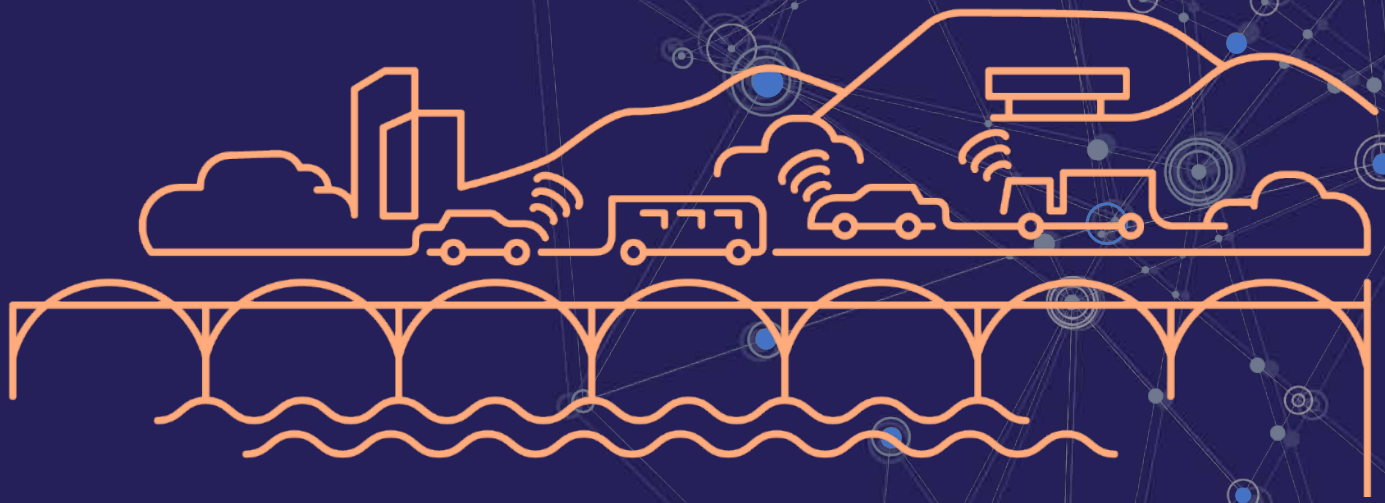
Advancing

Connected Automated Vehicles

in Nevada



Tracy Larkin-Thomason, PE

Nevada Department of Transportation

Deputy Director, Southern Nevada

NEVADA DOT

SAFE AND CONNECTED

What are automated vehicles

An Automated Vehicle (AV) is capable of driving itself by sensing the environment and navigating through:

- Radar
- LiDAR
- GPS
- Computer vision

No driver is needed with a fully autonomous vehicle

What are connected vehicles

A Connected Vehicle (CV) communicates with other connected vehicles, advanced roadside infrastructure, and cloud-based analytics:

- Traffic signal phase and timing
- Work zones
- Communicates over a secure network

In-vehicle devices capture vehicle data

Location, speed, brake status, vehicle dimensions, and bumper height

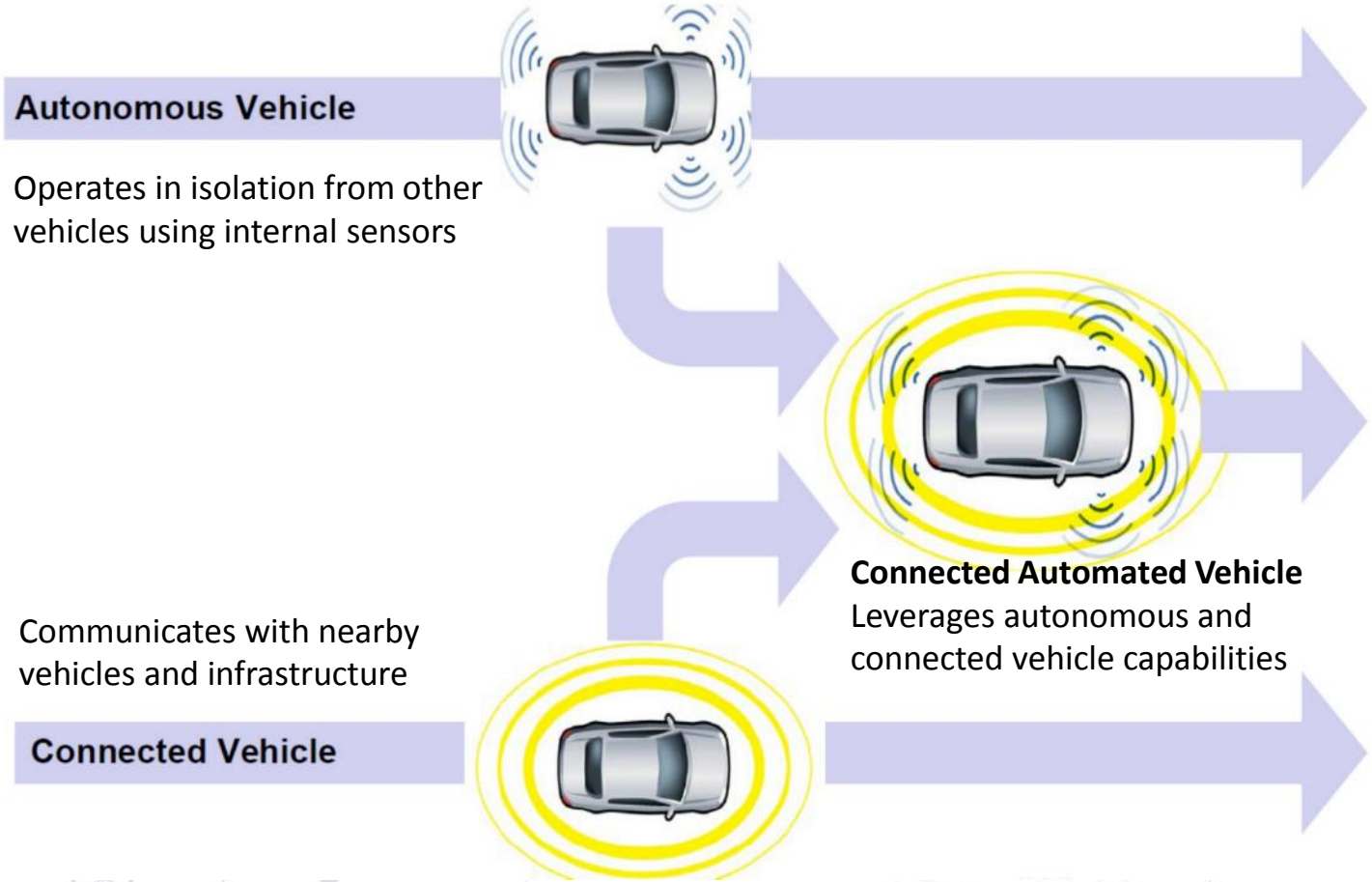
How connected vehicles work

Interoperable and networked wireless communications among vehicles (V2V), the infrastructure (V2I), and passengers' personal communication devices

