

# WSDOT efforts to prepare for connected and autonomous vehicles

## **Washington State Transportation Commission**

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Engineering Manager: Major Electrical Systems And Operational Initiatives

December 13, 2017

# What is a Connected Autonomous Vehicle?

## Connected Vehicle

Communicates with nearby vehicles and infrastructure; Not automated



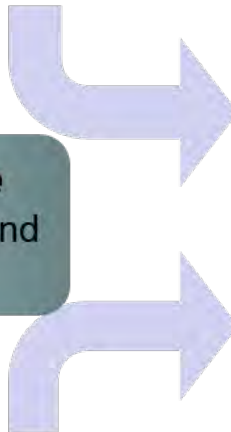
## Connected Automated Vehicle

Leverages autonomous automated and connected vehicles

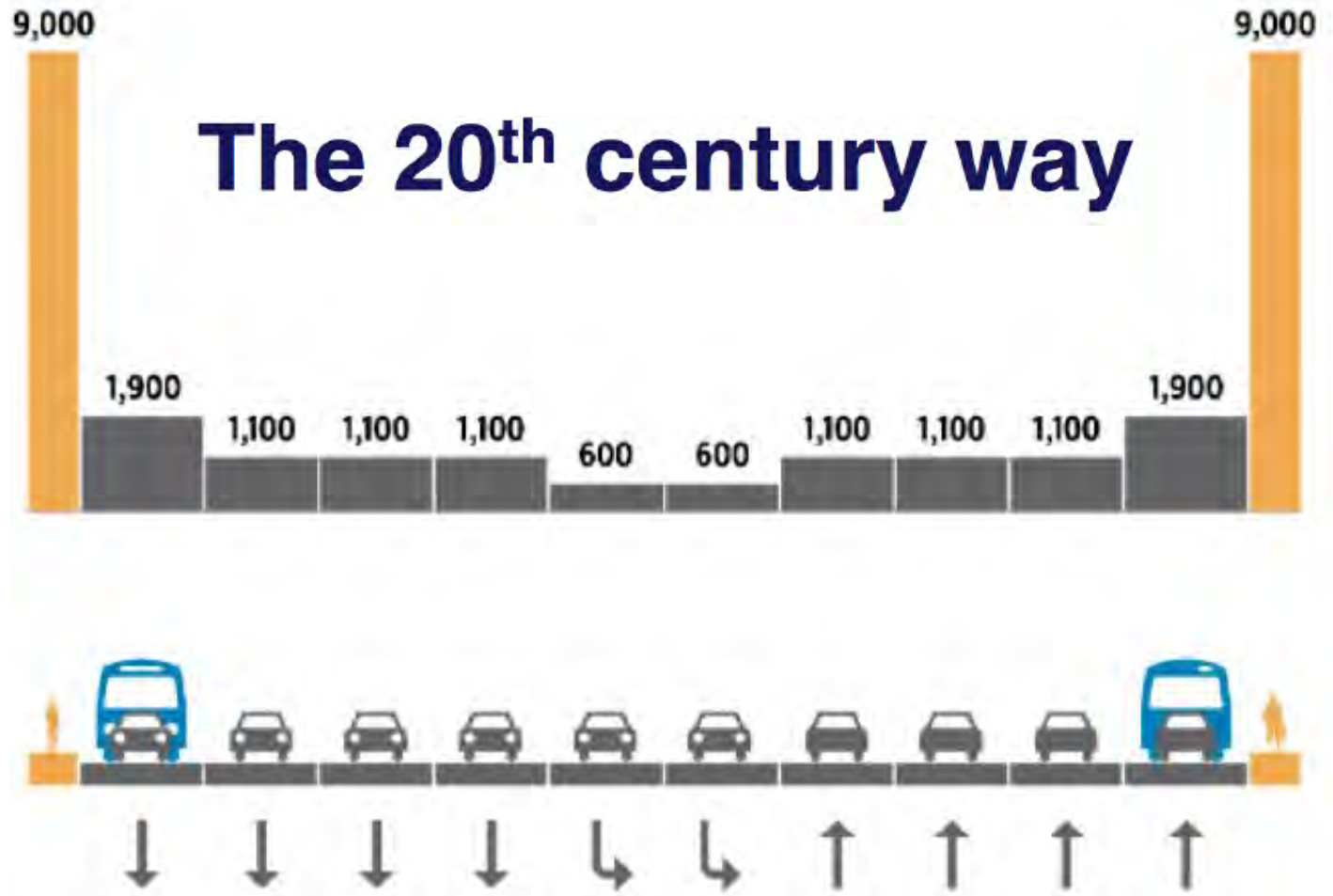


## Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors



# What should the focus be?



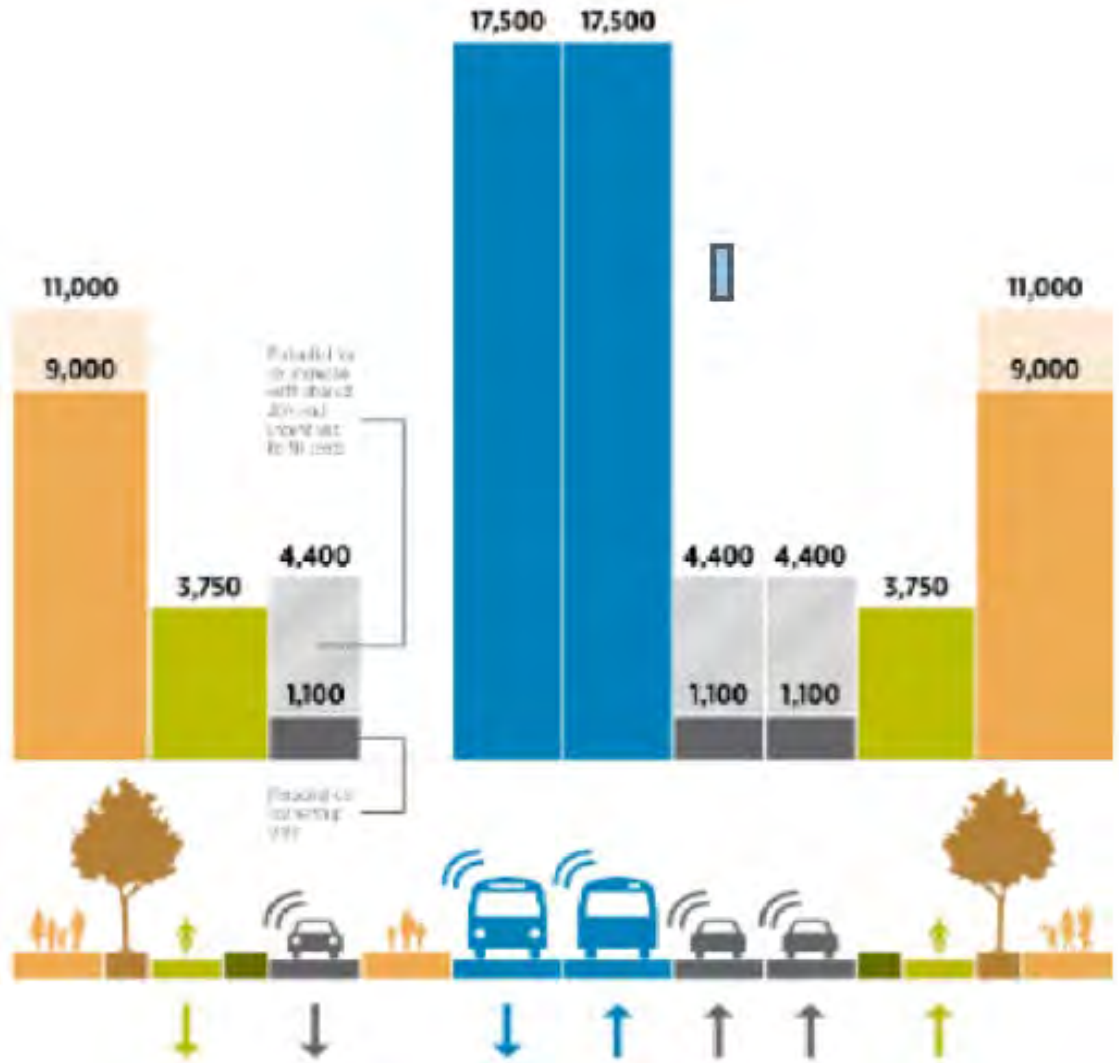
# What should the focus be?

