VTRC
Virginia Transportation Research Council

We bring innovation to transportation.

Connected and Automated Vehicle Implications for Planning and Operations

Cathy McGhee, P.E.

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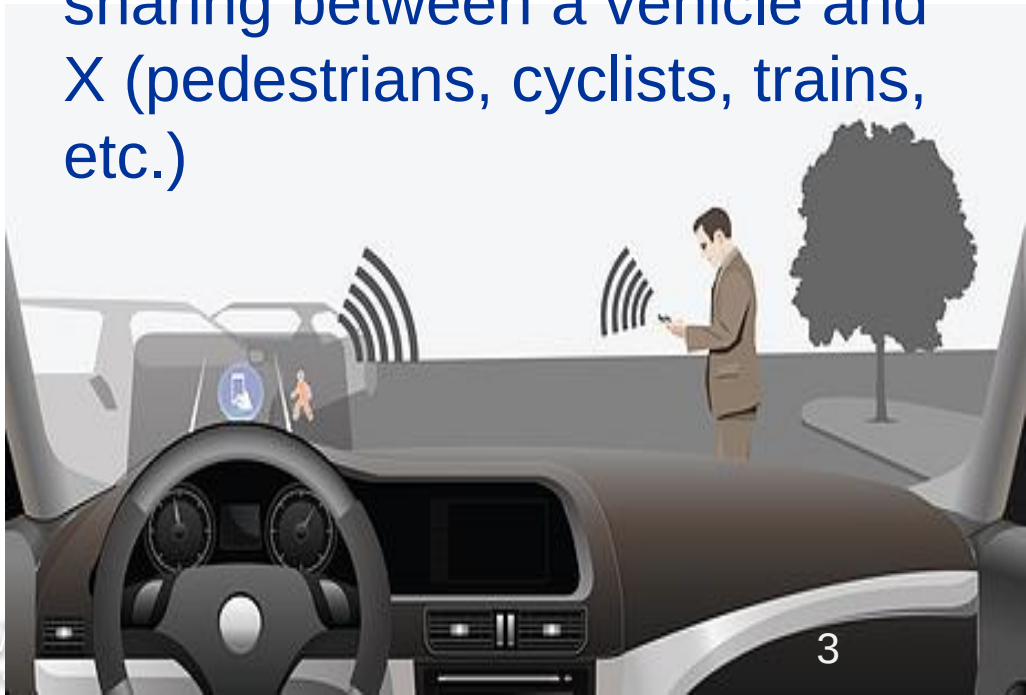
Technology Implications

- What changes will we see over the next 20 years and what impact will those changes have on our planning assumptions?

- What changes to our operational strategies and investments should we begin to make now to prepare for those changes?