- Safety applications
- Mobility applications
- Environmental applications

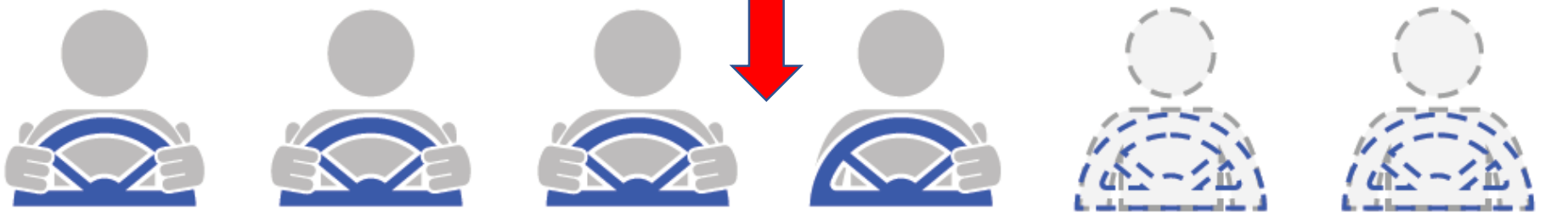
Data flows based primarily on dedicated short-range communications (DSRC)

Connected automated vehicles (CAV) leverage capabilities of both



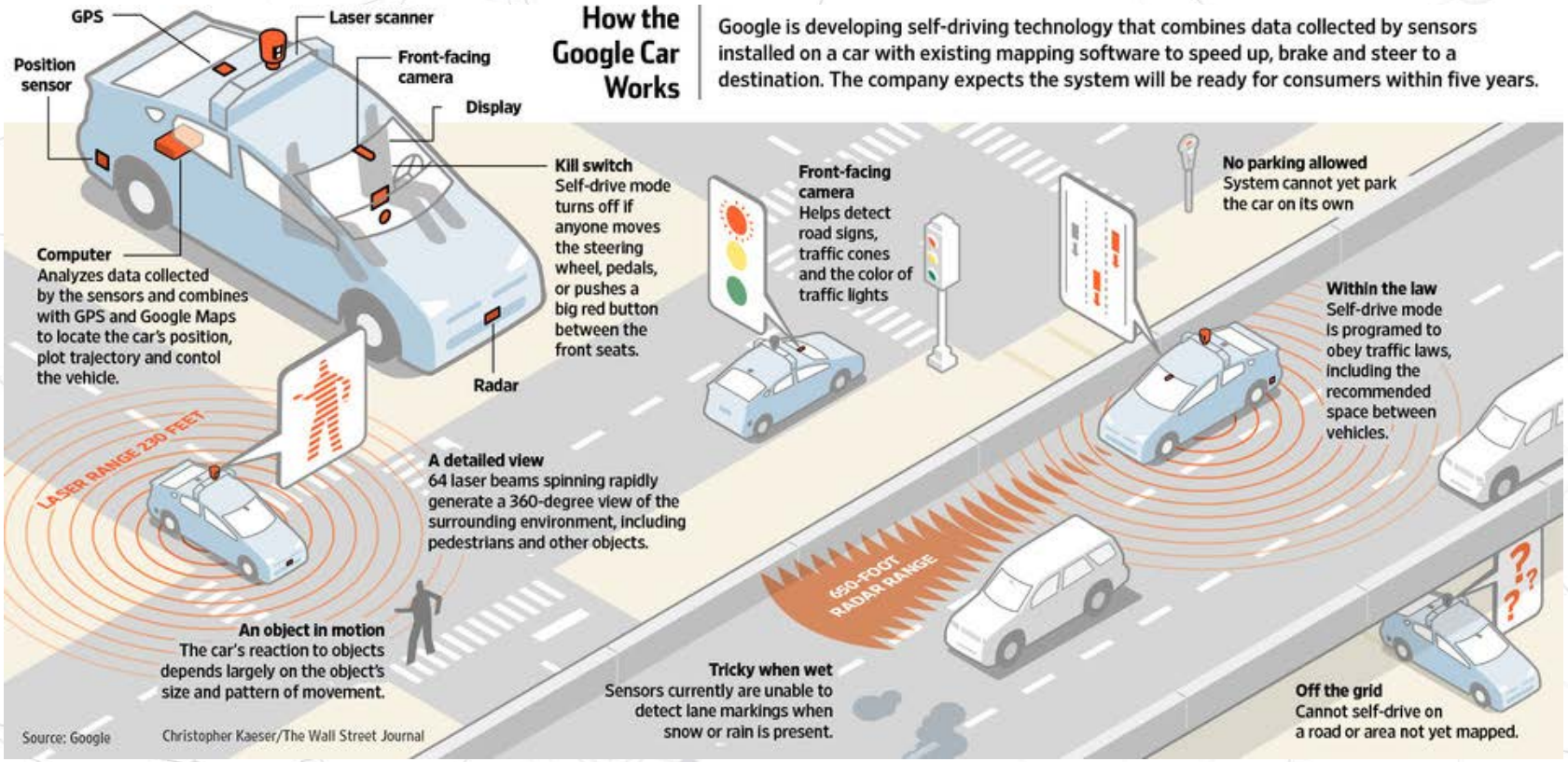
Data Sources: U.S. Department of Transportation ITS Joint Program Office

SAE Levels of automated vehicles



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.

How CAV work



Data Sources: Google

Interesting industry facts

- Half of Lyft will be AV by 2021
- Ride share will be the conduit into the technology
- GM currently has 150 AV cars on the road
- Ford has invested over $1B despite lack of federal framework

Cars spend **96%** of their time

NOT IN USE

History and policy of CAV in Nevada and across the US

History of CAV

Transportation Research Laboratory's automated 1960 Citroen

1964

1984

Carnegie Mellon *Navlab* Robotic Car

Ernst Dickmann's and Bundeswehr University of Munich's (Prometheus) Project

1987-1995

2011

Nevada worked with Google to help them become the first company to apply for, go through the interview, screening process, and formal drive demonstration to be issued the nation's first set of "red" autonomous testing license plate

Google Fully Autonomous Vehicle contains no driver controls

2014

July 1, 2016

- California, Nevada, Tennessee, Michigan, and Florida, plus the District of Columbia have state legislation allowing the testing of driverless cars on public roads
- One Iowa county has passed legislation
- Several other states are considering or have introduced legislation

