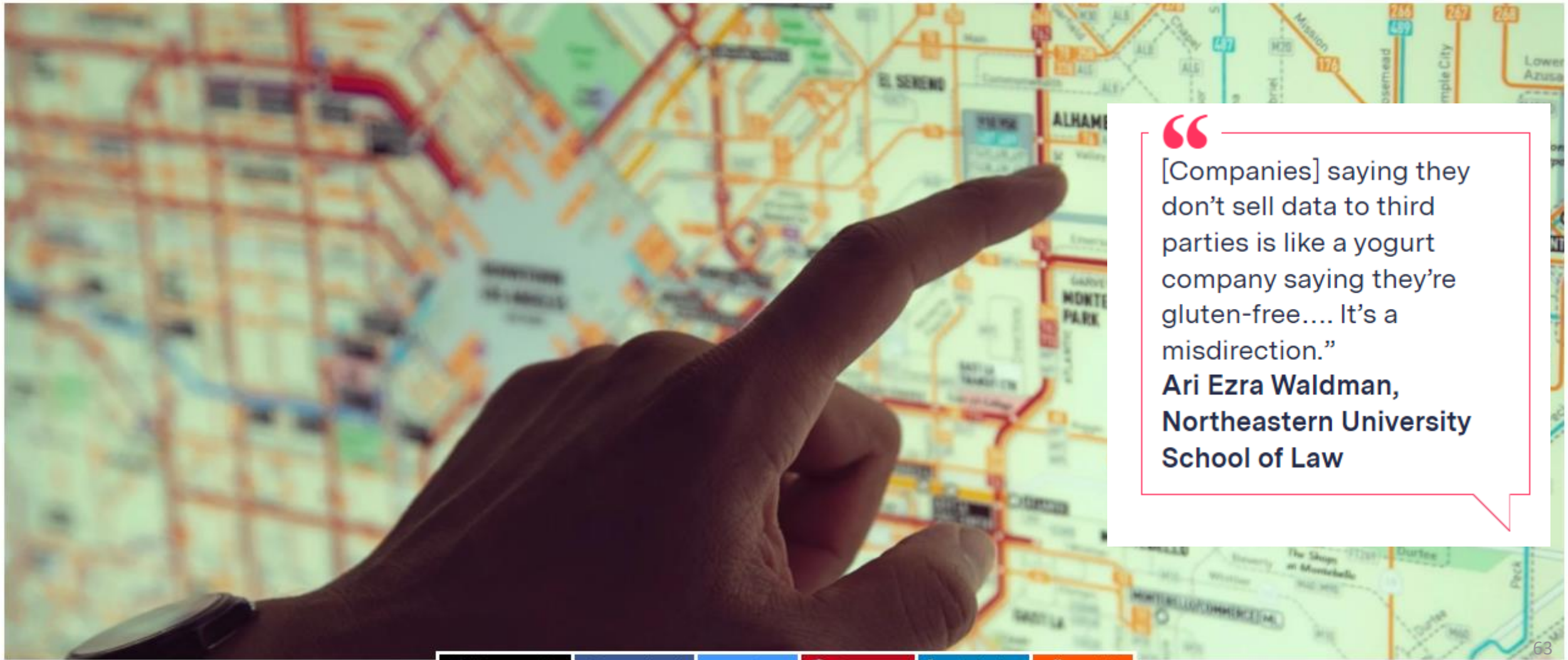
Connected Vehicles 202 – Security

- When the DSRC radio is installed in the vehicle, it gets a bunch of "certificates" from the security credential management system (SCMS)
  - Typically several years worth of certificates (digital signatures)
- The randomized ID number is "certified" with Public key / private key encryption so other vehicles and RSEs can trust that these BSMs are real
  - OBUs (or RSEs) that do not have the proper digital signatures are flagged by the receiving OBU/RSE as "misbehaving" and reported to the SCMS
- The DSRC radio at the traffic signal also uses SCMS certificates, but the ID number is not changed every 5 minutes since it is publicly-owned equipment

FEBRUARY 28

Apps sell your location data despite Apple policies, using simple workaround

Ben Lovejoy - Feb. 28th 2022 6:56 am PT @benlovejoy



> [Companies] saying they don't sell data to third parties is like a yogurt company saying they're gluten-free.... It's a misdirection."
> **Ari Ezra Waldman, Northeastern University School of Law**

27 Comments | Facebook | Twitter | Pinterest | LinkedIn | Reddit

50 Ways to Leak Your Data:
An Exploration of Apps' Circumvention of the Android Permissions System

Joel Reardon
University of Calgary
AppCensus, Inc.

