VDOT
Virginia Department of Transportation

Connected and Automated Vehicles and the Future of Transportation

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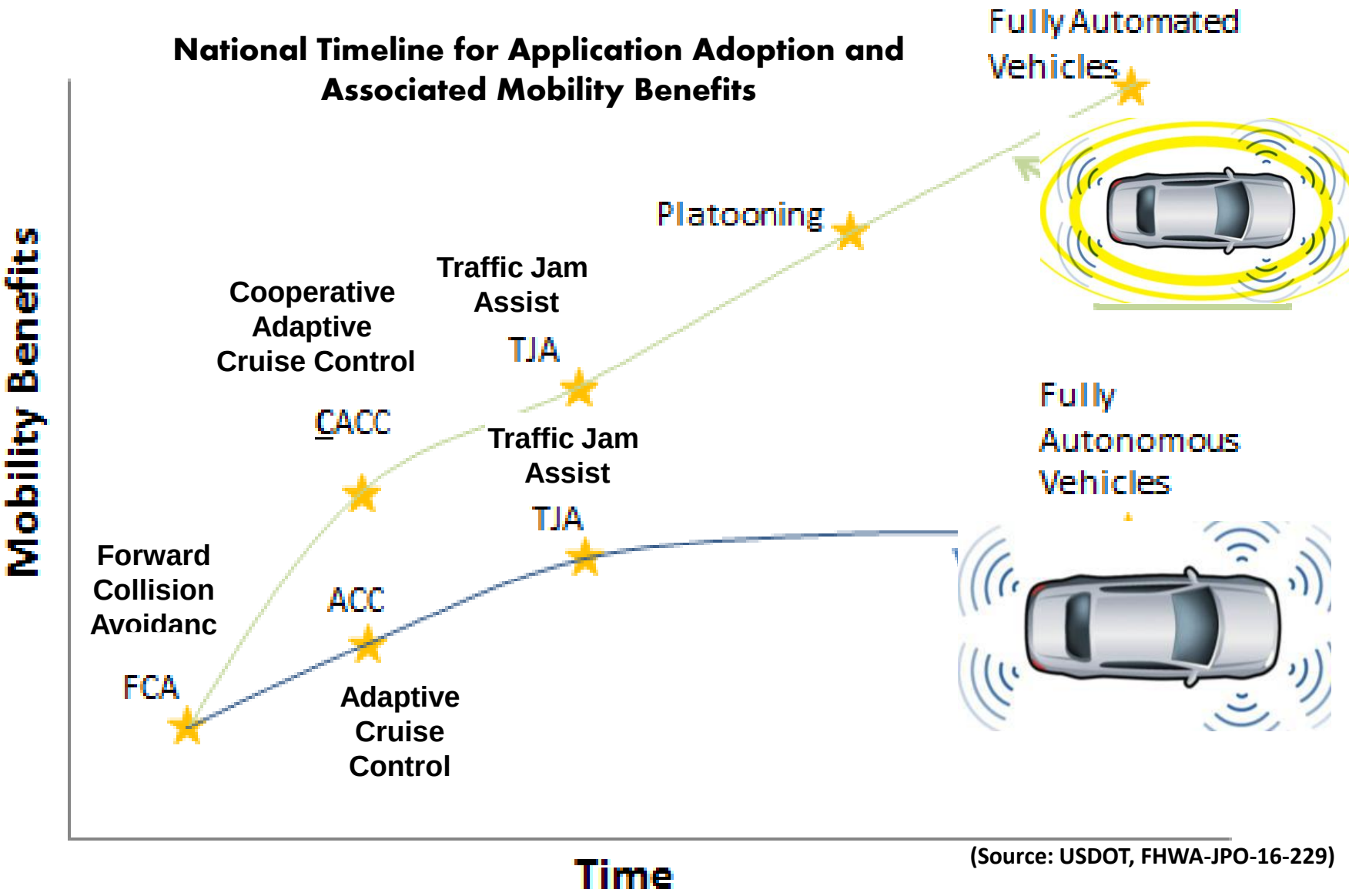
April 25, 2017

Why Connect?
What Benefits Can We Expect?



(Source: USDOT, FHWA-JPO-16-229)

Future of Transportation

- **Commonwealth Transportation Board (CTB) established an Innovation and Technology subcommittee**
- **Chaired by Hap Connors, Fredericksburg District**
- **6 CTB Members**
- **Focused on driving innovation and advocate use of transportation technology at Policy Level.**

VDOT Innovation and Technology Implementation Plan

1. **Improve safety to the goal of ZERO Annual fatalities.**
2. **Improve Operations, providing increased mobility and reduced congestion; connecting people and moving goods in a more timely and efficient manner.**
3. **Concurrently reduce infrastructure costs and improve State of Good Repair in order to repurpose spending from obsolete assets to core needs and innovative approaches.**
4. **Drive the implementation toward significantly reduced overall public sector transportation infrastructure investment.**

Quick Wins

1. **Develop the roadway of the future by beginning the replacement of traffic signals with connected vehicle technology in coordination with the automotive industry.**
   - **Target of 10 years for full implementation.**

2. **Begin deployment of enhanced edge of pavement and other lane markings in coordination with the automotive industry to eliminate road and lane departure crashes.**
   - **Target of 10 years for full implementation.**