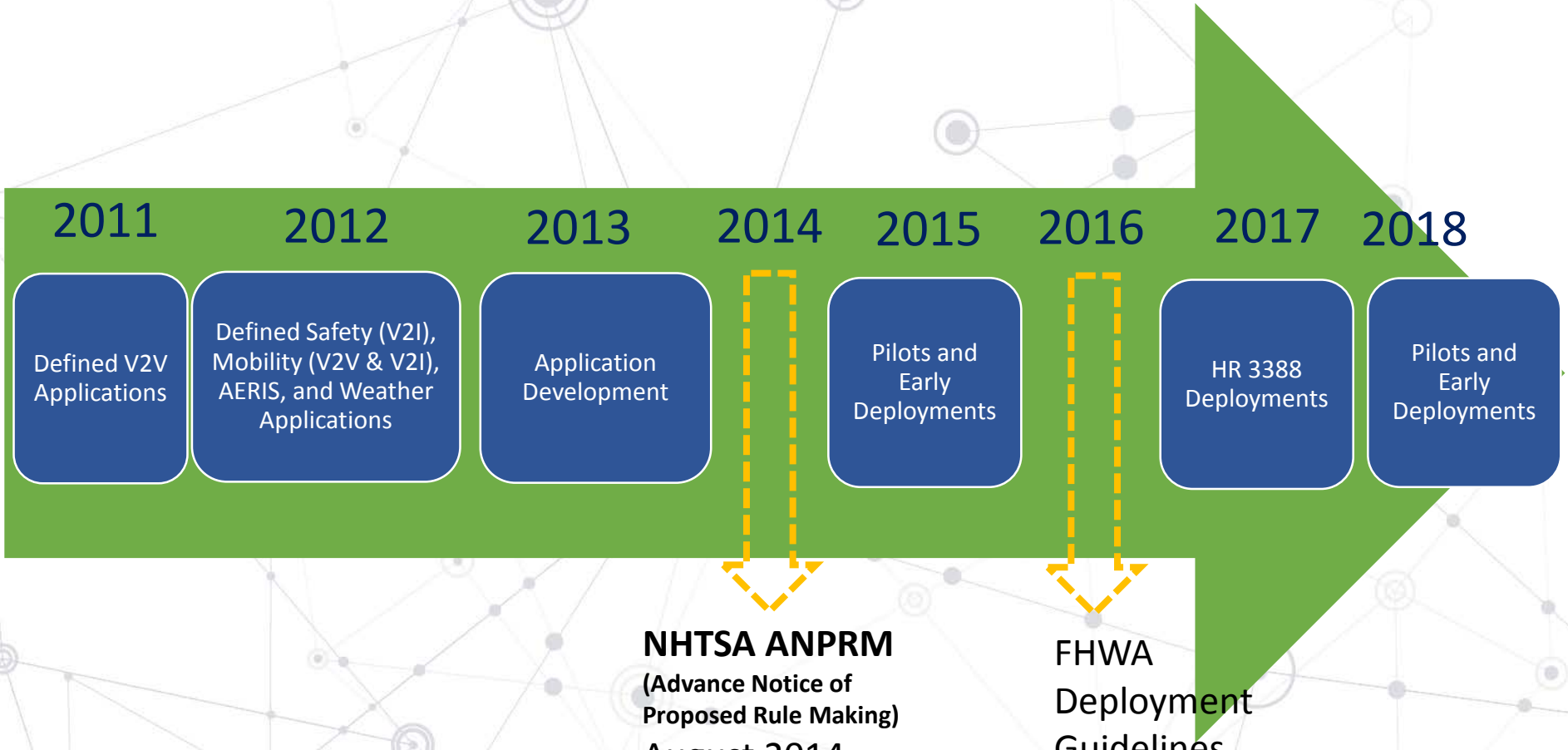
Sept 2016

Nevada is first state to offer AV restricted driver's license

2020

Several states conducting AV and CV pilot programs expect vehicles to be available to consumers

Path toward CAV deployment



USDOT Efforts

Trump Administration

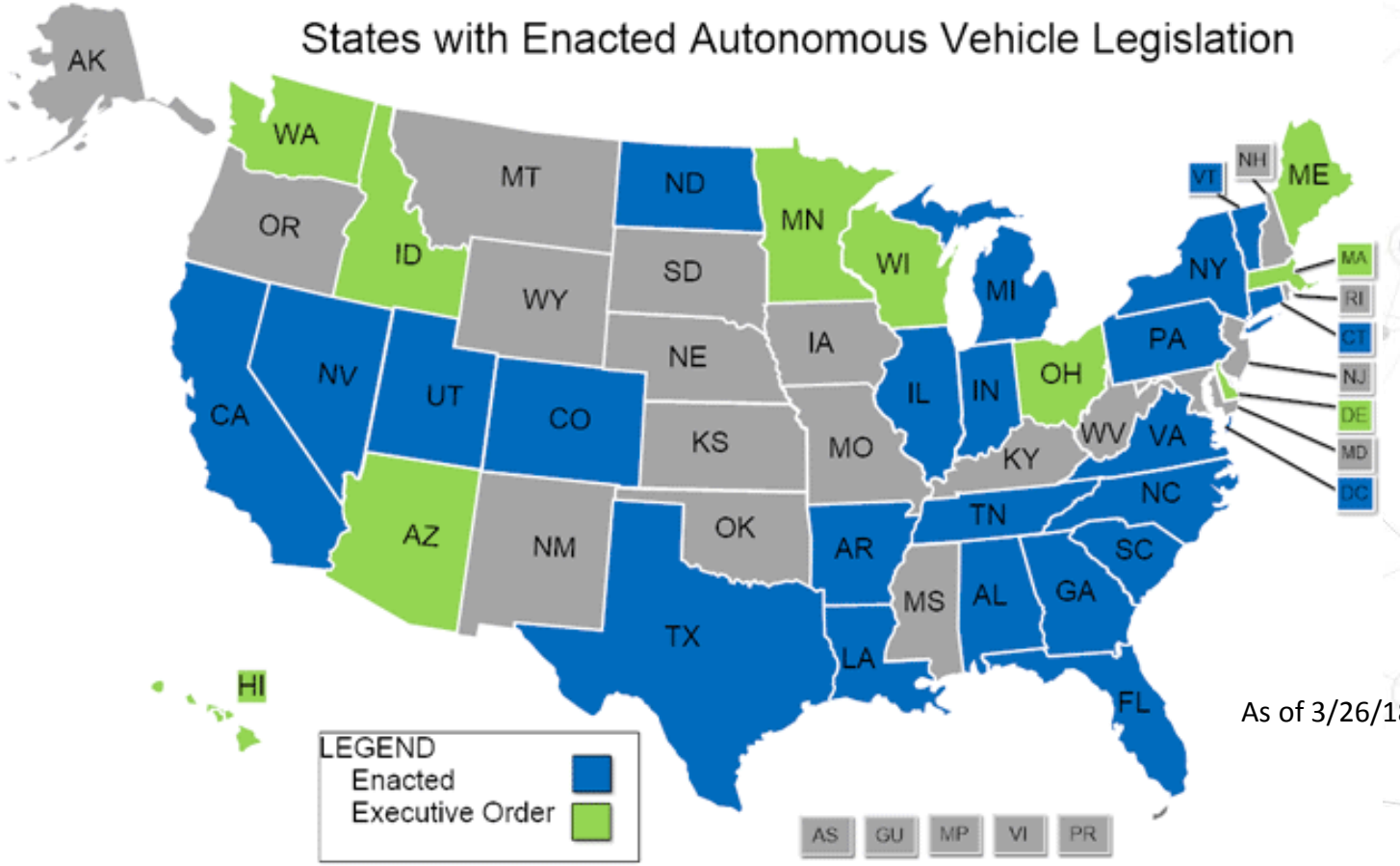
- 2018 could be the most consequential year for public policy on autonomous vehicles in a generation
- A Vision for Safety
- Voluntary Safety Self-Assessment (VSSA)