Álvaro Feal
IMDEA Networks Institute
Universidad Carlos III de Madrid

Primal Wijesekera
U.C. Berkeley / ICSI

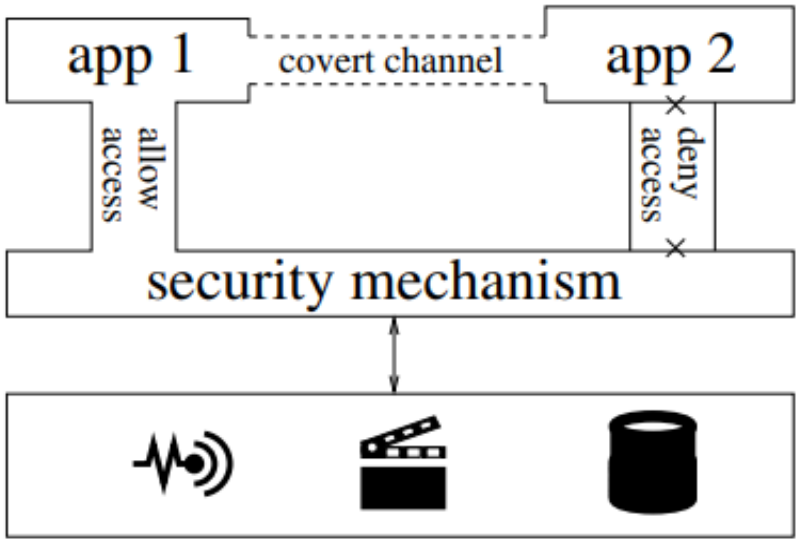
Amit Elazari Bar On
U.C. Berkeley

Narseo Vallina-Rodriguez
IMDEA Networks Institute / ICSI
AppCensus, Inc.

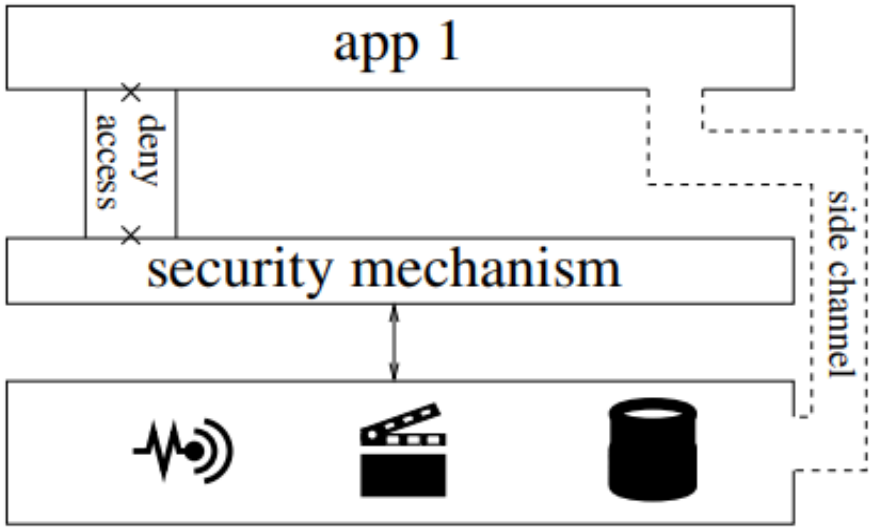
Serge Egelman
U.C. Berkeley / ICSI
AppCensus, Inc.

Table 2: SDKs seen sending router MAC addresses and also containing code to access the ARP cache. For reference, we report the number of apps and a lower bound of the total number of installations of those apps. We do this for all apps containing the SDK; those apps that *do not* have ACCESS_WIFI_STATE, which means that the side channel circumvents the permissions system; and those apps which *do* have a location permission, which means that the side channel circumvents location revocation.