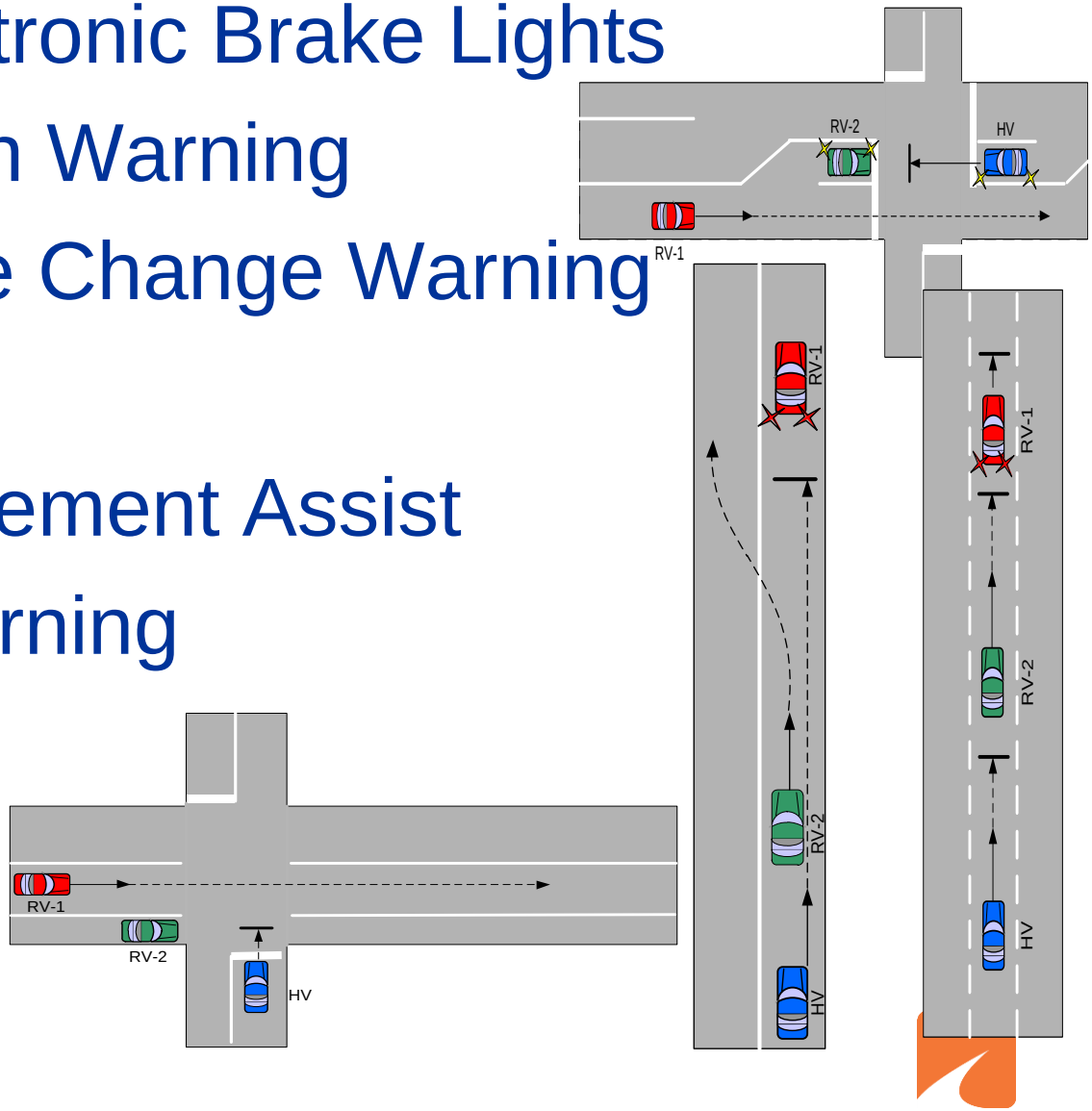
“Connected” Car?

- **V2V**: Bi-directional information sharing between vehicles
- **V2I**: Bi-directional information sharing between a vehicle and the roadway
- **V2X**: Bi-directional information sharing between a vehicle and X (pedestrians, cyclists, trains, etc.)



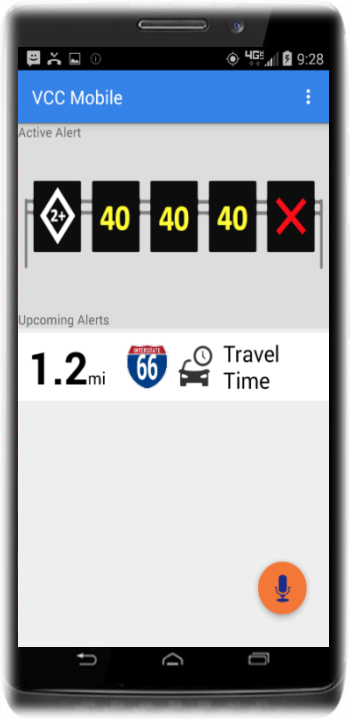
Example V2V Safety Applications

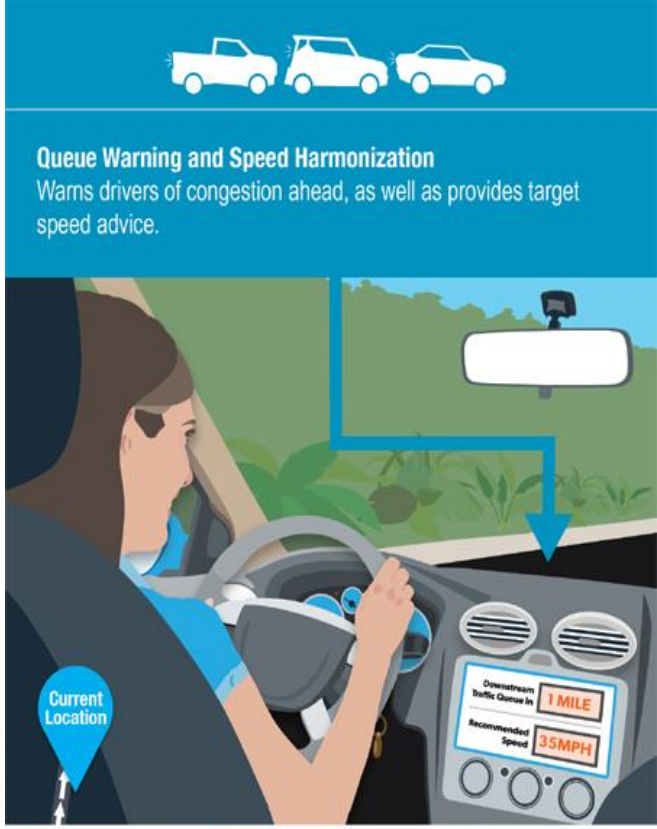
- Emergency Electronic Brake Lights
- Forward Collision Warning
- Blind Spot / Lane Change Warning
- Left Turn Assist
- Intersection Movement Assist
- Do Not Pass Warning
- Etc., Etc.