USDOT's 3.0 AV framework in expected summer of 2018

What is moving in Congress

- House
  - HR 3388, the SELF DRIVE Act, passed unanimously 9/6/17
- Senate
  - Senate wrote own bipartisan bill, S. 1885, the START Act
  - Stuck in the Senate due to objections based on desire for human driver as back-up
  - Bill may be attached to a larger infrastructure package

Policy and legislation status in the US



As of 3/26/18

Nevada's journey

2011
Senate Bill 511

- Authorized AV testing and operation
- Required DMV to create regulations
  - Define insurance requirements
  - Establish minimum safety standards
  - Provide for vehicle testing
  - Restrict to specific areas

2013
Senate Bill 313

- Further defined "autonomous technology" to not need human active control/monitoring
- Established $5M liability requirement
- Established aftermarket AV conversion liability

2015

- First red AV license in the Nation
- Daimler/Freightliner (May 5th)

2016

- Center for Advanced Mobility born
- Nation's leader in the testing and development of cars that drive themselves
- First AV restricted drivers license

2017
Assembly Bill 69

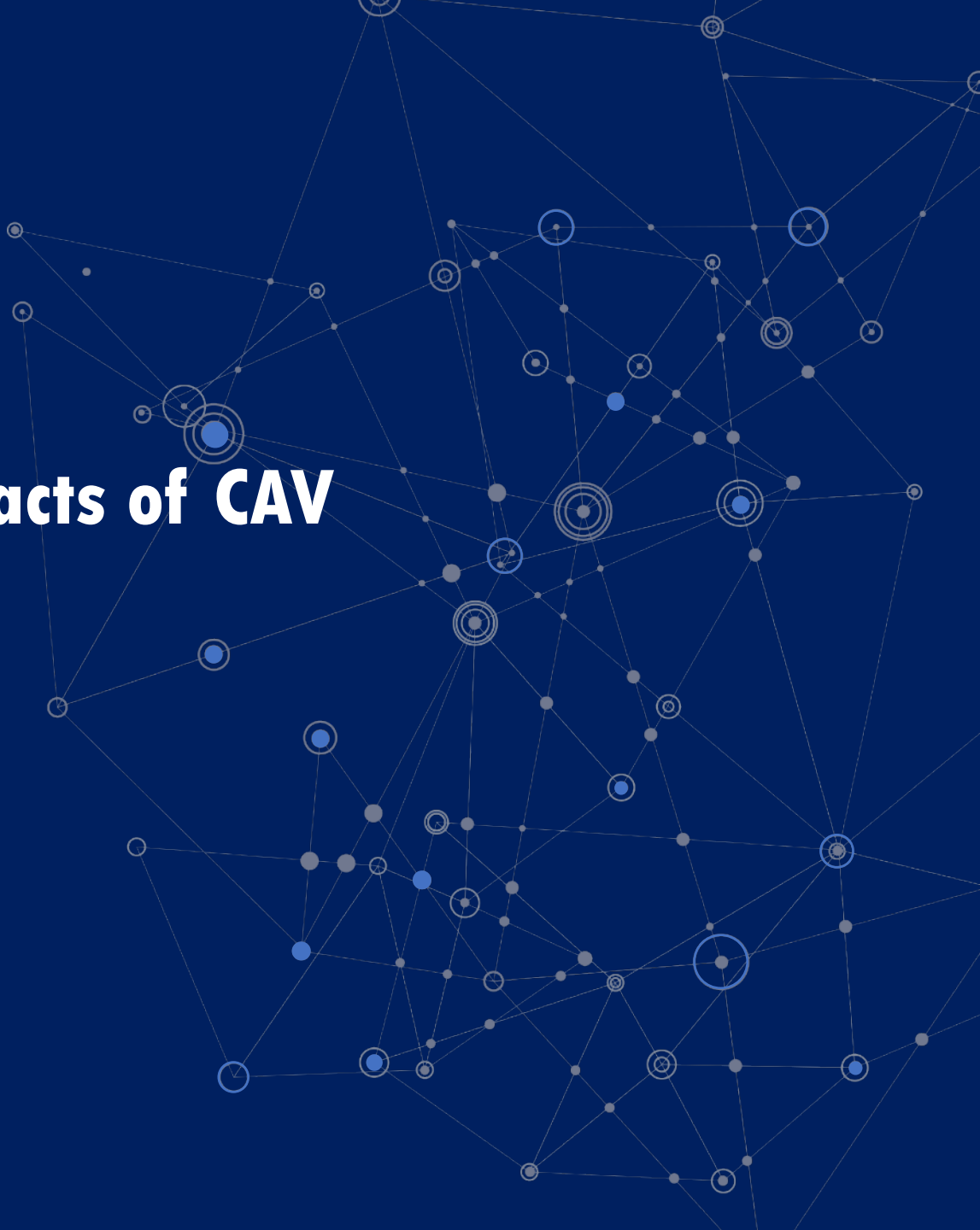
- Allows the use of driver-assistive platooning on state highways
- Permits the operation of fully autonomous vehicles in the state without a human operator
- Permits the use of AV by motor carriers and taxi companies
- Defines "driver" and "driver-assistive platooning"

Nevada is leading the way

FIRST

- To issue an AV restricted driver's license
- To create AV regulations for testing and consumer deployment
- To create an AV testing program
- To license a company for AV testing (Google)
- To license a commercial vehicle for testing

Benefits and impacts of CAV



Anticipated benefits from CAV

- Productive and happy ex-drivers (quality of life)
- Accident reduction
- Increased capacity and reduced travel times
- Reduced need for parking