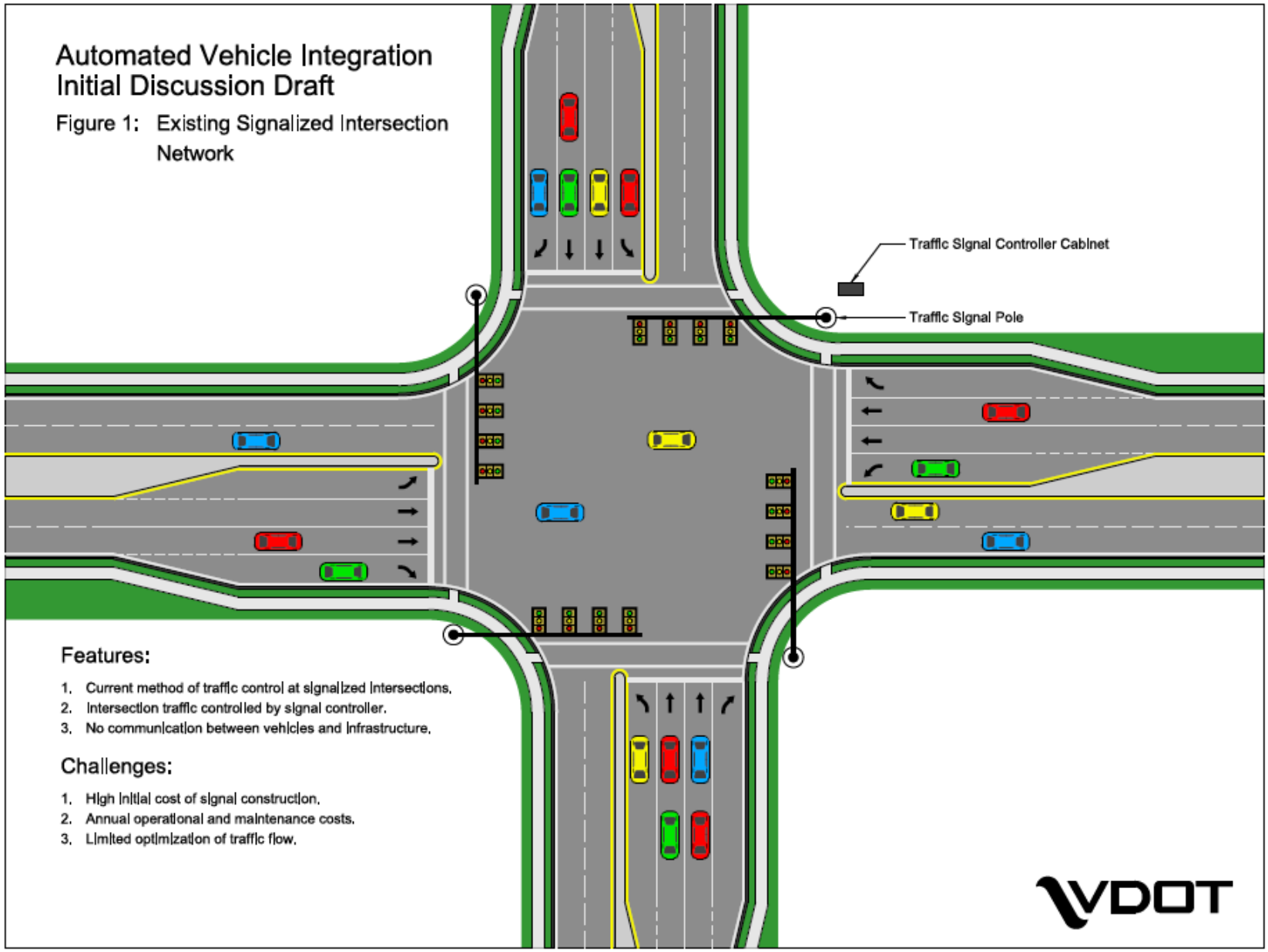
3. **Implement a cloud-based data portal to provide road condition, traffic incident, work zone, multimodal traffic data, and roadside signage information for connected and automated vehicle consumption.**
   - **Target 1 year for full implementation.**

Connected Vehicles Provide Opportunity to Reduce Infrastructure

- **VDOT wants to understand feasibility of eliminating certain high-dollar infrastructure through connected vehicle applications.**
  - **Overhead Guide Signs**
    - **1,000 signs x $100,000 per sign structure = $100 M**
  - **Overhead Changeable Message Signs**
    - **550 signs x $200,000 per sign = $110 M**
  - **Traffic Signals**
    - **3,200 signals x $250,000 per signal = $800 M**

Automated Vehicle Integration
Initial Discussion Draft

Figure 1: Existing Signalized Intersection Network



Features:

1. Current method of traffic control at signalized intersections.
2. Intersection traffic controlled by signal controller.
3. No communication between vehicles and infrastructure.

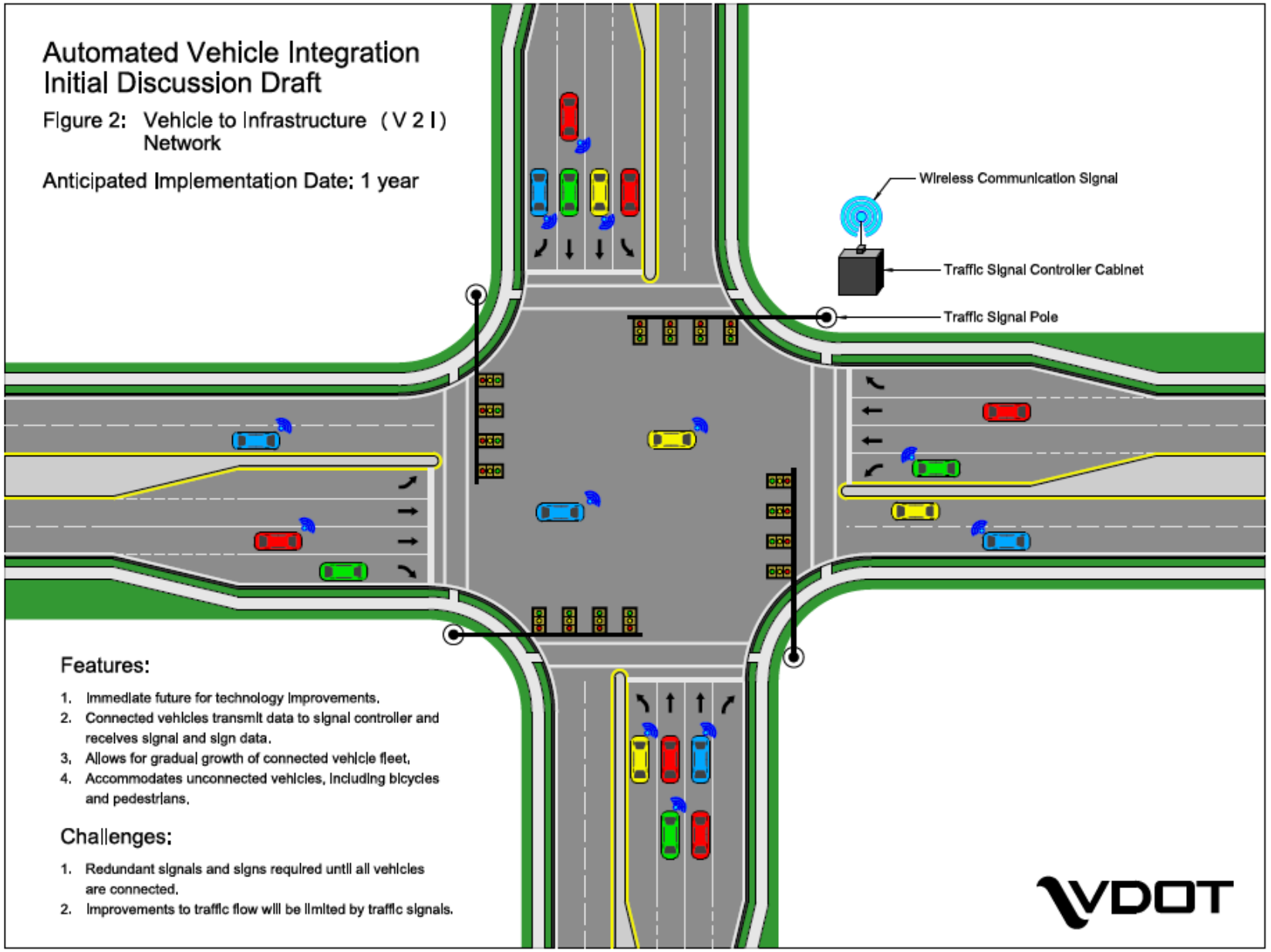
Challenges:

1. High initial cost of signal construction.
2. Annual operational and maintenance costs.
3. Limited optimization of traffic flow.