	Contact	Incorporation	Total Prevalance		Wi-Fi Permission		No Location Permission	
SDK Name	Domain	Country	(Apps)	(Installs)	(Apps)	(Installs)	(Apps)	(Installs)
AIHelp	cs30.net	United States	30	334 million	3	210 million	12	195 million
Huq Industries	huq.io	United Kingdom	137	329 million	0	0	131	324 million
OpenX	openx.net	United States	42	1072 million	7	141 million	23	914 million
xiaomi	xiaomi.com	China	47	986 million	0	0	44	776 million
jiguang	jpush.cn	China	30	245 million	0	0	26	184 million
Peel	peel-prod.com	United States	5	306 million	0	0	4	206 million
Asurion	mysoluto.com	United States	14	2 million	0	0	14	2 million
Cheetah Mobile	cmcm.com	China	2	1001 million	0	0	2	1001 million
Mob	mob.com	China	13	97 million	0	0	6	81 million



(a) covert channel

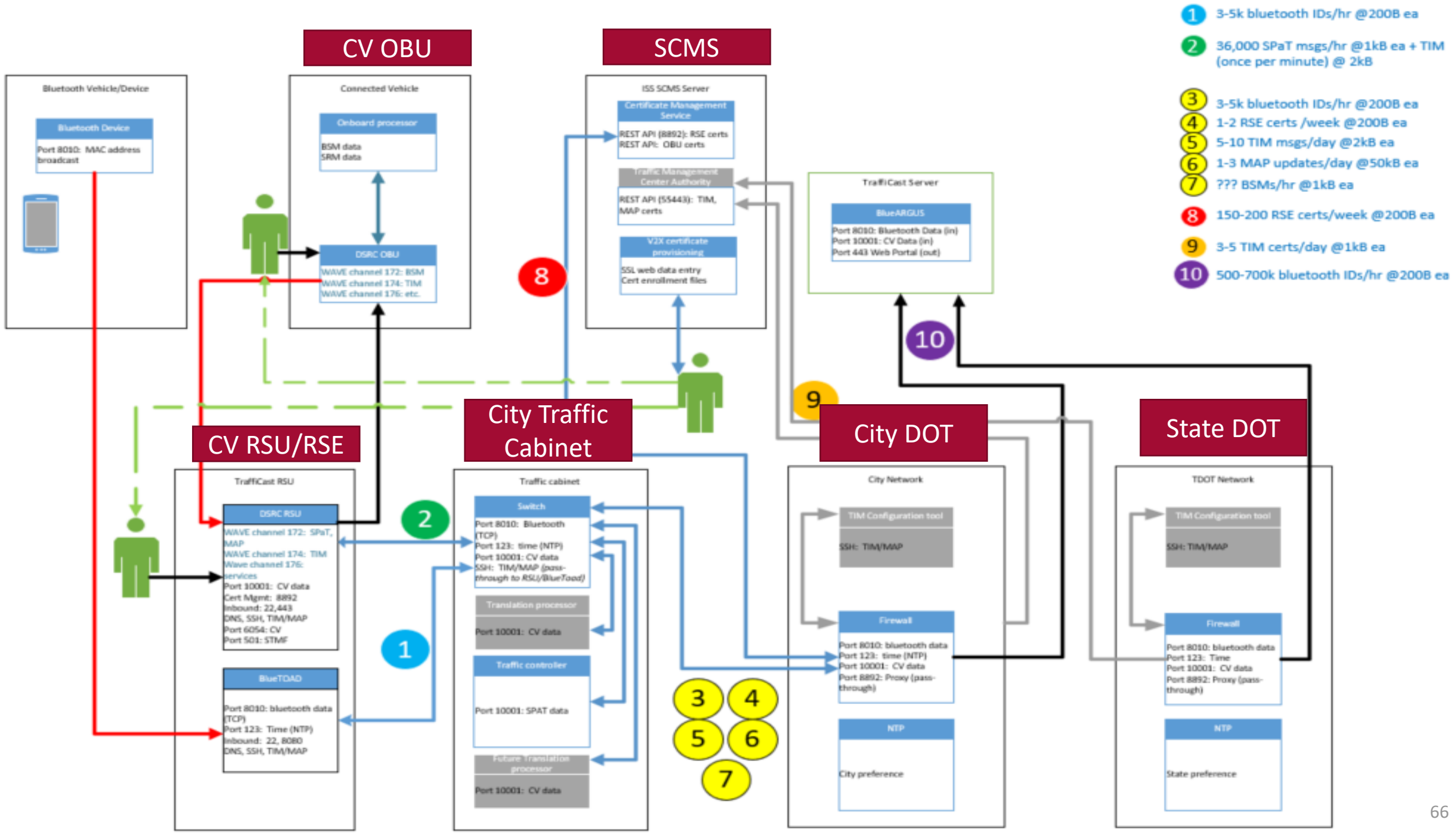


(b) side channel

https://www.ftc.gov/system/files/documents/public_events/1415032/privacycon2019_serge_egelman.pdf