**Are we focused on:**

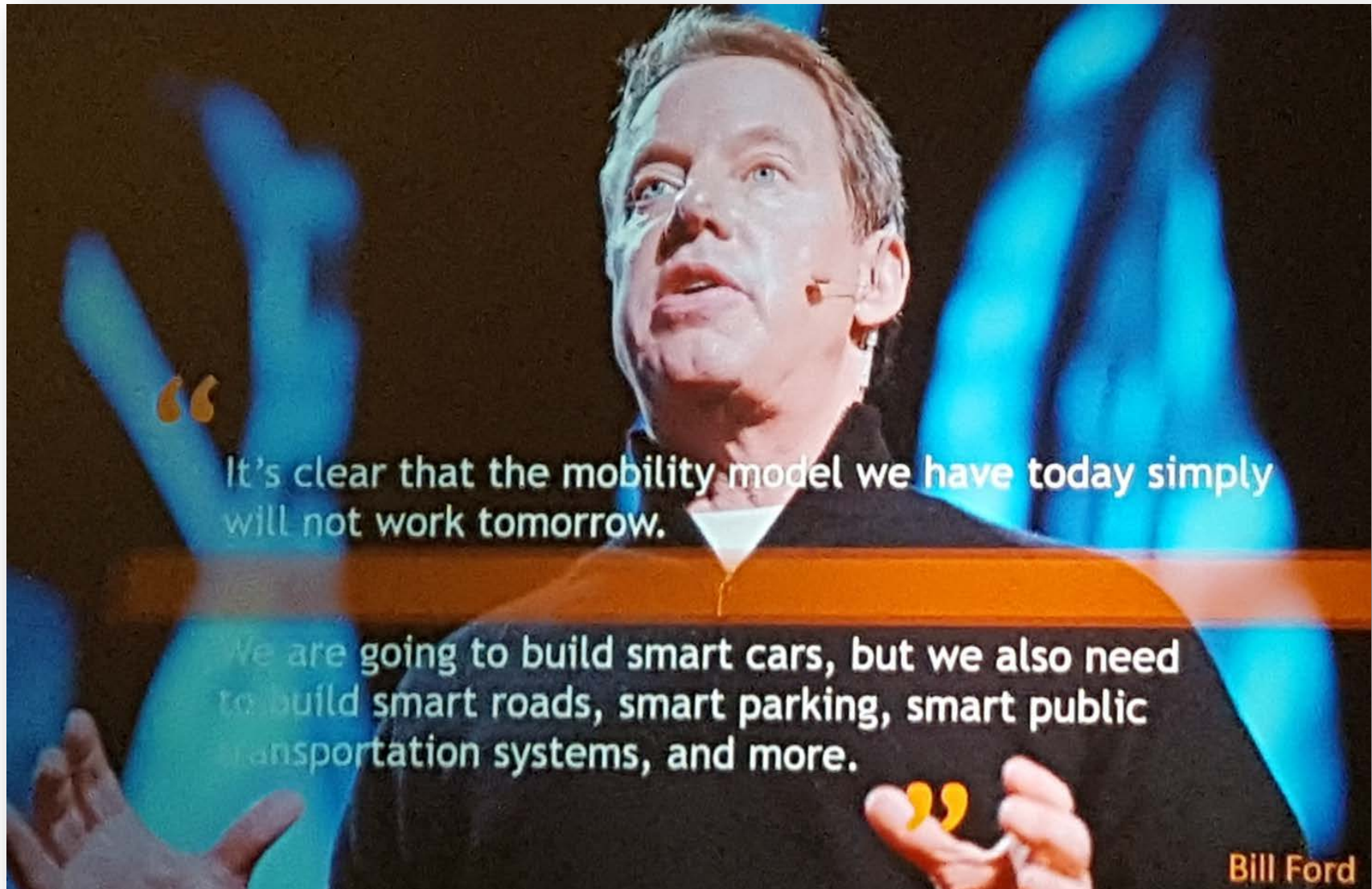
Replacing the human driver with a robot?

**or**

Enhancing the lives of the people we serve?