Automated Vehicle Integration
Initial Discussion Draft

Figure 2: Vehicle to Infrastructure (V2I) Network

Anticipated Implementation Date: 1 year



Features:

1. Immediate future for technology improvements.
2. Connected vehicles transmit data to signal controller and receives signal and sign data.
3. Allows for gradual growth of connected vehicle fleet.
4. Accommodates unconnected vehicles, including bicycles and pedestrians.

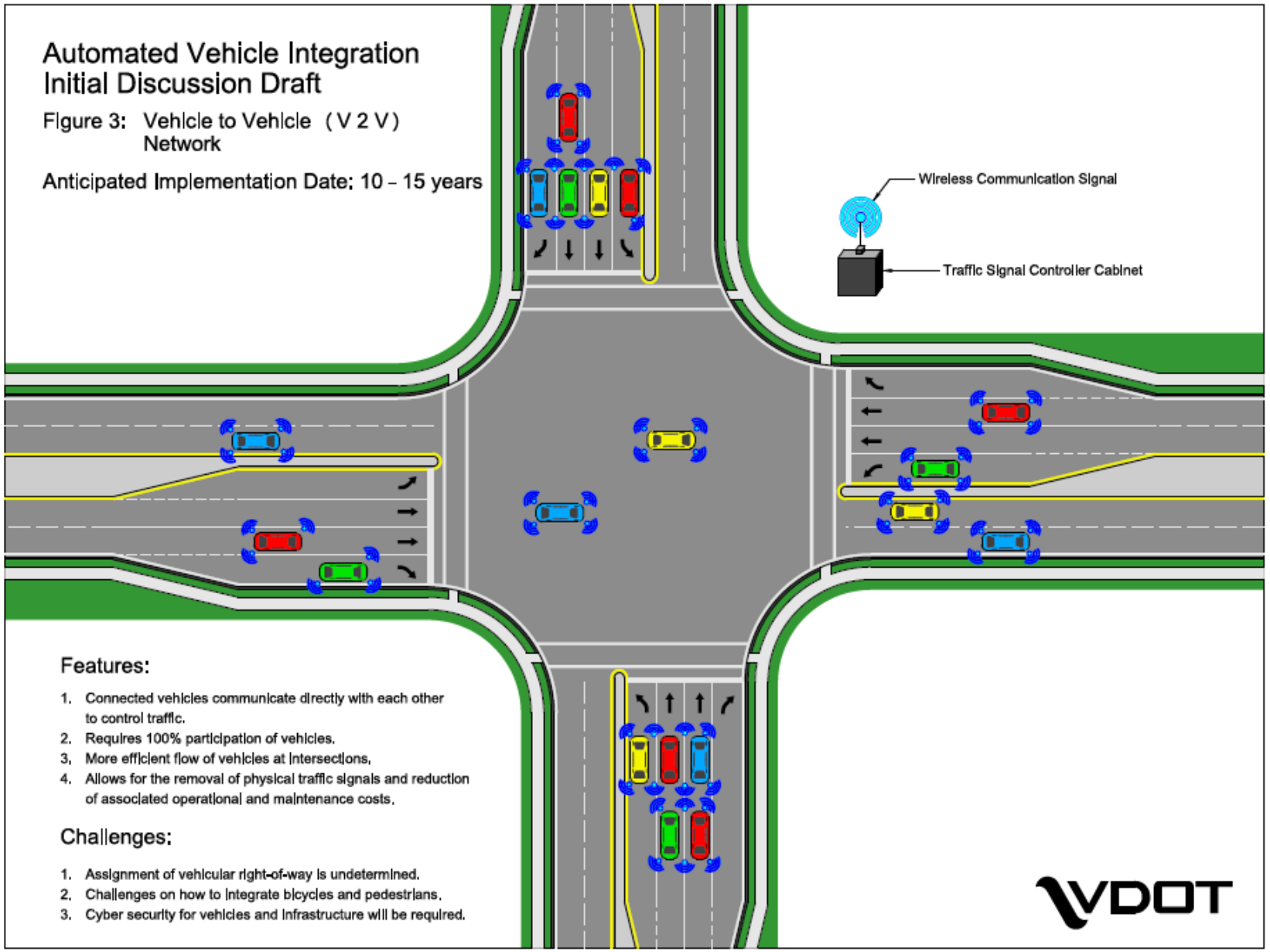
Challenges:

1. Redundant signals and signs required until all vehicles are connected.
2. Improvements to traffic flow will be limited by traffic signals.

Automated Vehicle Integration
Initial Discussion Draft

Figure 3: Vehicle to Vehicle (V 2 V) Network

Anticipated Implementation Date: 10 – 15 years



Features:

1. Connected vehicles communicate directly with each other to control traffic.
2. Requires 100% participation of vehicles.
3. More efficient flow of vehicles at intersections.
4. Allows for the removal of physical traffic signals and reduction of associated operational and maintenance costs.