New transportation options

"Mazda, pick up the kids from school so I don't have to leave work early"

CAVs have the potential to

- Improve public safety
- Alter the need for future long-term capacity projects
- Reduce travel time
- Improve mobility
- Improve energy efficiency
- New models for vehicle ownership
- New business models and scenarios

Deployment issues

- Security
- Communications
- Public Acceptance
- Interoperability

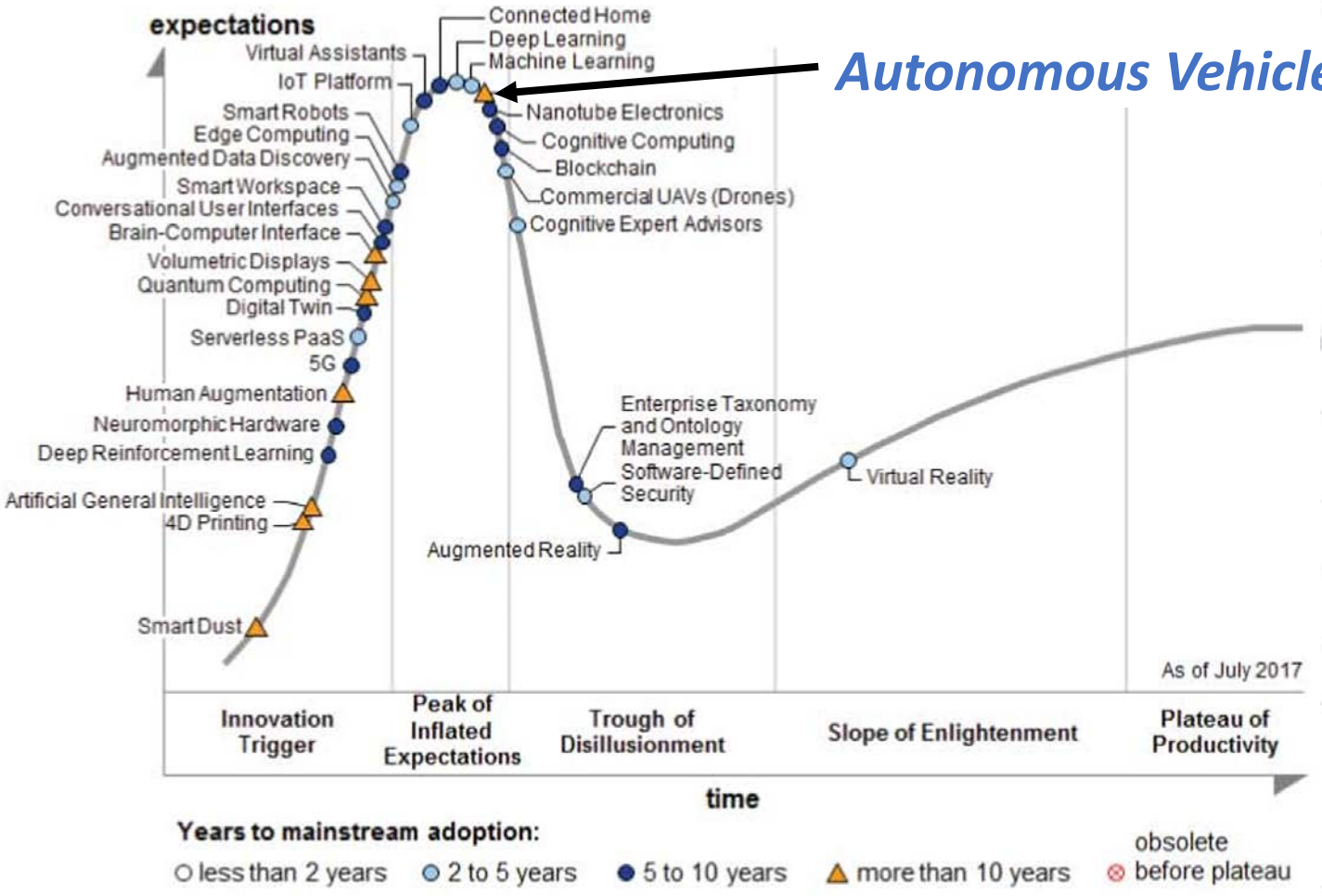
How do we prepare for the amount of data exchange in the future

Funds are limited and investments must last for decades

Policy issues

- Need for national standards
- Data governance
- Cybersecurity
- AV and traffic management systems
- Liability and Insurance clarification
- Process for approving AV for public use