# What should the focus be?



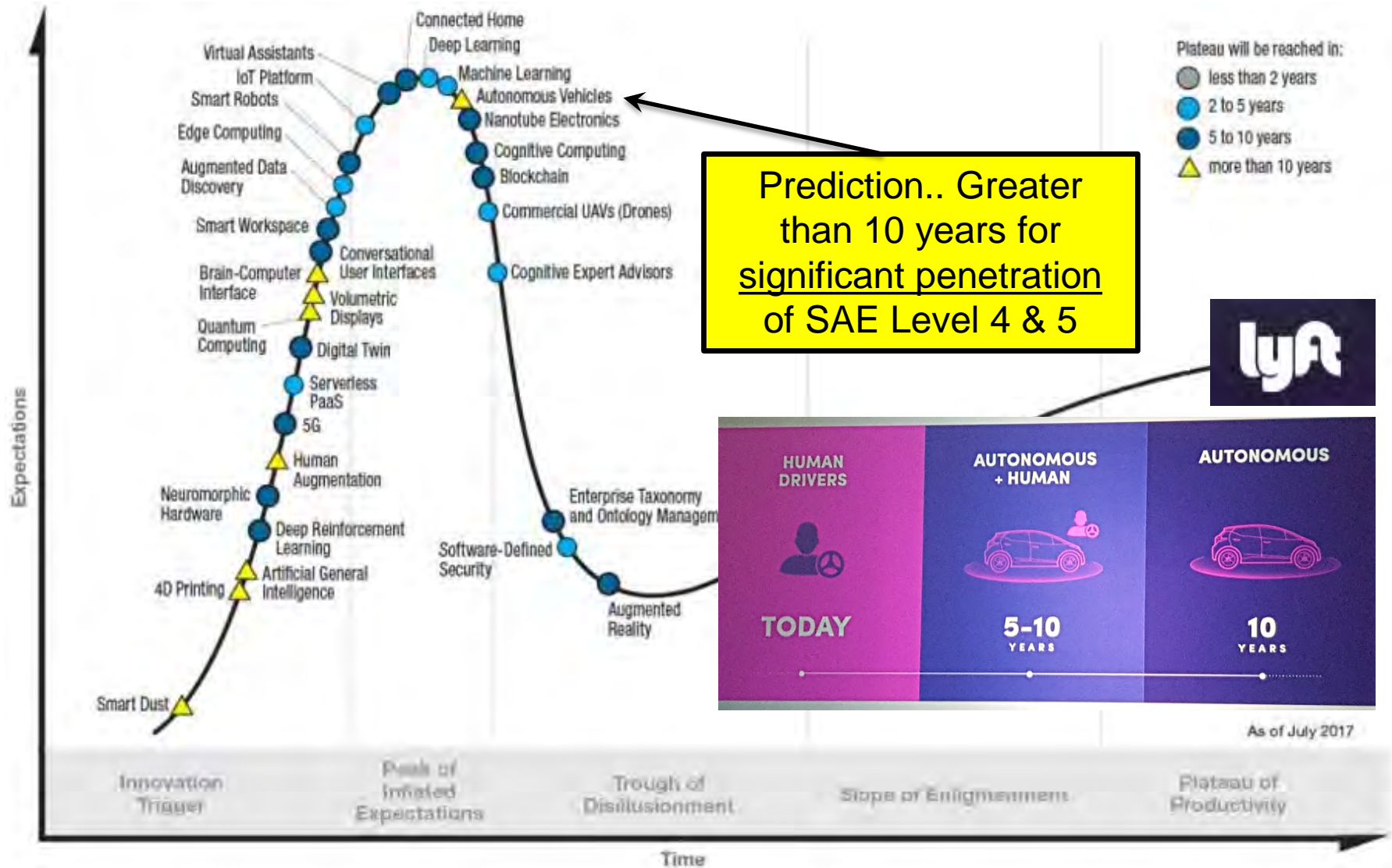
# So when will Autonomous Vehicles arrive?

		Steering and acceleration/ deceleration	Monitoring of driving environment	Fallback when automation fails	Automated system is in control
Human driver monitors the road	<b>0</b> NO AUTOMATION				N/A
	<b>1</b> DRIVER ASSISTANCE				SOME DRIVING MODES
	<b>2</b> PARTIAL AUTOMATION				SOME DRIVING MODES
Automated driving system monitors the road	<b>3</b> CONDITIONAL AUTOMATION				SOME DRIVING MODES
	<b>4</b> HIGH AUTOMATION				SOME DRIVING MODES
	<b>5</b> FULL AUTOMATION				

**Where  
we are  
Today**

# So when will Autonomous Vehicles arrive?

## Gartner **Hype Cycle** for Emerging Technologies, 2017



# So when will Autonomous Vehicles arrive?

- There are > 2,600 companies testing 2 to 3 vehicles each (SAE Level 4 or 5) somewhere in the world right now.
- Every single one of these vehicles was retrofitted.
- There could be a marketable retrofit kit available within 2-3 years

*Source:* Insurance Thought Leader, Guy Fraker: Tracking AV Startup companies world wide



# So when will Autonomous Vehicles arrive?

**However...** Tesla claims their current models are SAE Level 5 ready today from a hardware standpoint, what they are missing is the software and algorithms to fully utilize all the hardware. They also need favorable, ideally consistent nationwide, enabling legislation at some point in the future....

Many current Tesla owners will be able to go to Level 5 with an over the air firmware upgrade at some point in the future....



# Some of the benefits...

**Safety:** 34,000 deaths each year, 94% likely correctable

**Mobility:** “It Depends” VMT could go down 60% or up 200%,  
It depends on who owns the vehicles, private or  
shared mobility.

**Infrastructure Sustainability:** At full penetration of SAE  
Level 5 what is really needed beyond the pavement?

**Inclusion:** Reclaimed mobility, independence  
and quality of life for those that can no longer drive  
themselves

**Time:** Reclaimed ability to work, play, sleep, eat, text while you  
travel

**Environment:** Vehicles will likely be 100% electric and with shared  
mobility reduce VMT.

# Some of the challenges...

1. **Insurance** – How do you assign responsibility?
2. **Legislation** – Regulating too far too fast could hinder innovation
3. **Cybersecurity**
4. **Funding** for transportation system investments – Will AV's usher in a replacement for the gas tax? VMT based Road User Charge
5. **Public Acceptance**
6. **Technological requirements** are uncertain
7. **Pilot Testing** restrictions – Controlled facilities or public roads?
8. **Education** – Assessing the trusted sources for information
9. **Technical Capability and Capacity** of the current workforce
10. How do you plan for something that's **not fully understood**?
11. Too Many **Unknowns**

# Some of the challenges...

Is testing on public roads necessary?

## Public Acceptance

**How long would it take a fleet of 100 autonomous vehicles driving 24 / 7 / 365 at 25mph to demonstrate reliability?**

		Benchmark Failure Rate		
Statistical Question	How many miles (years <sup>a</sup> ) would autonomous vehicles have to be driven...	(A) 1.09 fatalities per 100 million miles?	(B) 77 reported injuries per 100 million miles?	(C) 190 reported crashes per 100 million miles?
	(1) without failure to demonstrate with 95% confidence that their failure rate is at most...	275 million miles (12.5 years)	3.9 million miles (2 months)	1.6 million miles (1 month)
	(2) to demonstrate with 95% confidence their failure rate to within 20% of the true rate of...	8.8 billion miles (400 years)	125 million miles (5.7 years)	51 million miles (2.3 years)
	(3) to demonstrate with 95% confidence and 80% power that their failure rate is 20% better than the human driver failure rate of...	11 billion miles (500 years)	161 million miles (7.3 years)	65 million miles (3 years)

<sup>a</sup> We assess the time it would take to complete the requisite miles with a fleet of 100 autonomous vehicles (larger than any known existing fleet) driving 24 hours a day, 365 days a year, at an average speed of 25 miles per hour.