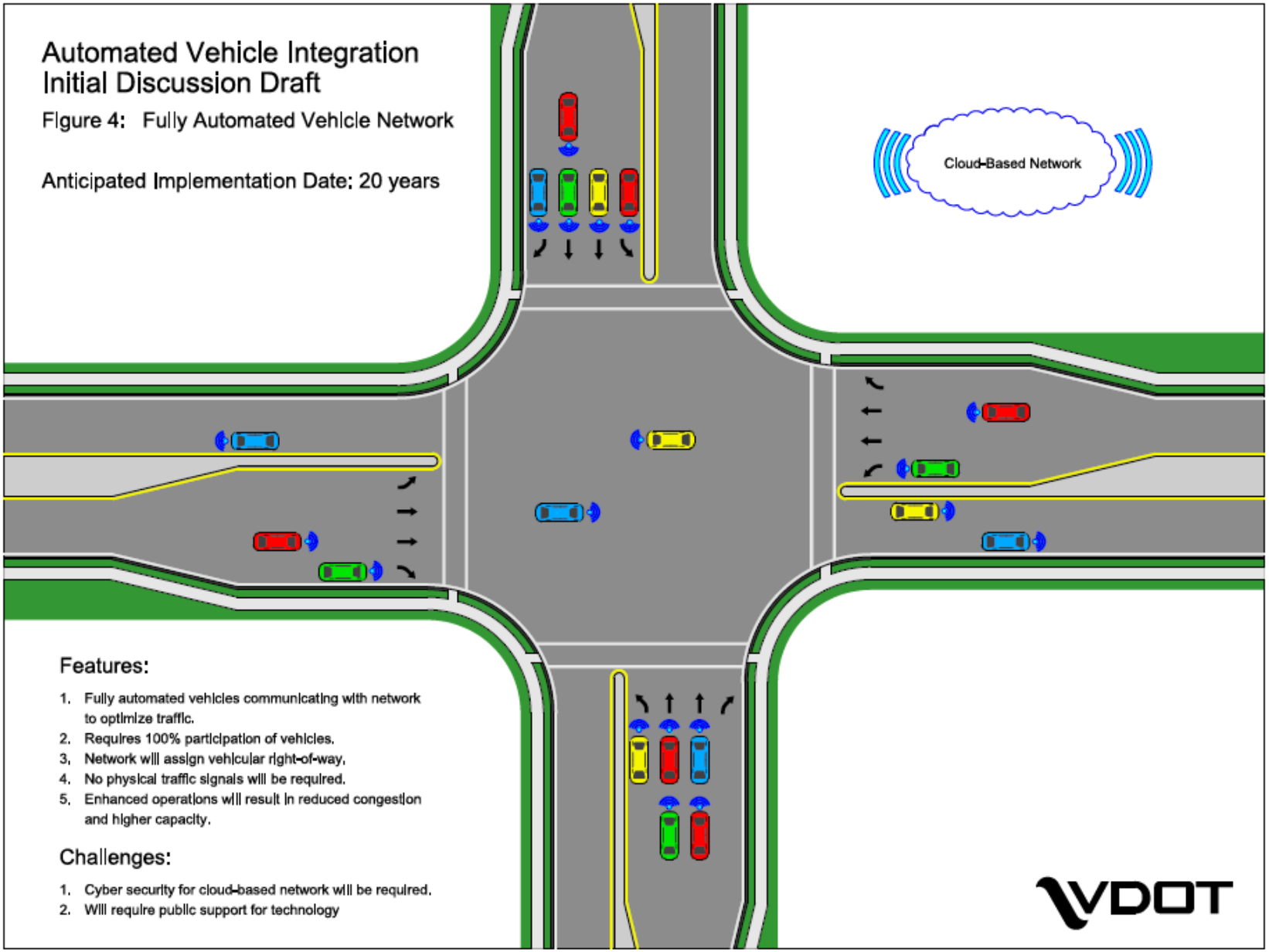
Challenges:

1. Assignment of vehicular right-of-way is undetermined.
2. Challenges on how to integrate bicycles and pedestrians.
3. Cyber security for vehicles and infrastructure will be required.

Automated Vehicle Integration
Initial Discussion Draft

Figure 4: Fully Automated Vehicle Network

Anticipated Implementation Date: 20 years



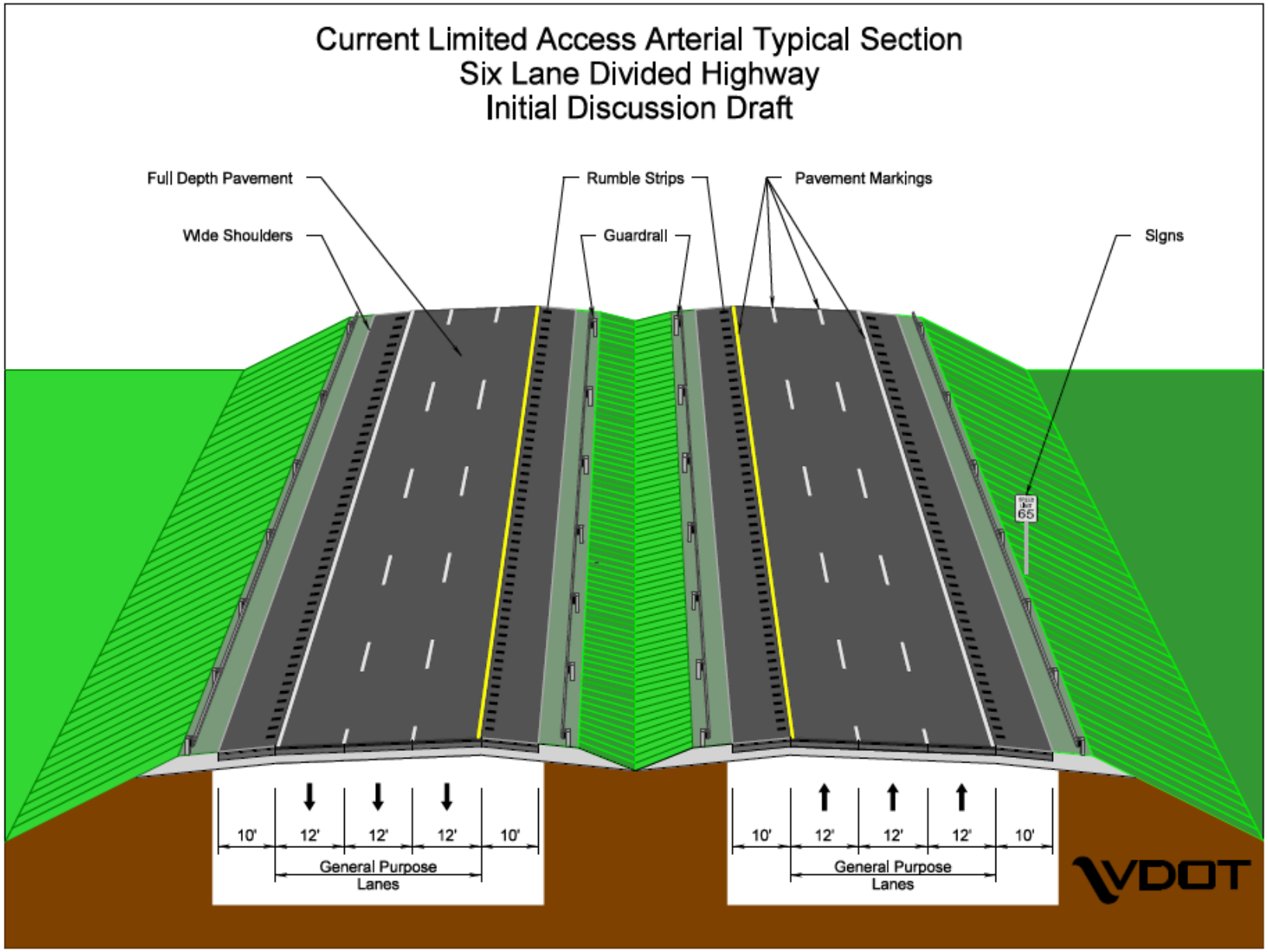
Features:

1. Fully automated vehicles communicating with network to optimize traffic.
2. Requires 100% participation of vehicles.
3. Network will assign vehicular right-of-way.
4. No physical traffic signals will be required.
5. Enhanced operations will result in reduced congestion and higher capacity.