Connected Vehicles 202 – Security

- All other security issues from center-to-field (RSE to TMC) are dealt with using traditional means in switch configuration and security software tools
  - Firewalls
  - VLANs
  - User permissions
  - Limitations on allowable ports
  - Outbound data only
  - Kerberos
  - Etc.


CV OBU
SCMS
CV RSU/RSE
City Traffic Cabinet
City DOT
State DOT
Bluetooth Vehicle/Device
Bluetooth Device
Port 8010: MAC address broadcast
Connected Vehicle
Onboard processor
BSM data
SRM data
DSRC OBU
WAVE channel 172: BSM
WAVE channel 174: TIM
WAVE channel 176: etc.
ISS SCMS Server
Certificate Management Service
REST API (8892): RSE certs
REST API: OBU certs
Traffic Management Center Authority
REST API (55443): TIM, MAP certs
V2X certificate provisioning
SSL web data entry
Cert enrollment files
TrafficCast Server
BlueARGUS
Port 8010: Bluetooth Data (in)
Port 10001: CV Data (in)
Port 443 Web Portal (out)
TrafficCast RSU
DSRC RSU
WAVE channel 172: SPaT, MAP
WAVE channel 174: TIM
Wave channel 176: services
Port 10001: CV data
Cert Mgmt: 8892
Inbound: 22,443
DNS, SSH, TIM/MAP
Port 6054: CV
Port 501: STMF
BlueTOAD
Port 8010: bluetooth data (TCP)
Port 123: Time (NTP)
Inbound: 22, 8080
DNS, SSH, TIM/MAP
Traffic cabinet
Switch
Port 8010: Bluetooth (TCP)
Port 123: time (NTP)
Port 10001: CV data
SSH: TIM/MAP (pass-through to RSU/BlueTood)
Translation processor
Port 10001: CV data
Traffic controller
Port 10001: SPAT data
Future Translation processor
Port 10001: CV data
City Network
TIM Configuration tool
SSH: TIM/MAP
Firewall
Port 8010: bluetooth data
Port 123: time (NTP)
Port 10001: CV data
Port 8892: Proxy (pass-through)
NTP
City preference
TDOT Network
TIM Configuration tool
SSH: TIM/MAP
Firewall
Port 8010: bluetooth data
Port 123: Time
Port 10001: CV data
Port 8892: Proxy (pass-through)
NTP
State preference
1 3-5k bluetooth IDs/hr @200B ea
2 36,000 SPaT msgs/hr @1kB ea + TIM (once per minute) @ 2kB
3 3-5k bluetooth IDs/hr @200B ea
4 1-2 RSE certs /week @200B ea
5 5-10 TIM msgs/day @2kB ea
6 1-3 MAP updates/day @50kB ea
7 ??? BSMs/hr @1kB ea
8 150-200 RSE certs/week @200B ea
9 3-5 TIM certs/day @1kB ea
10 500-700k bluetooth IDs/hr @200B ea

Connected Vehicles 202 – Spectrum

- For almost 20 years, 70+Mhz around 5.9Ghz has been reserved for DSRC
- 7 channels, different “music”
- NHTSA for a variety of reasons never mandated DSRC in production vehicles
- FCC ruled recently that 5.9GHz be split in two groups – the lower 45Mhz for WiFi and upper 30Mhz for CV2X
- DSRC to vacate upper 30Mhz within the next ~18 months