Where is CAV on the curve of technology's life cycle

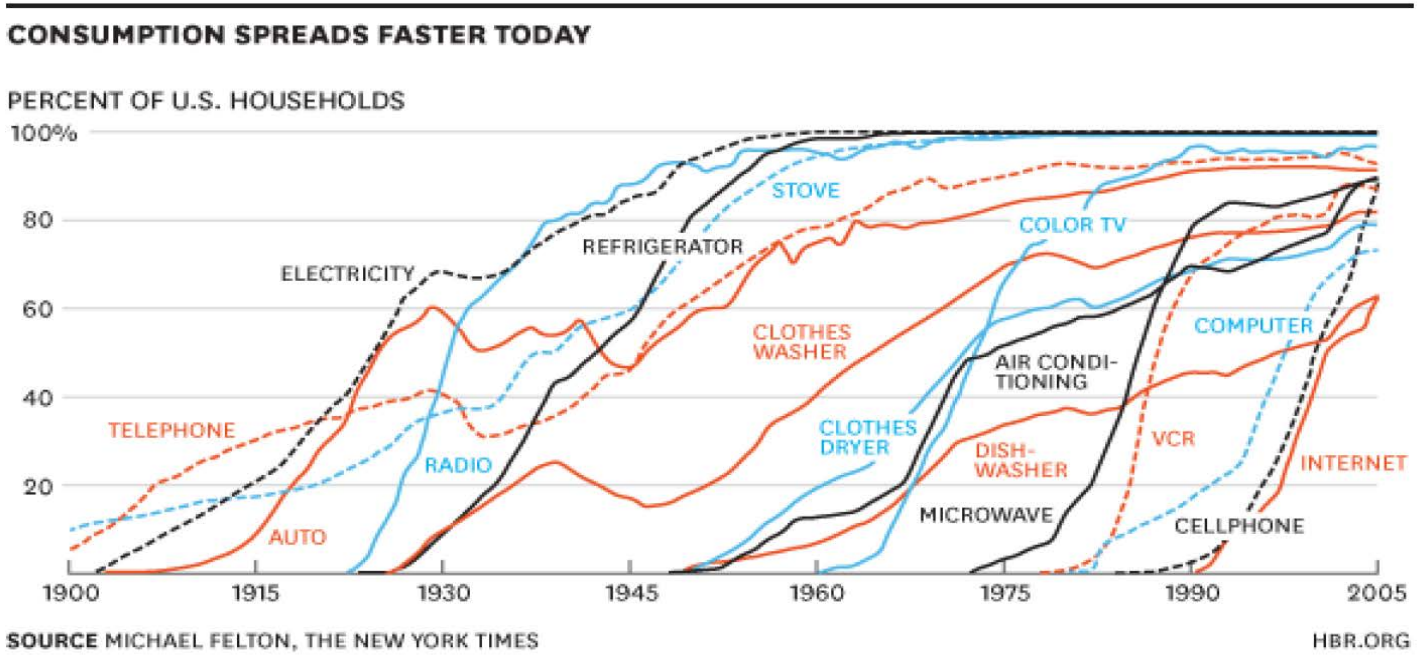


Challenges

- Extent of automation
- Role of the private sector
- Expectation on the public sector
- Impact on urban mobility
- Impact on rural residents and the underserved
- New entrants and new business model
- Impact on workforce

How quickly will CAV be adopted

> **History tells us that consumer adoption of new technology is speeding up over time…**



What to watch for

- Patchwork of laws/requirements from state
- More “real world” testing – streamline development
- Push to provide relevance to rural Americans – not just for cities/interstate
- Application of cybersecurity to AVs
- Data availability – integration

We still have to care for what we have

- Highways and bridges
- Driver operated vehicles and vintage vehicles
- AVs are not expected to be the majority of cars on the road for another three decades

Exciting, Fast, and Uncertain

NOT the standard for most transportation agencies

Nevada's CAV Initiatives

Successful collaboration

- Nevada's Center for Advanced Mobility (NCAM)
- Nevada Governor's Office of Economic Development (GOED)
- RTC of Southern Nevada
- RTC of Washoe County
- Nevada Department of Motor Vehicles
- Nevada Department of Transportation

City of Las Vegas' Downtown Innovation District

- Technology projects include Genivi, autonomous shuttle, and connected corridors
- Sensors and cameras
- Analytics for pedestrians and vehicle counts
- Soofa kiosks installed on Downtown Loop route
- CLV and RTC to provide fiber connectivity along Grand Central Parkway and into medical district

Fremont East Innovation District

A section of downtown Las Vegas earmarked for testing and expansion of new technologies

City of Las Vegas' Downtown Innovation District Driverless Shuttle

- Launched first self-driving public shuttle
- Largest self-driving pilot in real world traffic
- First to be fully integrated

Mobility
on Demand

Integrates with ITS, data analytics, transit CAD/AVL, and commercial ride-share (Uber, Lyft) system

WayCare

- Predictive analytics platform
- Harnesses vast amount of in-vehicle data alongside municipal and state traffic data
- Optimizes emergency services response and enable proactive allocation of resources

Reduce accident identification time by an average of

12 minutes

Nexar

- Vehicle-to-vehicle (V2V) network
- Smartphone app providing drivers with real-time alerts
- Prevent vehicle, cyclist, and pedestrian collisions

Nexar
AI dashcam app to monitor
road safety

Audi Countdown to Green

- Traffic signal network connected to vehicles
- Dashboard shows time to signal change with a 2 second alert
- Two-way communication with traffic lights and cameras helps identify better routes and traffic incidents on roadways

Audi

Time-to-Green feature

Modifies driver behavior to be prepared and focused

Integrating Mobile Observations

Using Transformative Technology with Connected Snowplows

- Improve safety and reduce incidents from adverse weather conditions
- Outfit snowplows with GPS, sensing involving Radar, LiDAR, Forward-looking Infrared-based, and DSRC/5G radios

Real time

local, national, and mobile weather

Recommends roadway treatments and timing

Enhanced work zone safety

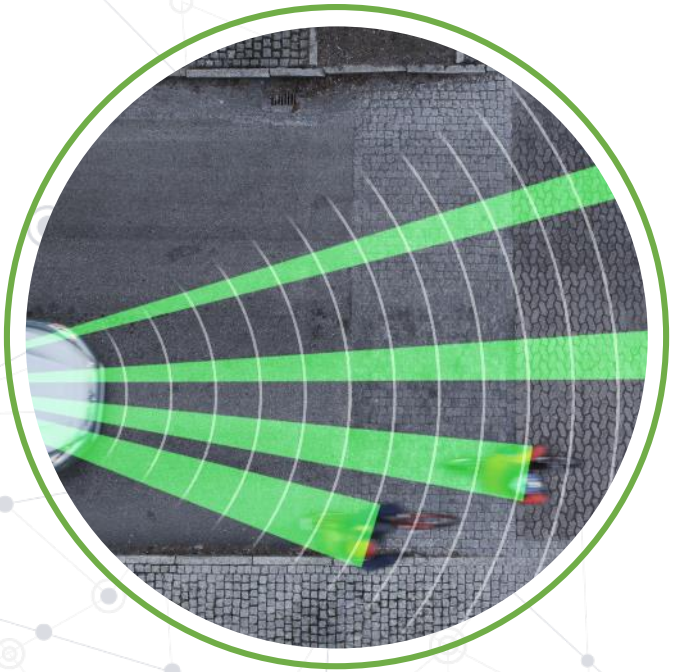
- Maintenance workers with V2P sensors to integrate worker location data with AV/CV collision avoidance systems
- Establish automated speed reduction and lane avoidance in maintenance zones
- Automatically reroute traffic from areas of maintenance

Alcatel Lucent Enterprises

- Real-time data monitoring congestion
- Provides latest traffic/ safety updates
- Future-proof data infrastructure

Pedestrian Safety Pilot Program

- Innovative technology reducing pedestrian injuries/fatalities
- First pedestrian pilot using LiDAR
- Future phases – Advance alerts



Clark Avenue between Casino Center Boulevard and 3rd Street in the Las Vegas Innovation District

WAZE

- New Traffic Light reporting feature
- Automated process to receive notices
- Data evaluation
- Making Waze data useful

Terbine and Voyomotive

- First large-scale commercial-grade system designed to curate Internet of Things/physical data
- Voyomotive to collect and make available vehicle sensor data
- Devices have been installed in 15 paratransit vehicles and are collecting data

Connecthings

- Transforms urban physical assets into mobile connected experiences
- These assets interact with mobile users – providing valuable information
- Immediate access to transit schedules in real time