Challenges:

1. Cyber security for cloud-based network will be required.
2. Will require public support for technology

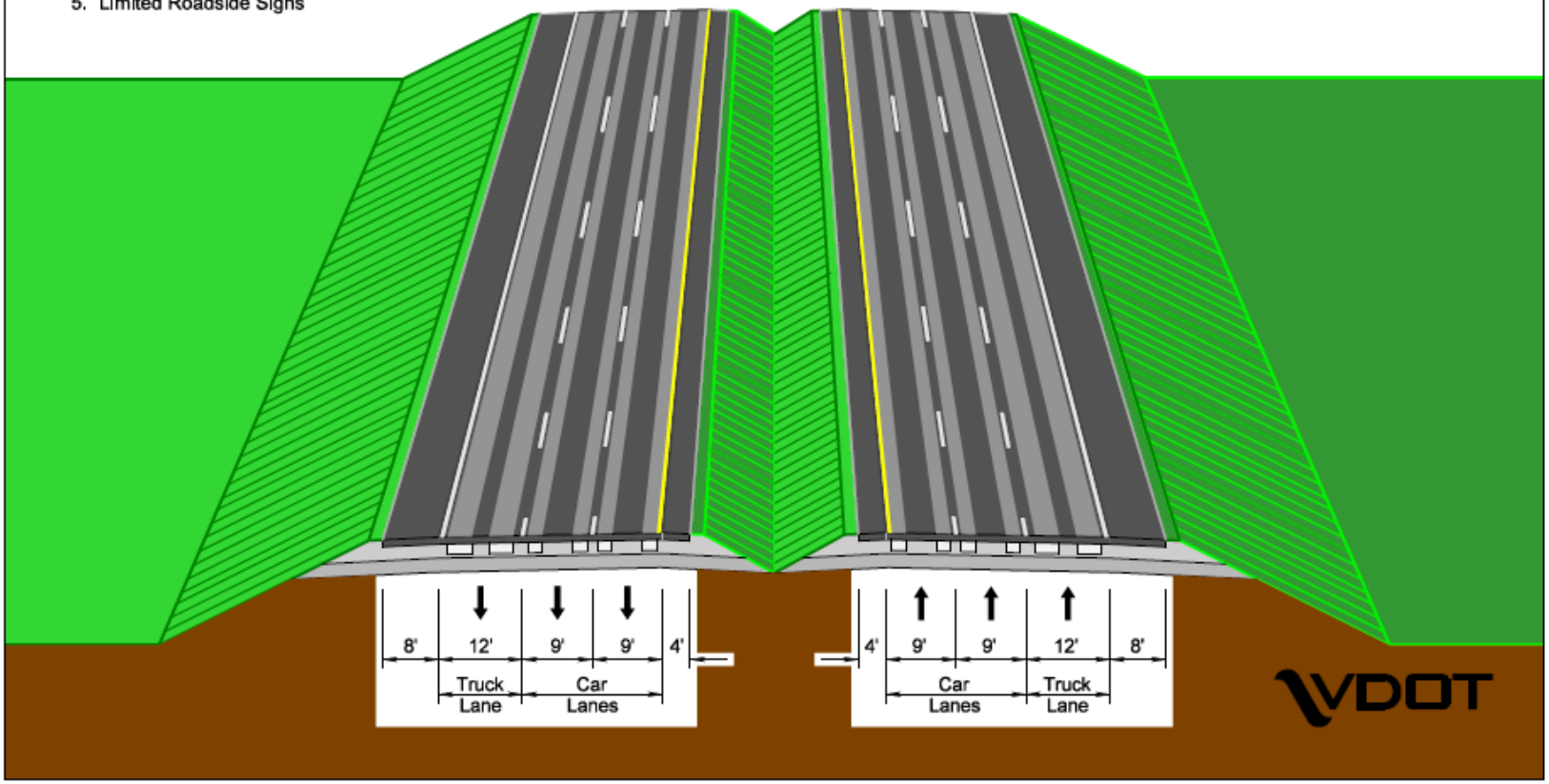
Current Limited Access Arterial Typical Section
Six Lane Divided Highway
Initial Discussion Draft



Future Limited Access Arterial for Automated Vehicles
Six Lane Divided Highway
Initial Discussion Draft

Features:

1. Wheel-Path Pavement
2. Narrow Shoulders
3. Limited Guardrail with No Rumble Strips
4. Enhanced Pavement Markings
5. Limited Roadside Signs



V2I Deployment Challenge

- "Chicken and Egg" problem
- Discussion within V2I DC TWG 1:
  - How do we encourage / initiate broad V2I deployment?
  - How do we demonstrate commitment to OEM and private industry?
  - What is a reasonable, early expectation?
- Signalized Intersections (low-hanging fruit)

V2I Deployment Challenge

- Deployment of roadside DSRC hardware broadcasting Signal Phase and Timing (SPaT) on:
  - a coordinated corridor of at least 20 intersections
  - in each state
  - by 2020
- Commitment to operate for at least 10 years

V2I Deployment Challenge

Goal of the Challenge:

- Give DOTs an entry into V2I deployment and operations
  - valuable experience with procurement, installation, operations
- Show a commitment to OEMs and developers
  - Break through the “chicken and egg” problem
- Help promote future (more advanced) V2I deployments

Resources / Tools

Original Resources Identified by TWG 1:

1. Guidelines for selecting corridors
2. Procurement guidance
3. DSRC licensing information
4. Implementation guidance
5. Estimated costs (install & maintenance)
6. Identification of existing funding sources that agencies may consider

Connected Vehicle Pooled Fund Study

20 Core/Voting Members

*** VDOT is lead agency with technical/administrative support from UVA**

Associate Members

- **Palm Beach Co, FL; Oakland Co, MI; MTC (Bay Area), San Diego's Regional Planning Agency, Los Angeles County Metropolitan Transportation Authority (Metro), Arizona DOT, Rijkswaterstaat and North Texas Toll Authority**