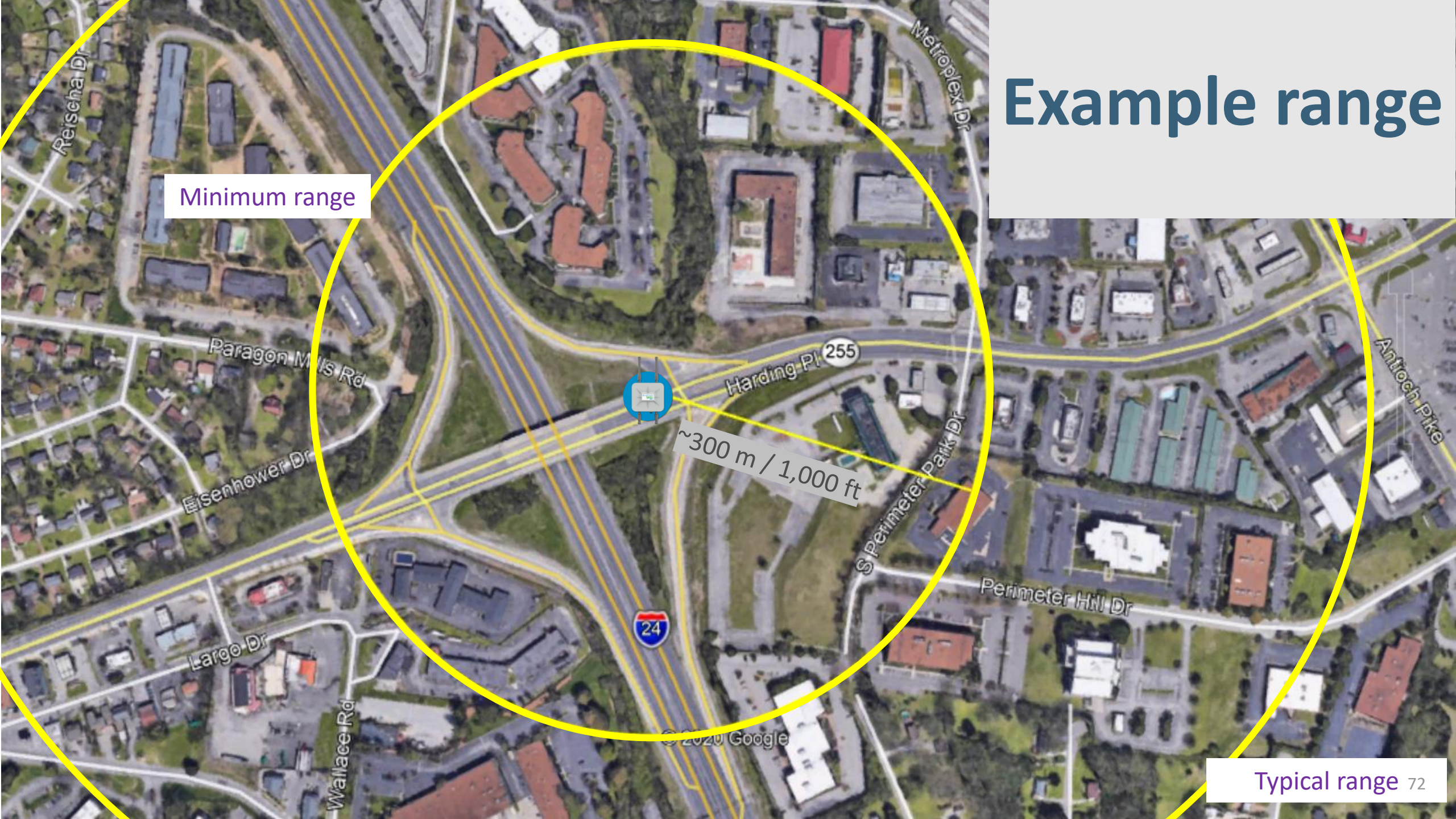
Why FCC? Why?

- We didn’t use it enough…
- WiFi use increased 75% during COVID
- CV2X is based on cellphone chipsets, DSRC is old-school chip tech
- You gotta pick one…. DSRC ←→CV2X doesn’t work

Is 30 MHz enough?