Clark County Small Cell Study

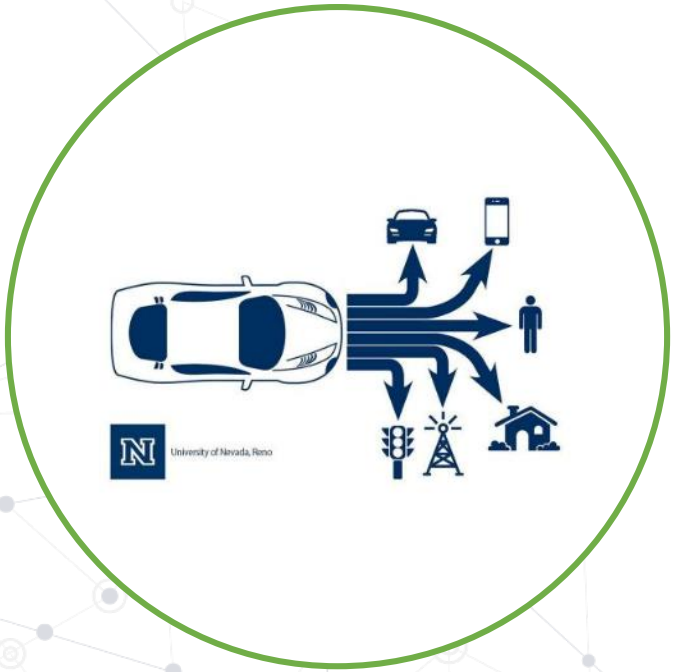
- Provide broadband/WiFi across the jurisdiction

Switch Superloop

- 10gb fiber network connecting City of Las Vegas, Clark County, RTC, Lou Ruvo Brain Institute, Smith Center for Performing Art, and others for use with Smart Communities data transfer

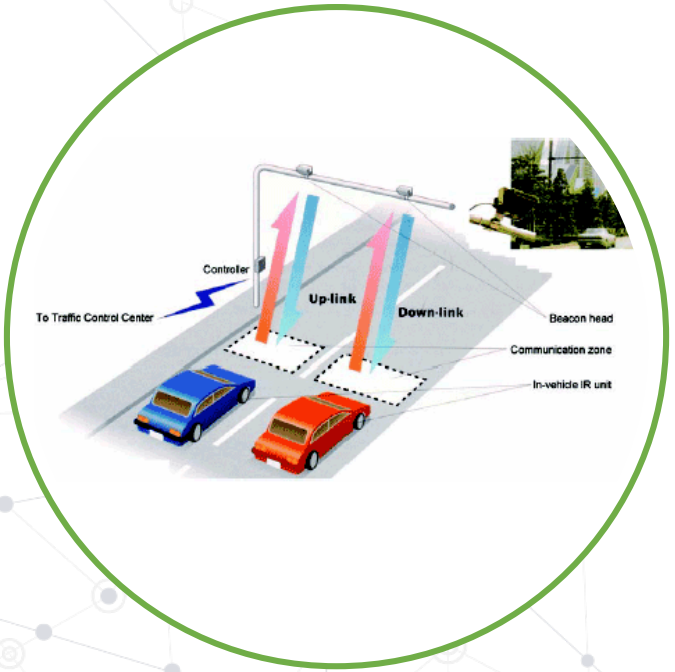
Northern Nevada Intelligent Mobility Living Lab

- Learn how to use BIG data
- Lab includes systems that sense, gather, and integrate data



City of Henderson Technology Initiatives

- GPS-based pre-emption using GTT Opticom
- Thermal Traffic Signal Detection– thermal image traffic signal detection of vehicles, bicycles, and pedestrians
- Traffic Performance Monitoring– Wi-Fi reader that provided travel time, delay, speed, and origin-destination data



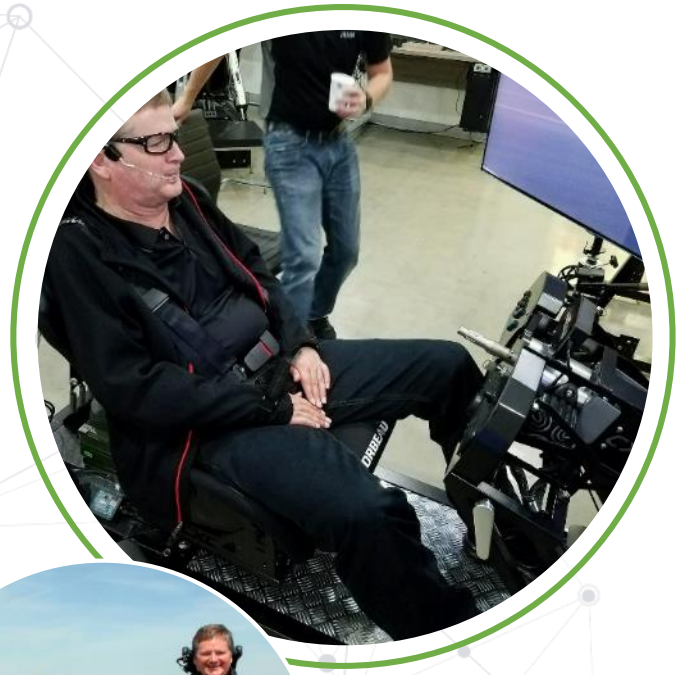
Vehicle to infrastructure technology

- Genivi Pilot
- Audi launches Connected Signals, the first Vehicle-to-Infrastructure technology in the US

Connected Signals

Mobility for disabled residents

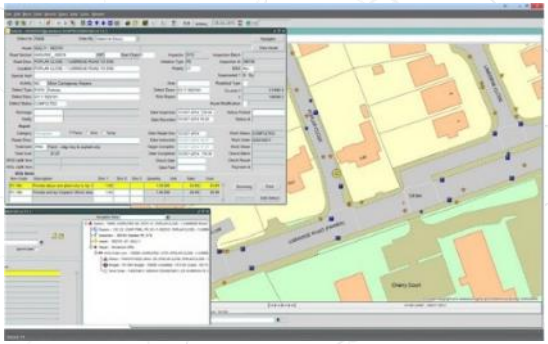
- Collaborate with OEMs and aftermarket AV technology companies to outfit passenger vehicles
- Integrate with corridor ITS, DSRC/5G/WiFi, other ICT, and data centers
- License and insure disabled drivers



Paralyzed from neck down, former Indy racer, Sam Schmidt, drives again thanks to technology

Robust asset management

- Collect pavement, bridge, and fleet asset information from CAV sensors
- Transmit data to NDOT's Transportation Asset Management (TAM) system
- Conduct predictive analytics based on CAV, ITS, and weather data to accurately predict asset deterioration
- Support more accurate capital planning and maintenance projects
- Efficiently deploy maintenance personnel to address high-priority projects



Path Forward

Next for Nevada

Continue to be the pioneer for transportation innovation

- Continue collaboration with public and private partners
- Expand public and legislative outreach
- Deploy innovative projects