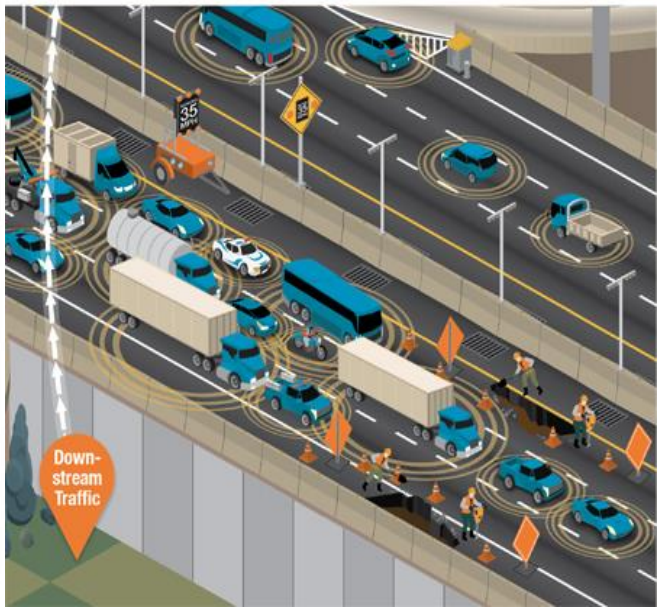


Example V2I Applications

- Queue Detection and Warning
- Red Light Violation Warning
- Merge Assistance
- Emergency Vehicle Preemption
- Transit Signal Priority
- Eco Traffic Signal Timing
- Dynamic Driver Messaging
- ATM Integration

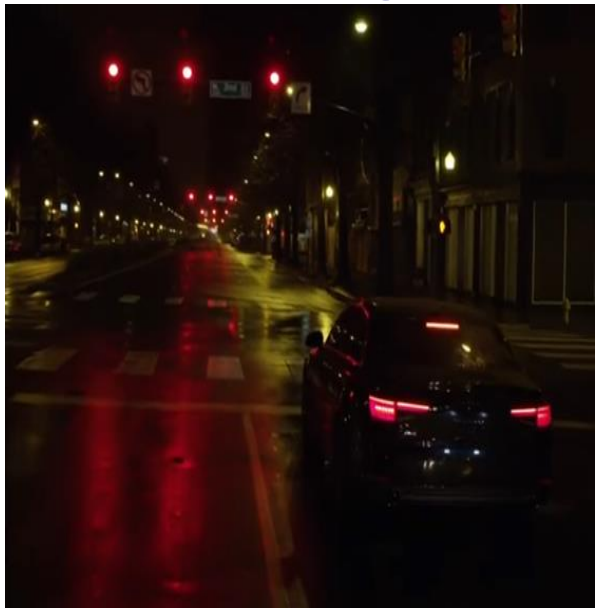






Early Implementation Example

- Audi PRIME traffic light feature
- Interface to centralized signal control system in several cities
- Counts down Red to Green phase change
- Uses cellular communications



Implications of Connected Vehicle Deployment

- Safety
  - V2V alone may address up to 81% of crashes involving unimpaired drivers (27K fatalities, 1.8M injuries, 7.3M property damage)[2]
  - V2I alone may address up to 19% of crashes involving unimpaired drivers[2]
- Mobility
  - Improved traffic flow and reduce delays (27%) [1]
  - Increased awareness of and access to multi-modal choices
  - More direct, actionable information for drivers (re-routing, incidents, weather, etc.)
- Environmental
  - Combined Eco-Signal apps may reduce CO2 and fuel consumption (11%)[1]
  - Signal and freeway lane management combined reduce fuel consumption (22%)[1]