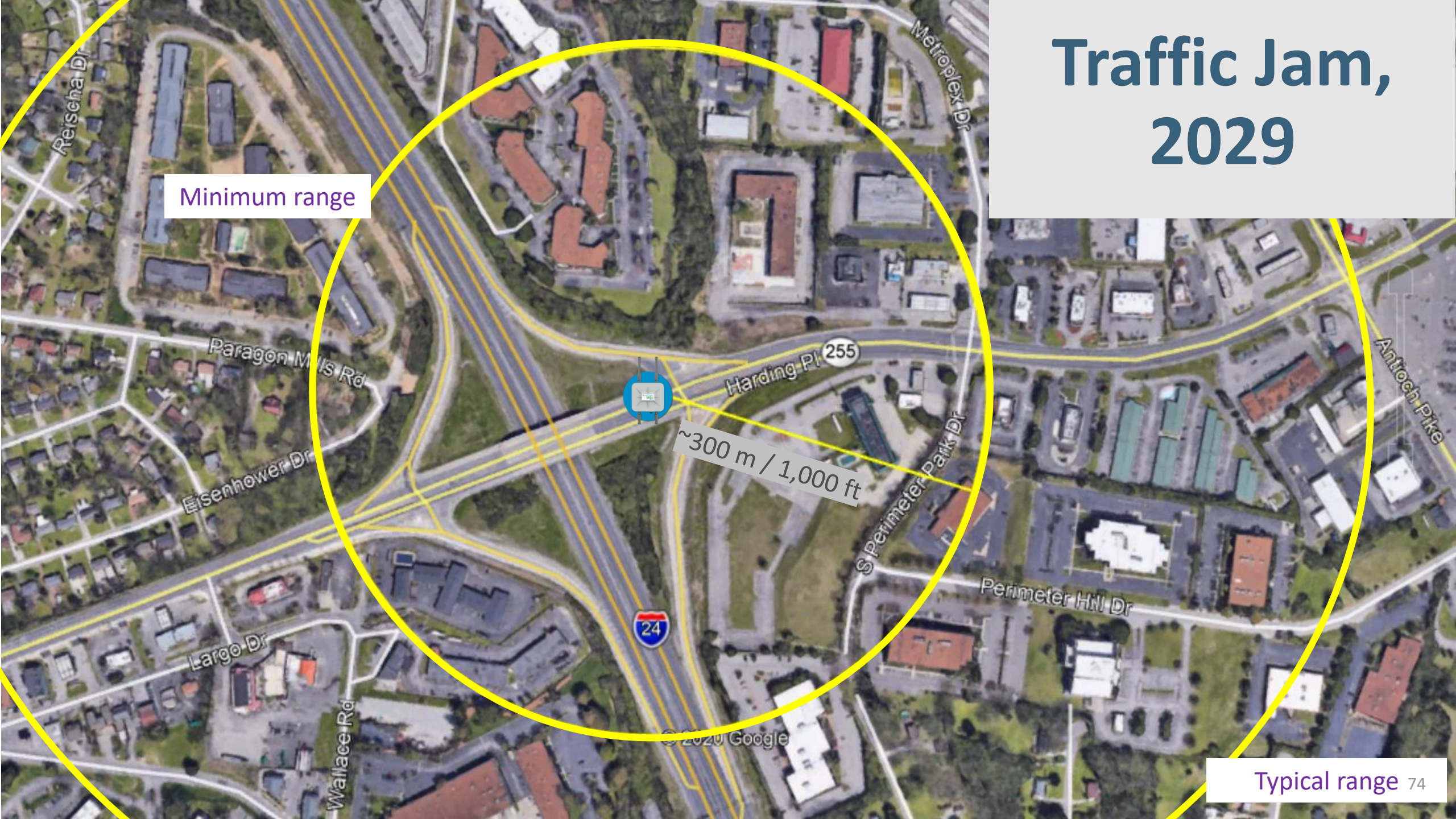
- Roughly speaking, ~200 vehicles in range of each other saturates a 10Mhz channel
- Current CV2X/DSRC deployment is roughly 1 vehicle in every 6000
- Even in areas where DSRC/CV2X is intentionally deployed to concentrate interactions, achieving 200 vehicles in range of each other is rare
- At the current rate of fleet turnover, even with a CV2X mandate, it would take about 7 years to get to 50% penetration (and still channel saturation would be rare during congested conditions……..)
- Next generation CV2X (5GAA) is already considering these situations

Example range



Typical case, 2023

Traffic Jam, 2029



LEARN. COLLABORATE. SHARE. ENERGIZE.

Kimley»Horn

SMART CITIES TECHNOLOGY FORUM

Connected Vehicles
Privacy, Security, and Spectrum

April 2022

Douglas Gettman, Ph.D.