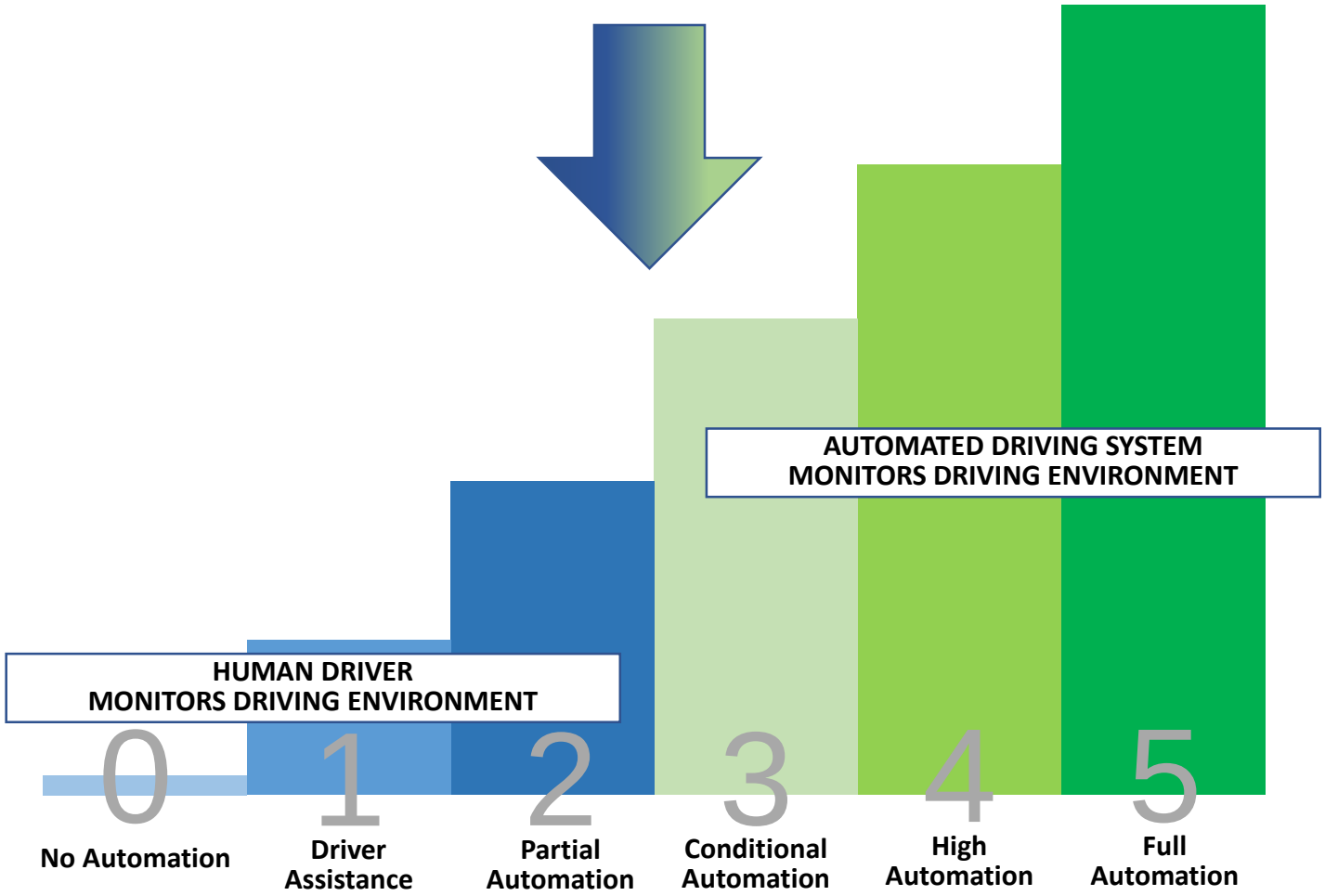
Smart cities

- Enhanced infrastructure and data collection capabilities
- Connected, fully interoperable, public sector data sets
- Real-time and predictive analytics from collected CAV data
- Enhanced city and state planning tools and information apps
- Full multimodal data integration across cities and regions

SB 53 – Providing Conduit for Fiber

- Allows NDOT to pursue fiber sharing trade agreements with telecommunications companies within state right-of-way.

The CAV technology is here



Source: SAE International

Why be part of it

- Nevada has a voice in shaping national policy
- Improved technologies support Improved Safety and Economic Vitality in the state and nation
- Economic benefits to the State in new job opportunities and new technology investments

Advancing

Connected Automated Vehicles

in Nevada

Is changing the way we travel

Thank you ITE and ITS Alaska!

An example of CV: The SPaT Challenge

Challenge

Deployment of DSRC 5.9 GHz infrastructure with SPaT broadcasts in at least one corridor in each of the 50 states by January

2020

- Signal Phase and Timing (SPaT) message
- Requires intersection to broadcast MAP/GID (Geographic Intersection Description) data

https://transportationops.org/spatchallenge

Initiation of the Connected Fleet Challenge

- DSRC to broadcast Safety Message Spat/Map

Challenge

For fleet operators to equip at least one vehicle by 2021

https://transportationops.org/spatchallenge

What about public transport

- 20-25 million trips per month on MBTA rail system
- Governments would be wise to keep their underground systems in good working order

—"Jam Tomorrow," The Economist, January 20, 2018

Observations and industry predictions

- Within 10 years of regulatory approval of autonomous vehicles, 95% of US passenger miles traveled will be served by on-demand autonomous electric vehicles owned by fleets, not individuals, in a new business model we call "transport-as-a-service"

  —RethinkX, "Rethinking Transportation 2020-2030," May 2017

- By 2020, it is expected that 10 million self-driving cars will be on the road while there will be more than 250 million smart cars–cars connected to high-tech networks–sharing the road with them

  —Forbes, November 2017

The future…

ITE Update

- ITE Position Statement on CV/AV (www.ite.org)
  - Starting point for dialogue; welcome feedback.
  - Will be updated
- ITE CV/AV Steering Committee – Chair: Steve Kuciemba
  - Current focus – coordinating ITE response to rulemakings, RFI, etc.
  - Future focus – helping ITE members with emerging practice guidance
- Member Engagement
  - ITE Annual Meeting – Minneapolis, August 20-23
    - **Smart Communities Workshop – August 20 – Emphasis on Connectivity, Smart Communities Solutions, AV deployment**
    - **Technical Program – includes CV/AV sessions, exhibits, demos**
  - National Rural ITS Meeting – Scottsdale, October 22-24
    - **Technical Program – includes CV/AV for rural and small communities**
    - **USDOT National Dialogue session – October 24-25 (tentative)**

ITE Focus: Design, management and operation of local public infrastructure in a connected and automated future

National Particpation

- Insuring Nevada is participating in national conversations and research regarding CAV
  - AASHTO
  - NGA
  - ITS
  - NAS