1 - Estimated Benefits of Connected Vehicle Applications: Dynamic Mobility Applications, AERIS, V2I Safety, and Road Weather Management, http://ntl.bts.gov/ lib/56000/56200/56238/FHWA-JPO-16-255.pdf

2 – Harding, J., Powell, G., R., Yoon, R., Fikentscher, J., Doyle, C., Sade, D., Lukuc, M., Simons, J., & Wang, J. (2014, August). Vehicle-to-vehicle communications: Readiness of V2V technology for application. (Report No. DOT HS 812 014). Washington, DC: National Highway Traffic Safety Administration.

SAE Levels of Automation

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

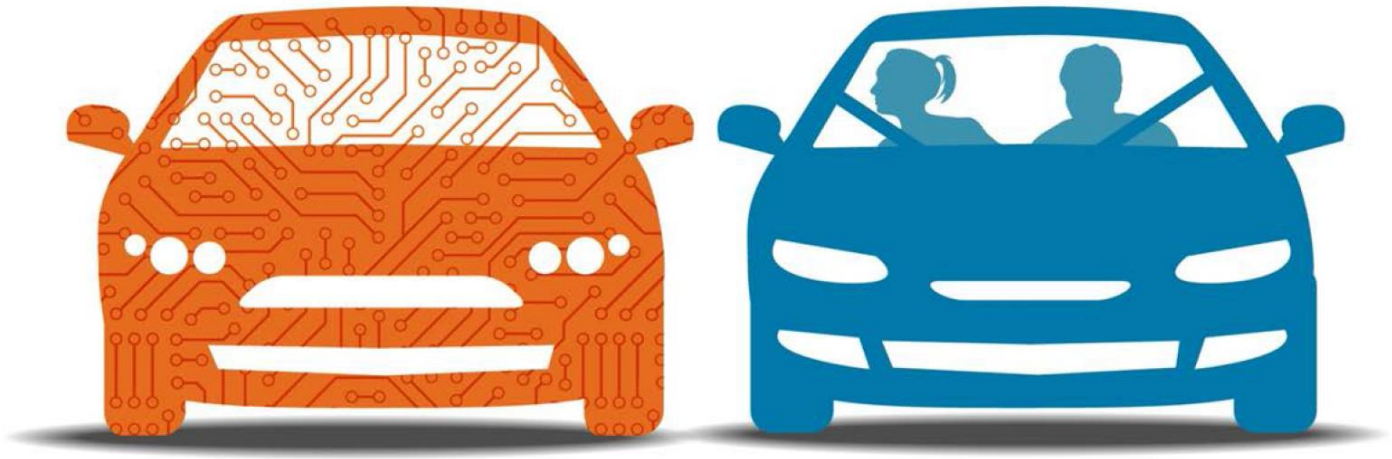
Difficult AV Challenges

Implications of Automated Deployment

- Implications depend on type of automation and level of adoption
  - Safety Implications
  - Roadway Capacity
  - Travel Demand
  - Auto-ownership
  - Mobility as a service

GHSA offers the following five pieces of advice for states as they grapple with the issue of AVs:

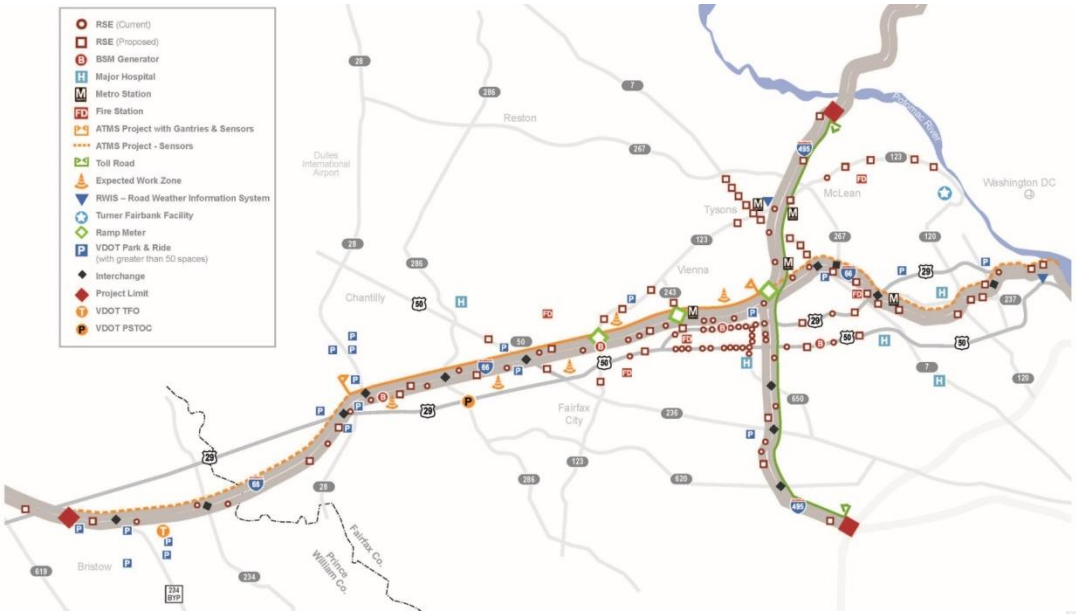
1. Be informed.
2. Be a player in your state.
3. Understand the role of states.
4. Don't rush into passing laws or establishing regulations.
5. Be flexible – this is a new game.