**In order to have 95% confidence that AV's are 20% safer than Human Drivers: 1 Fatality per 100 million vehicle miles AV's would need to drive 11 billion miles which in this case would take 500 years.**

Reference: Rand Corporation: *Driving to Safety*, Nidhi Kalra, Susan Paddock, 2016

# Department of Licensing Autonomous Vehicles: Self Certification Testing in WA State

The screenshot shows the Washington State Department of Licensing website. The top navigation bar includes a search box, a login link for 'License eXpress', and links for 'Office Locations' and 'Forms'. Below this is a main menu with buttons for 'Home', 'Drivers', 'Vehicles', 'Professions', 'List of Licenses', and 'Moving to WA'. On the left side, there is a vertical list of links for various services, with 'Self-certification for testing in Washington State' highlighted in a blue box. The main content area features a blue header for the current page, followed by a section titled 'Who needs to self-certify?' with a brief description. Below that is a 'How to self-certify' section with a link to a 'Self-certification form'. The page then details 'Testing with human operators present' and 'Testing without human operators present', each with a list of requirements. A 'Self-certified companies' section lists 'Simple Solutions' and 'TORC Robotics'. Finally, a 'Related information' section includes a link to the 'Autonomous Vehicle Testing & Technology in Washington State and Autonomous Vehicle Work Group'.

**Autonomous vehicles: Self-certification for testing in Washington state**

**Who needs to self-certify?**  
Companies conducting, testing, and operating autonomous vehicles on the roads of Washington state.

**How to self-certify**  
Before beginning a pilot program, submit a [Self-certification form](#) confirming that you are compliant with the following:

**Testing with human operators present**

- Only a trained employee, contractor, or other person authorized by the company developing the autonomous technology can operate or monitor the vehicles.
- Vehicles must be monitored, and an operator must have the ability to direct the vehicle's movement if assistance is required.
- Anyone operating an autonomous vehicle needs a valid U.S. driver license.
- Proof of insurance is required by [RCW 46.30.020](#) (*leg.wa.gov*).

**Testing without human operators present**

- Vehicles must be equipped with an automated driving system that performs all driving tasks on a part or full-time basis within their operational design limits. Vehicles must also be able to make it to a safe condition in the event of a system failure.
- Vehicles must comply with [Washington state motor vehicle laws](#) (*leg.wa.gov*) relevant to the vehicle's operational design limits.
- Proof of insurance is required by [RCW 46.30.020](#) (*leg.wa.gov*).

**Self-certified companies**

- Simple Solutions
- TORC Robotics

**Related information**

- [Autonomous Vehicle Testing & Technology in Washington State and Autonomous Vehicle Work Group](#)

# How is WSDOT preparing?

## Internal CAV Task Force

- Learn, Monitor, Engage, Educate, Advise, Make recommendations to be enacted within the next 5 years

## Research, Pilot Projects, Demonstrations

- Winter Operations, Work Zone Safety, I-5 ATM, Traffic Signal Operations and Modeling

## External Engagement

- Conferences, Technical Training, Pooled Funds, Peer Exchanges, Policy Forums, Governor's AV Workgroup, TRB, Review State and Federal Legislation, Multijurisdictional Coordination

## Communication

- Weekly News Clips, News Media

## Near Term Products

- Preparing a CAV Readiness Roadmap with preliminary recommendations
- Preparing a plan to improve Pavement Markings and Signing

# Internal CAV Task Force

- Started in May 2017, Monthly Meetings
- Serves as a consolidated clearinghouse to communicate, coordinate, evaluate and pursue CAV related issues
- Provide insight, guidance and direction within WSDOT
- Participate regionally and nationally
- Recommend research, pilots, changes to policies, procedures, standards, operations, organizational structure, funding levels that will enable CAV

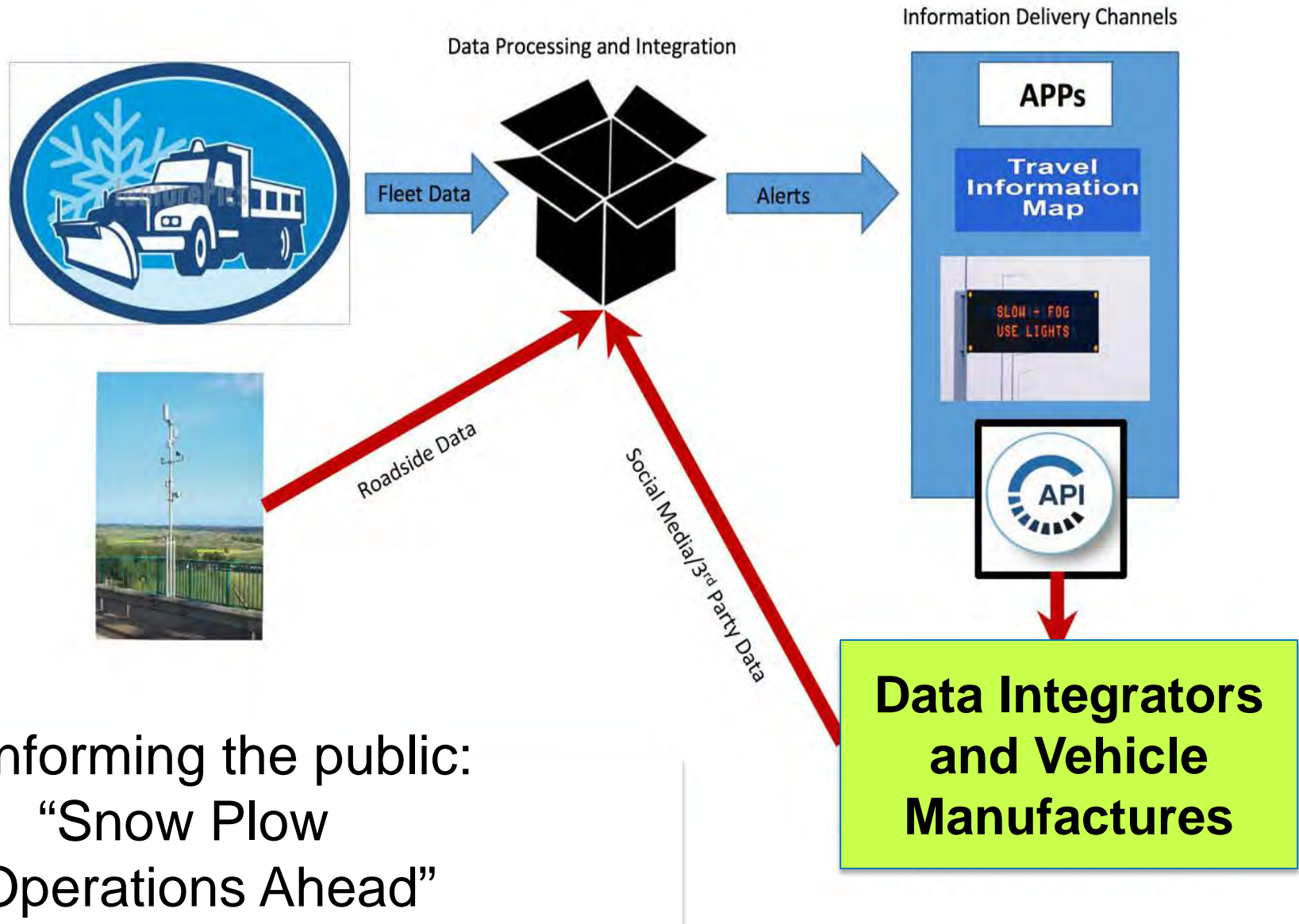
# I-5 Active Traffic Management Connected Vehicle Demonstration