Liaisons

- **NCHRP/SHRP 2; AASHTO**

Connected Vehicle Pooled Fund Study

Completed Projects:

- Connected Vehicle Traffic Signal Control Algorithm
- Pavement Maintenance Support Algorithm
- Evaluation of Signal Phase and Timing Data
- Connected Vehicle Certification Program
- Aftermarket On-Board Equipment
- Traffic Management Centers in a Connected Vehicle Environment
- 5.9GHz DSRC Vehicle Based Road and Weather Condition Application
- Surveying/Mapping for CV Applications

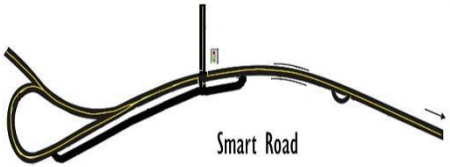
Current Projects:

- Basic Infrastructure Message Development and Standards Support for Connected Vehicles Applications
- 5.9 GHz Dedicated Short Range Communication Vehicle Based Road and Weather Condition Application, Phase 2
- Multi-Modal Intelligent Transportation Signal System (Phase III – Deployment Readiness Enhancement)


Transportation Needs
VDOT Performance Measures & Goals
CV Applications
(Priority indicated within parenthesis)
Reduce recurring congestion
I-66 corridor currently experiences average travel speeds of approximately 40 mph during the peak periods
Increase travel reliability
I-66 has a PTI value over 3 during both the morning and evening peak periods
Reduce non-recurring congestion
Incident duration in the Northern Region has averaged 52 minutes over the last year
Reduce crashes
Facilities within the VCC experienced 2961 crashes (5 fatal and 70 severe injury crashes) in 2014
Delay
Vehicle Hours of Delay
GOAL: Reduce VHD
Reliability
Planning Time Index
GOAL: Reduce PTI
Duration
Incident Duration
GOAL: Reduce Incident duration by 5 min in 5 years
Safety
Number of crashes
GOAL: Reduce fatal & injury crashes by 3% per year (from 2010 baseline)
(1) Advanced Traveler Information
(2) Work Zone Alerts for Drivers and Workers
(3) Incident Scene Alerts for Drivers
(4) Red Light Violation Warning System
(5) Queue Warning
(6) V2V – Forward Collision Warning
(7) V2V – Emergency Electronic Brake Light
(8) Parking Availability
(9) Probe Enabled Traffic Monitoring
(10) Integrated Traffic Signal System
(11) Transit Signal Priority
(12) Emergency Vehicle Preemption

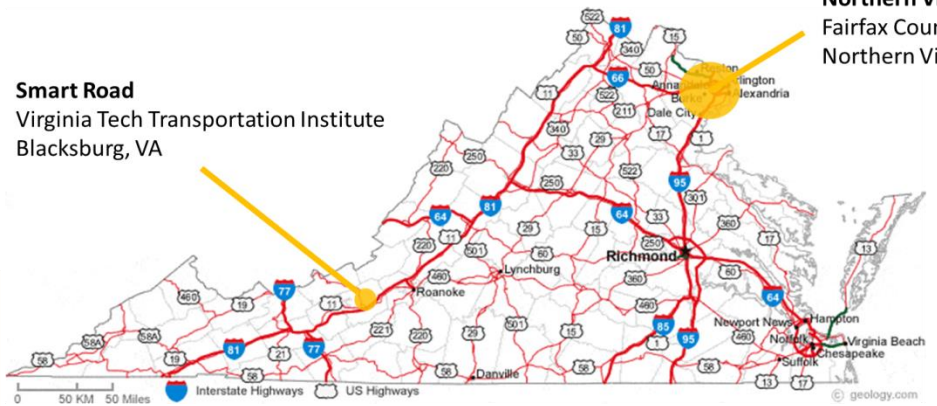
Conduct testing and pilots under live traffic