»KITS
A Kimley-Horn Software Solution

»Traction
A Kimley-Horn Software Solution

»Kadence
A Kimley-Horn Software Solution

Consumer Electronics Show – 2022
“An Engineers Tale – There and Back Again”

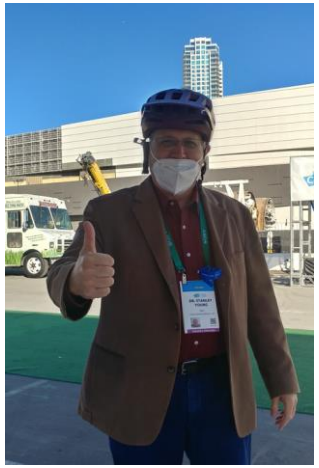
Stan Young, Chief Data Officer
The Eastern Transportation Coalition

Started with a ride in the Tesla Tunnel

It brought the ‘It’s a Small World’ ride from Disneyland to mind ……..

Not automated, but sure beats a bus!!!

Micro-Mobility Galore & Test Drives



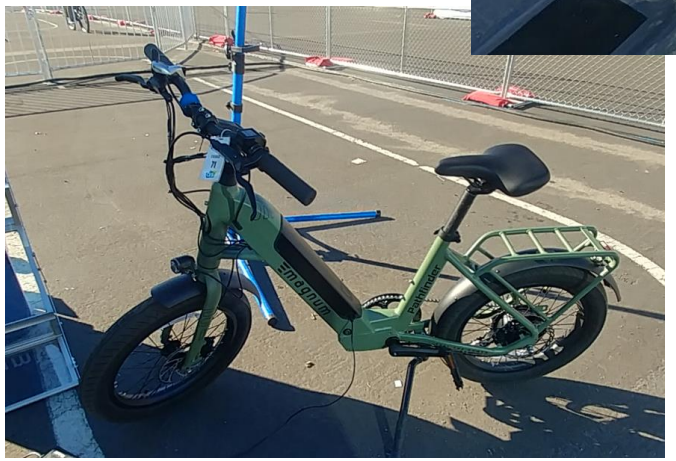
Ready to go!!!

All shapes and sizes

Wins the retro look award.

See the Lumber rack?

Wall-E comes to mind



My Favorite – Easy ON, and big soft seat.

A bike or a scooter – you decide

Lots of Robots for use around the house

Could use this before I left for Vegas

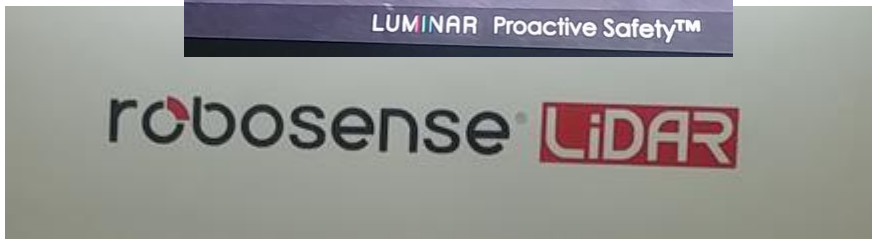
EV Charging ROBOT from Quanergy

From Hyundai – think of scene from the Incredibles on the island, or the Wonkavator from Willy Wonka's chocolate factory (but does not fly).

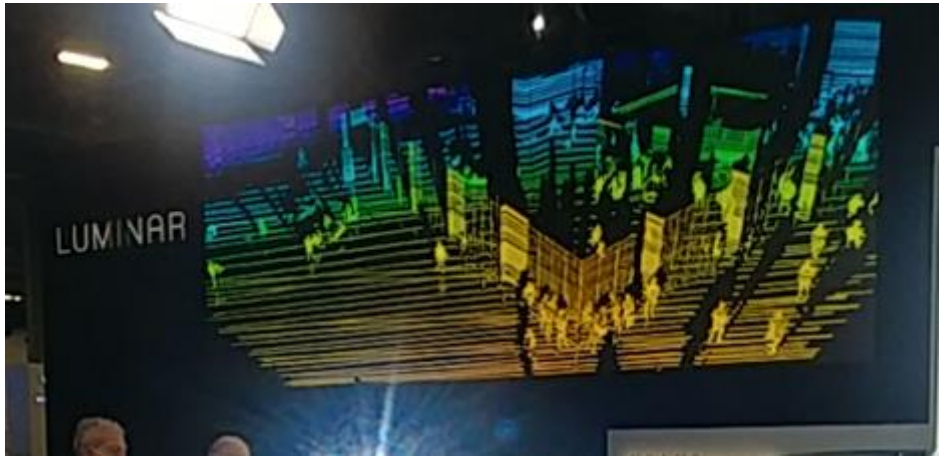
Lidars –Lidars – and more Lidars

The Luminar demo was a highlight – get ready for hard braking.