**Successfully** Tested Vehicle 2 Infrastructure (V2I) technology on I-5 to replicate the functionality of Active Traffic Management through in-vehicle messaging using DSRC connected vehicle technology.





# Winter Operations Pilot



# University Research (UW & WSU)

1

## Preparing for Connected Vehicle Opportunities – UW

- Provide guidance on what CAV issues / technologies we should pursue as a State DOT in relation to Smart Cities.

2

## Enhancing Roadway Safety and Operations – UW

- Collecting and sharing information between pedestrians, bicycles, transit vehicles and traffic signals to enhance safety and operations through DSRC

3

## Preparing for changes in Traffic Signal Operations – WSU

- What locations would benefit from CV equipment first and how should we adjust traffic signal timing?

# Traffic Signal Pilot Project



**Communicating traffic signal information to vehicles through the cloud**



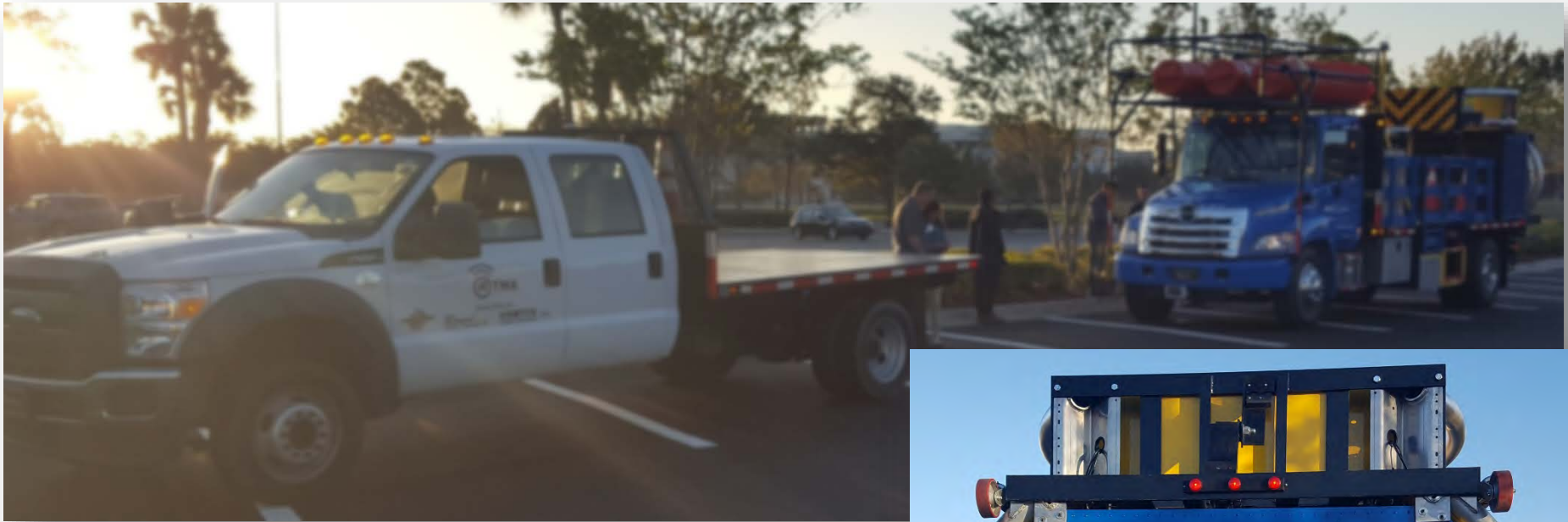
# Traffic Signal Pilot Project

- 2 Locations along US 2 North of the City of **Spokane**
- 2 Locations along US 2 West of the City of **Spokane**
- 10 Locations along SR 522 North of Lake Washington through the **Cities of Lake Forest Park and Kenmore**
- 6 Locations along SR 305 from the **Bainbridge Island Ferry Terminal to the City of Poulsbo**
- 4 Locations along SR 500, between I-5 and I-205, through the **City of Vancouver**



**AASHTO SPaT – Initial locations planned for DSRC CV Technology Deployment**

# Work Zone Safety Pilot



- Pilot Truck and Autonomous Attenuator Vehicle
- 2018 Pilot with Other States
- Considering Low Speed Striping Operations



# Incorporating CAVs into the Long Range Planning Process

WTP 2040

## **Text Suggested during Public Comment Period:**

Connected and Autonomous Vehicles (CAV), Electric Vehicles and Shared Mobility are all technological developments that will have significant implications on our transportation system. While FHWA predicts CAVs will significantly increase safety and reduce crashes, researchers and analysts do not agree on whether these developments will drastically increase or decrease vehicle miles traveled (VMT). Anticipating and planning for the interaction of these developments may not be easy, but planners should take a number of possibilities into consideration.

For example, if shared mobility and CAVs develop and quickly become dominant vehicles, do plans consider the impacts on an increase in parking demand, or a substantial decrease in parking demand? What will the demand be for park and rides in a CAV dominant scenario? How will plans consider the changes in associated land use? How can CAVs be an extension to a robust transit system to serve the first mile Last Mile needs? At the end of the day, any long-range planning process needs a thorough exploration of the potential impacts to the transportation system given a wide array of potential outcomes.