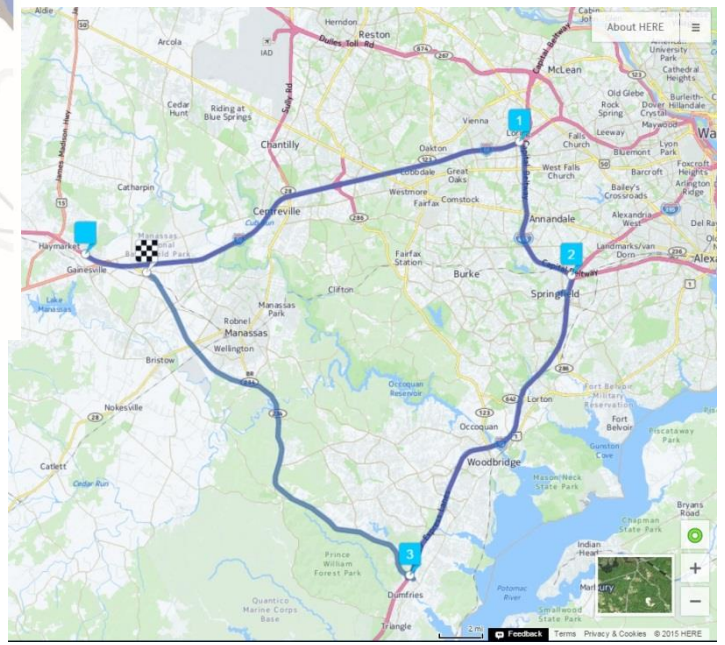


So what is VDOT doing?

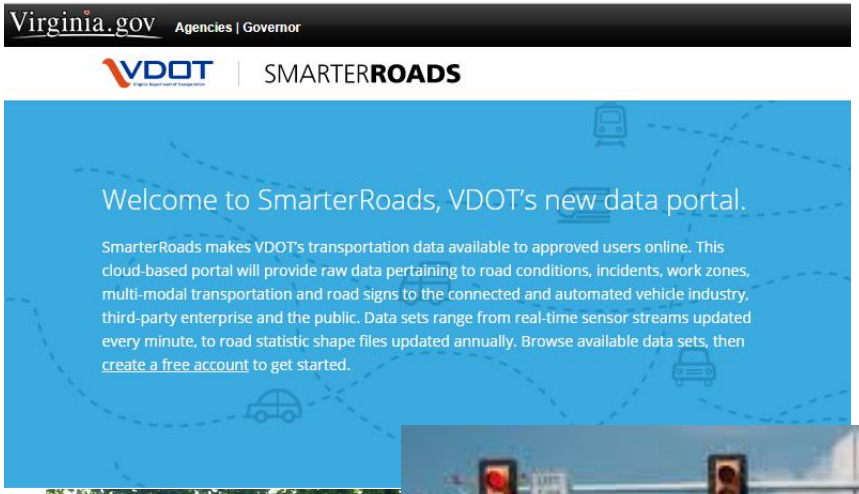
- Taking an evolutionary approach
- Focusing on implementation from the beginning
- Targeting existing challenges with new, technology-based solutions
- Supporting private development with minimal regulation

Virginia Connected and Automated Corridors





Recent Activities



For more information:

Cathy.McGhee@VDOT.Virginia.gov