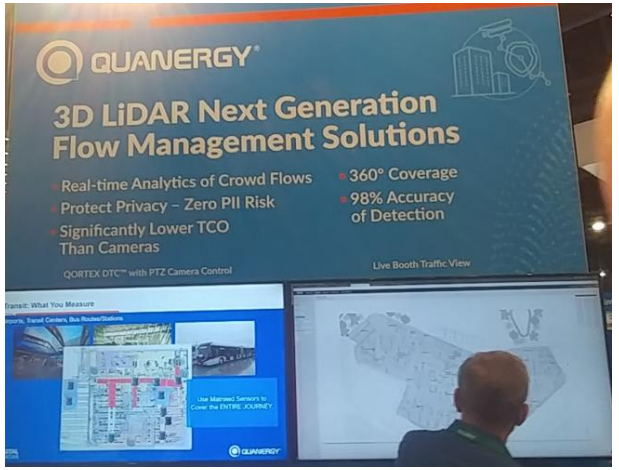
Bring the charging to your car!



Solid state & 4D LiDARs introduced!



Many more LiDAR vendors –



Announced at CES 2022

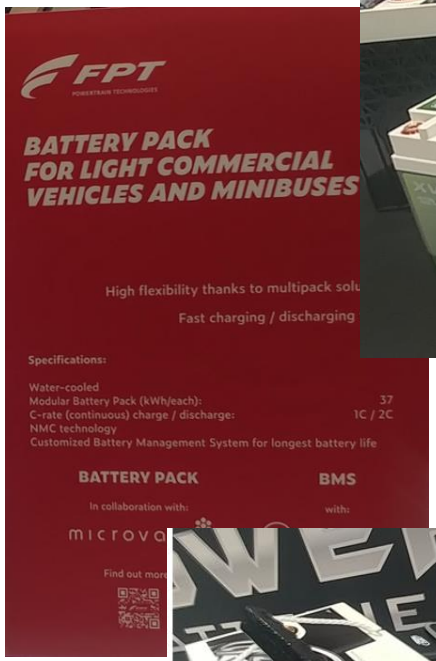
Indy Autonomous Challenge

Medium and Heavy Duty EVs & AVs prevalent at the show

Danner showed up with Robotics Research, whose commercial

More EV Manufacturers

Batteries & charging products were popular ----

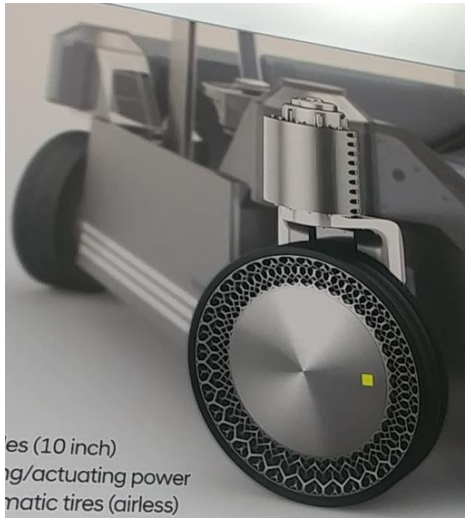


Hyundai – all about Robotics

Recall they purchased Boston Dynamics

Pets were allowed on the show floor

Soda vending machine?



4-wheel steering was popular, it never caught on for Chevy

Our AMPs platform candidate

Nothing cooler than a John Deere ….
Except an automated
John Deere.

Questions and Discussion

Lisa Miller, Innovation Program Associate
The Eastern Transportation Coalition

Wrap Up

Meeting information & presentations will be posted to The Eastern Transportation Coalition website.
Participants will receive a link to the presentations after they are posted.

THE EASTERN TRANSPORTATION COALITION

CONNECTING FOR SOLUTIONS

THANK YOU!

For Questions or Additional Information, please contact:

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