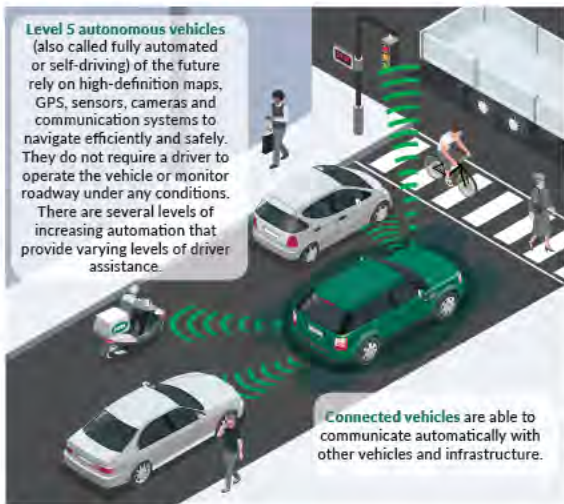
# Developing Educational Information



DRAFT

OCTOBER 2017

## Connected and Autonomous Vehicles



**SAFETY**  
CAVs have tremendous potential to improve roadway safety by eliminating driver errors, which are the major contributing factor in roughly 94 percent of all fatal vehicle crashes.

**CONGESTION REDUCTION**  
By communicating with vehicles and infrastructure around them, CAVs have potential to reduce highway congestion and commute times while decreasing the need for more lanes.

**INCREASED MOBILITY**  
Autonomous vehicles could improve mobility for the elderly and people with disabilities who can't currently drive a traditional vehicle.

VEHICLE AUTOMATION LEVELS					
0	1	2	3	4	5
<b>No Automation</b>	<b>Driver Assistance</b>	<b>Partial Automation</b>	<b>Conditional Automation</b>	<b>High Automation</b>	<b>Full Automation</b>
Driver performs all driving tasks.	Driver controls vehicle, but some driving assist features are included.	Vehicle has combined automated functions, such as steering and acceleration, but driver must remain engaged with driving and monitor environment at all times.	Driver necessary but not required to constantly monitor the environment. <b>DRIVER MUST BE READY TO TAKE CONTROL WITH NO NOTICE.</b>	Vehicle can perform all driving functions under certain conditions. Driver may have option to control vehicle.	Vehicle can perform all driving functions under any condition. Driver may have the option to control the vehicle.

## WSDOT AND CONNECTED AUTONOMOUS VEHICLES

WSDOT is committed to preparing for CAV technology and is researching infrastructure needs, planning considerations for future projects and impacts to existing roadways and technology.

### WSDOT CAV Task Force

WSDOT's internal CAV Task Force is investigating the challenges and opportunities CAVs bring to Washington roadways – and how to best prepare roadways and infrastructure for the new technology.

The task force has hired a consultant to review other states' efforts in this field and produce a roadmap with recommend next steps for WSDOT initial readiness. Some CAV challenges to resolve include:

- Difficult to plan for still-evolving technology
- May require more frequent striping and sign maintenance to allow CAVs to "see" road markings
- Best way to include CAV in all future project planning
- More education and pilot testing needed about CAVs to achieve widespread public acceptance
- Effect of CAVs on traffic modeling and predictions.
- CAV impacts to existing and future smart technology infrastructure.

### Pilot projects

WSDOT is conducting pilot projects using CAV technology including:

**Winter Operations Pilot** – Using various connected vehicle technologies, WSDOT will share real-time road conditions from snow plows, etc., to give motorists direct information (via apps or vehicle safety systems) of road conditions and adverse weather. Could also provide info about nearby roadway work.

**Traffic signals** – Test how existing WSDOT signal systems can communicate with CAVs to improve

intersection safety and timing as well as overall traffic operations. Will also test how WSDOT systems can communicate the presence of pedestrians and bicyclists to avoid potential collisions.

**Automated Work Zone vehicles** – Test how autonomous vehicles could improve work zone safety. An autonomous attenuator vehicle – placed before a work zone to absorb the impact of any motorist crashes – would no longer need a driver, who is still at risk during an impact.

### State Level

WSDOT staff are on the Governor's Autonomous Vehicles Work Group, engaged in a broad range of CAV issues. The work group also includes:

- Governor's Office
- Commerce Department
- Department of Licensing
- Washington State Patrol
- Washington Traffic Safety Commission
- Governor's Office for Regulatory Innovation and Assistance
- Other Public and Private Advisors

Governor Jay Inslee's June 2017 Autonomous Vehicle Testing and Technology executive order promotes the safe testing and operation of autonomous vehicles, including ongoing pilot programs, to help Washington remain a technology innovator. It also calls on all state agencies to assist in these efforts and formally establishes the work group.

### MORE INFORMATION

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# Preparing to improve roadway Signing and Striping

**“Good for human drivers today ..... Prepares for  
AV’s tomorrow”**

Preparing a plan for how to approach an increased  
programmatic biennial investment in signing and  
striping



# What else could we pursue?

1. Look at cities and counties that are focused around **pick-up drop-off zone policies**. Allowing people to be picked up and dropped off anywhere may negatively impact congestion.
2. Support **legislation that supports continued DSRC** deployment and protects the **5.9 GHz public safety band** for interference-free operations.
3. Consider **opportunities to leverage public roadway** right of way assets in support of CV deployments. (e.g. Delaware recently passed legislation to allow telecom companies to construct cell towers on state R/W in exchange for the installation of CV supporting technologies)
4. Explore the potential to **expand the scope** of use for the funds that are generated from the current **\$150 Electric Vehicle** car tab fee.
5. Improve real-time **communication of ongoing work zone operations**
6. Improve real-time **communication of construction activities**

# What else could we pursue?

## Autonomous Shuttle Pilot?



**1<sup>st</sup> Mile / Last Mile  
Connection to  
Transit through  
partnerships with  
rideshare  
companies?**

# What else could we pursue?

## Pierce County, Wash., Transit Deploys System to Help Buses Avoid Collisions with Pedestrians, Bicyclists

*Researchers at the University of Washington are compiling data on the system to help determine whether it is “as effective as claimed.”*