Design & Test



Smart Road
Virginia Tech Transportation Institute
Blacksburg, VA

Northern Virginia Test Bed
Fairfax County, VA
Northern Virginia



Deploy & Evaluate

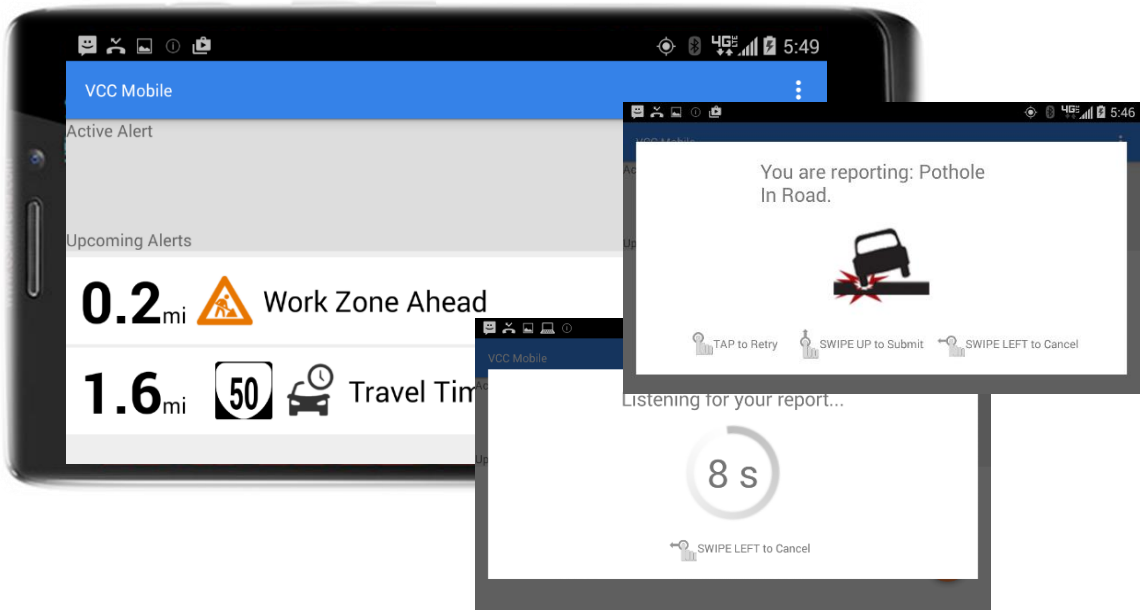
CV Applications

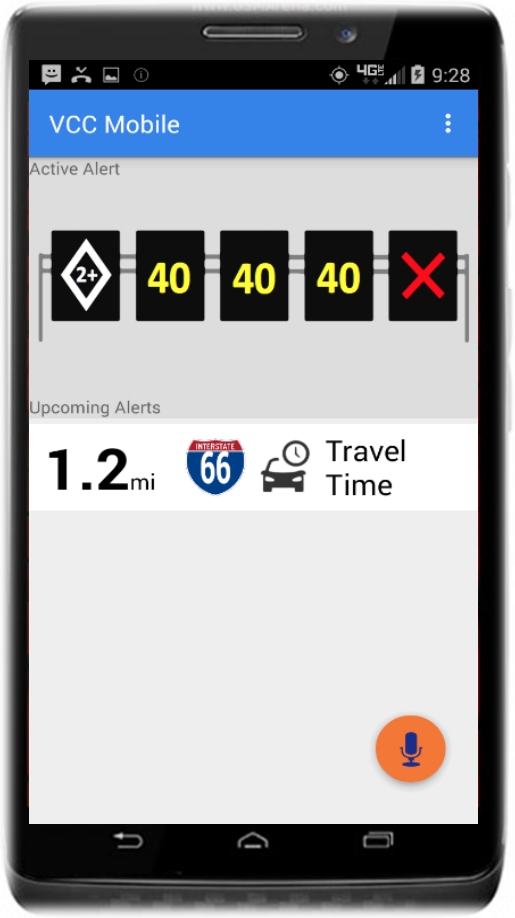
Virginia Connected Corridors

Virginia Connected Corridor Leverages Smart Road for Testing Prior to Deployment on I-66

VDOT is piloting a Traveler Information Message App

- DSRC or Cellular only option
- Statewide deployment for cellular users
- Speech recognition and reporting





Automated Vehicle Demo Drives

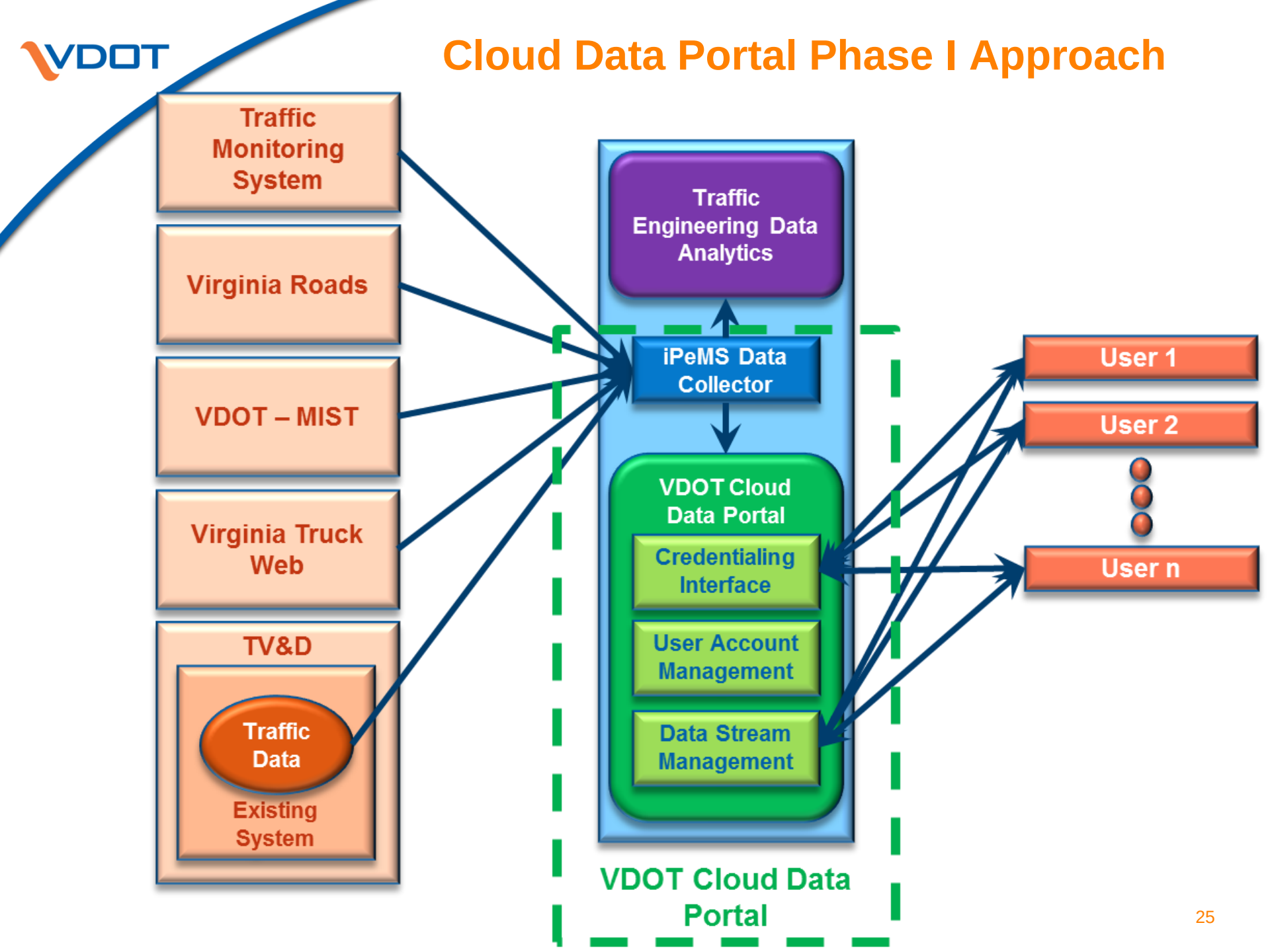
Virginia is Leveraging New Initiatives to Accelerate Connected and Automated Vehicles

- **VDOT's Traffic Operations Cloud Data Portal**
- **I-95 Corridor Coalition and Statewide Truck Parking Initiatives**
- **Executive-Level Interest, Involvement, and Commitment**
  - **VDOT's Chief of Innovation**
  - **Secretary's Office Strategic Plan for Automated Vehicles**
  - **CTB Technology and Innovation Subcommittee**

Cloud Data Portal Objectives

- **Accelerate the CAV technology development by exchanging transportation data and video with private sector CAV business, application developers, and university partners.**
- **Provide all relevant VDOT data beyond current traffic operations data in one portal site.**
- **Encourage auto manufacturer device, application, and business development to increase the frequency, quality, and accuracy of data shared with private sector in Virginia.**
- **Improve 2-way data exchange for VDOT to publish and obtain data for internal use.**
- **Simplify the process to add new users and manage existing users.**
- **Serve as a national model for other state DOT's.**

Cloud Data Portal Phase I Approach



I-95 Corridor Coalition Truck Parking Initiative

Objectives:

Demonstrate proof-of-concept to show:

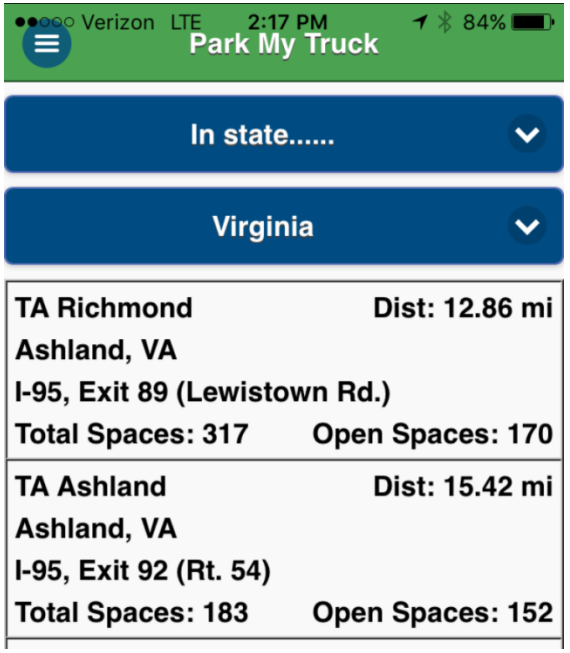
- Technology can accurately identify available parking spaces.
- Parking information can be communicated to drivers in a timely, useful, and efficient fashion.

Demonstrate feasibility of the concept in a limited deployment in Maryland and Virginia

Develop an approach that can be expanded and replicated beyond this pilot deployment.

Real-time truck parking info can be shared using various tools

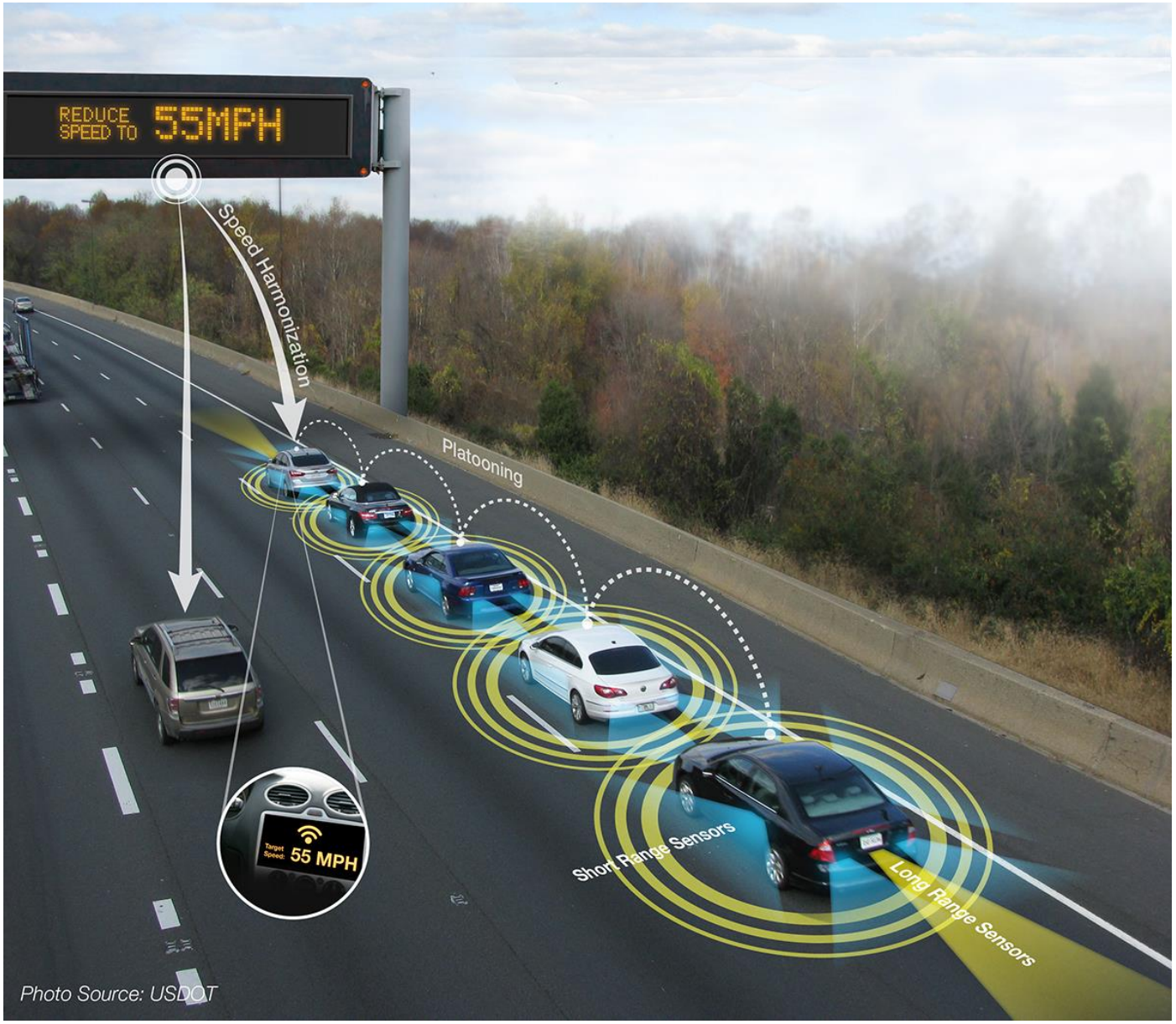
- Using a dynamic parking sign in advance has mixed results.
  - A 2007 study by University of California, Berkley campus report driver's preferred the VMS method for receiving information
  - A 2017 study by American Transportation Research Institute (ATRI) report driver's prefer using apps/websites.



- 511 Virginia product suite (mobile app, website and phone)
- 3rd Party Applications (Park My Truck, Roadbreakers, Flying J, TA, etc.)

Implementation Plan for Phase 1

- Acquire parking system using existing ATMS Contract (Q-Free)
  - System operational – Summer 2017
- Install field devices (sensors & signs) using a No-plan RAAP construction contract
  - Complete Design by Summer 2017
  - Advertise contract in September 2017
  - Complete field installation by December 2018
- Integrate data into 511 Virginia suite (existing contract)
  - Complete integration of field devices by corridor (66, 81, and 95)
  - Share public parking information with NATSO
  - Post private space availability on 511 for real-time, accurate feeds
- Accelerate I-66 corridor using ITS On-Call Task Order for pilot field installations
  - Operational by Fall 2017
- Phase 1 funded by ITTF funds


REDUCE SPEED TO 55MPH
Speed Harmonization
Platooning
Target Speed: 55 MPH
Short Range Sensors
Long Range Sensors
Photo Source: USDOT


Tethered drone test
Dec. 16, 2016


Questions?