BY ADAM LYNN, THE NEWS TRIBUNE (TACOMA, WASH.) / OCTOBER 18, 2016

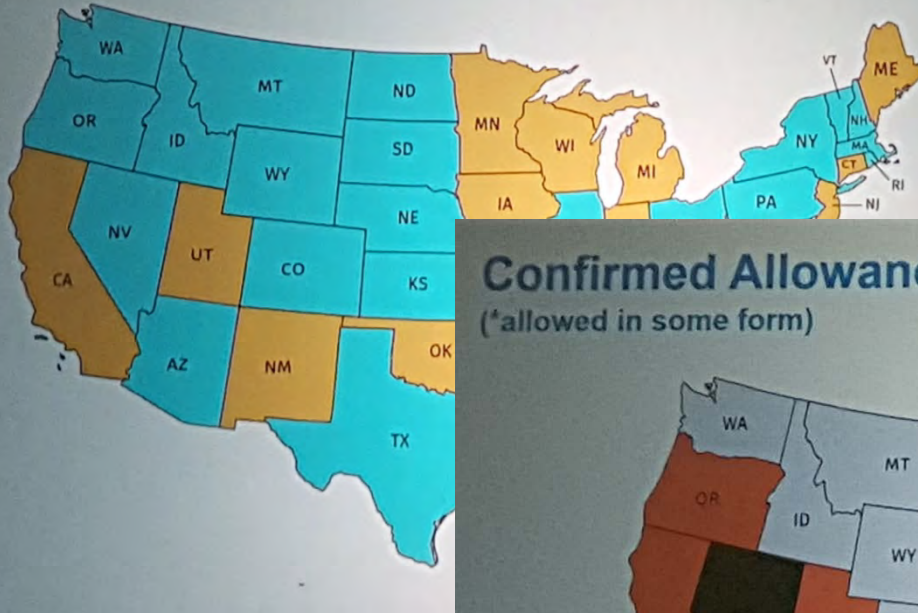


FLICKR/SOUNDERBRUCE

**Continue automated pedestrian and bicycle detection pilots with the addition of automated braking and connection to traffic signals operations.**

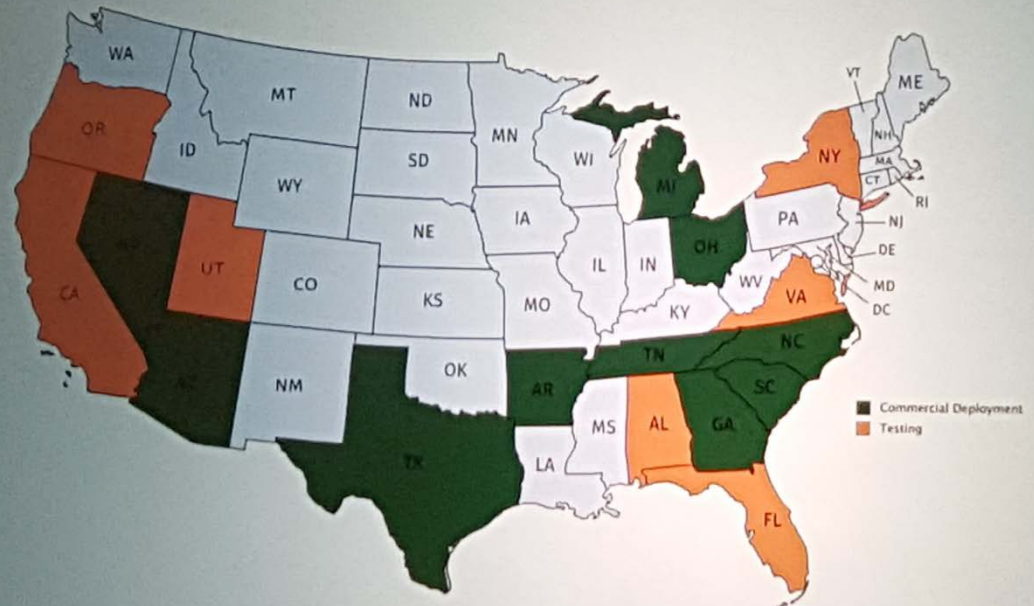
# What else could we pursue?

“Following Too Closely:” Qualitative vs Quantitative Laws



**Truck  
platooning  
pilots?**

Confirmed Allowance\* of Truck Platooning  
(\*allowed in some form)

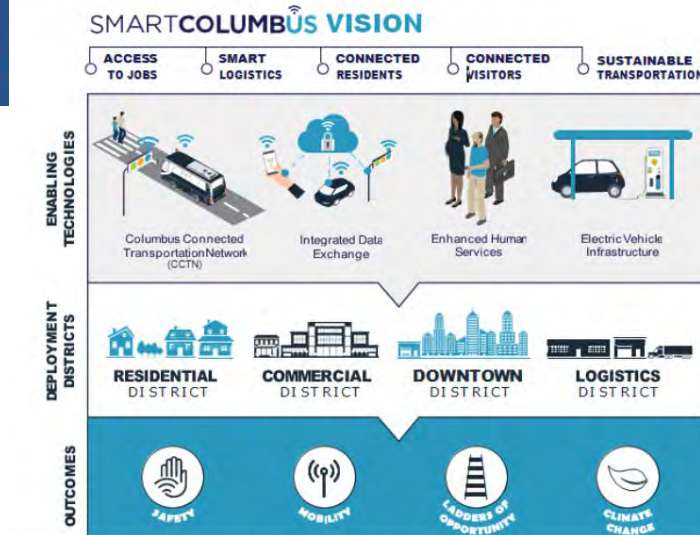


**May require some  
changes to state  
statutes?**

# What else could we pursue?



## Columbus Smart City Challenge Implementation Vision



Prepare for the next Federal Grant Opportunity

## Connected Vehicles Connected Vehicle Pilot Deployment Program



New York City DOT Pilot



Tampa-Hillsborough Expressway Authority Pilot



Wyoming DOT Pilot

# What else could we pursue?



Consider a new or existing local forum / summit / conference that could help consolidate and coordinate the discussion in WA State

A banner for a "Seminar Series" titled "AUTOMATED - CONNECTED - ELECTRIC - SHARED". It features logos for Discovery Institute, ACES Northwest Network, and Cascadia. Below the logos, it says "Brought to you by: UCLA Luskin Center for Innovation, UCLA Center for the Safety and Reliability of Systems, Local Government Commission, Caltrans, Connected Consulting, and Transpo". At the bottom, it says "THE AGE OF MOBILITY IS NOW".



# How are we / should we invest compared to other State DOTs?

## CURRENT LEVEL OF ENGAGEMENT

As technology advances, state and regional agencies are increasingly engaging in policy and planning to respond to the challenges and opportunities presented by Connected and Autonomous Vehicles (CAV). This snapshot summarizes high level results from a 2017 survey. For more information contact Matt Hardy of AASHTO.

How would you best describe your agency's level of engagement in policy and planning for connected and autonomous vehicles?



# WSDOT Investment Level

What should the target be?

## Level A Status Quo: Existing WSDOT CAV Task Force member Divisions commit to 20% of an FTE

Listening, Learning, Some Advising, Passive Regional and National Engagement, some partnership / pilot funding (Federal Research Funds)

## Level B Identify \$450k from existing 17-19 resources

Seat at the table to support partnership initiatives and pilot deployments

- \$50k – National Academies / TRB Forum – Preparing for AV and Shared Mobility
- \$100k – Connected Vehicle Pooled Fund

Funding to support Governor's AV Working Group – Technical Advisory Body

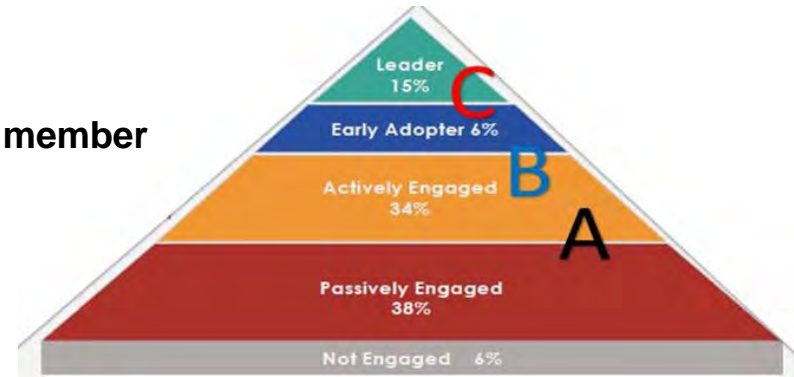
- \$100k – Consultant Contract to create an Initial WSDOT CAV Readiness Roadmap for the next 5 years

Funding to Support Pilots:

- \$100k – Work Zone Safety – Autonomous Truck Mounted Attenuator (TMA) Pilot
- \$100k – AASHTO SPaT Challenge – Connecting Traffic Signal Operations to Vehicles

## Level C Additional funding beyond existing resources

- \$900k – 2-3 Dedicated FTEs to implement WSDOT CAV Readiness Roadmap
- \$150k – Maintain partnership level commitments regional and nationally
- \$2M – Match funds to support federal grant and partnership opportunities





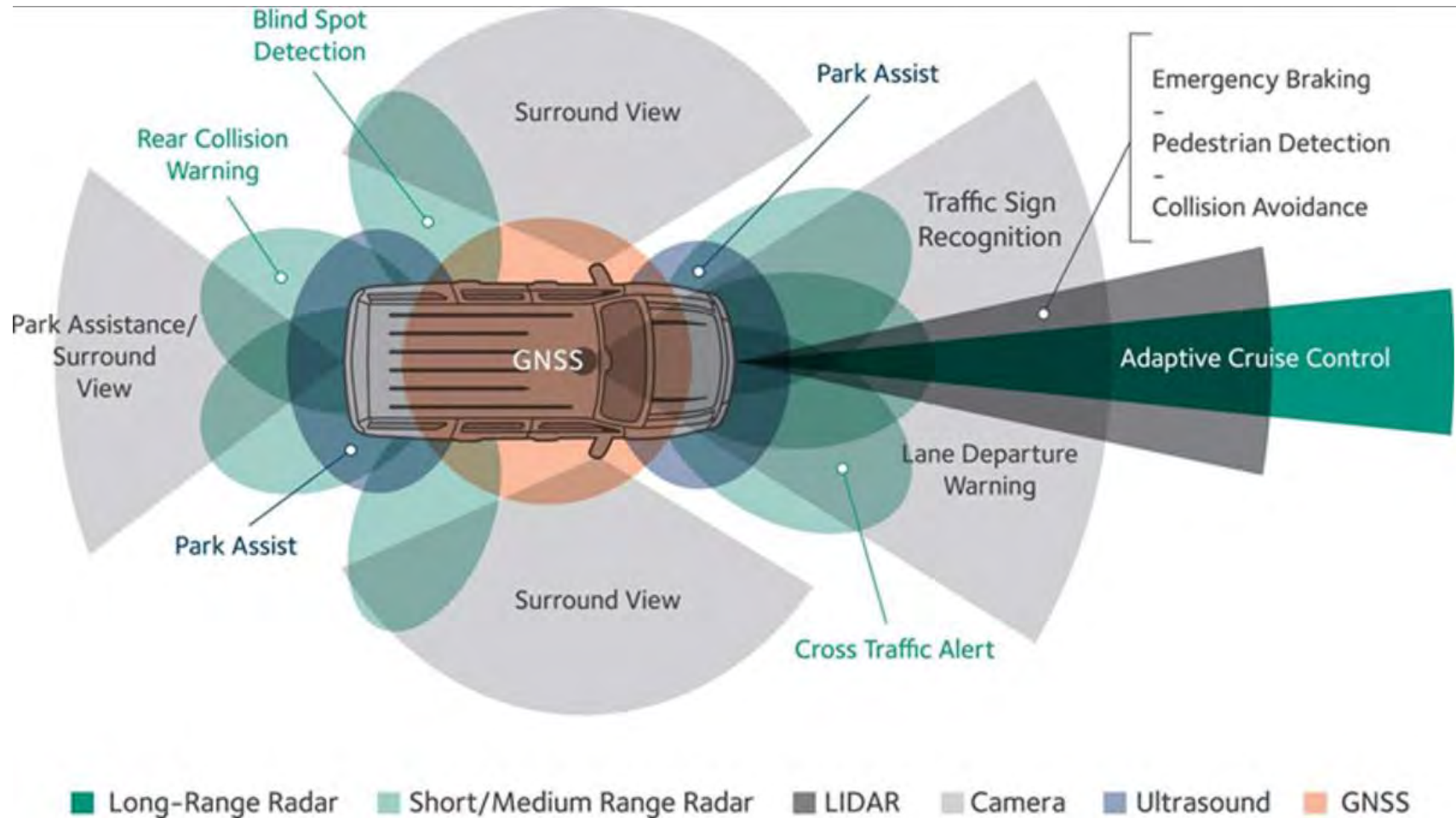
# Something to think about...

Is the ideal autonomous car one that will let you do what you want when you want right up until the point until you have an incident then the technology takes over?

## **Toyota thinks so...**

- They are developing a system called “Guardian.” The goal is to make a human driven car un-crashable.
  - Toyota Level 4 cars will be sold with the Guardian System
  - Full Level 4 in a geofenced area
  - Full self-control with “guardian backup” in areas where humans still desire to drive the car.

# THANK YOU



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