Session 1: Innovation & Emerging Technologies
Infrastructure Readiness for Connected Vehicles & Traffic Signal Performance Measure Applications

- Number of state sponsored/hosted pilot programs in the following areas:
  - Connected vehicles – 1: IMO and   2: if grant is successful
  - Automated vehicles – 0 but some research
  - Fully autonomous vehicles – 0
- Which wireless technologies does your agency currently use for infrastructure-based (I2I/V2I/I2V) communications?
  - 5.9 GHz DSRC – testing phase
  - Commercial Cellular Services – yes – common place for AVL, temp communication & place that are cost prohibitive for fiber (standard)
  - WiMax – no and Wi-Fi – no
  - Bluetooth – some
- Does your agency have a formal institutional structure for overseeing the deployment/management of strategies to support I2I/V2I/I2V communications?
  - Yes and No: depending on technical needs of the system.

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‣ Number of signals currently broadcasting Signal Phase and Timing (SPaT) info: 1 pending

‣ Number of SPaT broadcast deployments currently planned by 2020: 700 if we are awarded grant, 200 if not

‣ Number of other roadside units (RSUs) broadcasting infrastructure information: none, 650 if awarded grant (RCS, DMS, etc.), 150 if not

‣ Approximate breakdown (%) of signal controller inventory by the following standards (intended to ensure compatibility with connected vehicle applications)?

  ◦ ATC 5.2b: currently working on procurement specification
  ◦ Model 2070LX: 0
  ◦ Model 2070E: 0
  ◦ Model 2070L: 0
  ◦ NEMA, Modern (e.g., Econolite ASC3, Ethernet port is present): ~400
  ◦ Type 170, Modern (Ethernet port is present): 670, without Ethernet port
  ◦ Incompatible (e.g., NEMA Legacy, Electromechanical): 900

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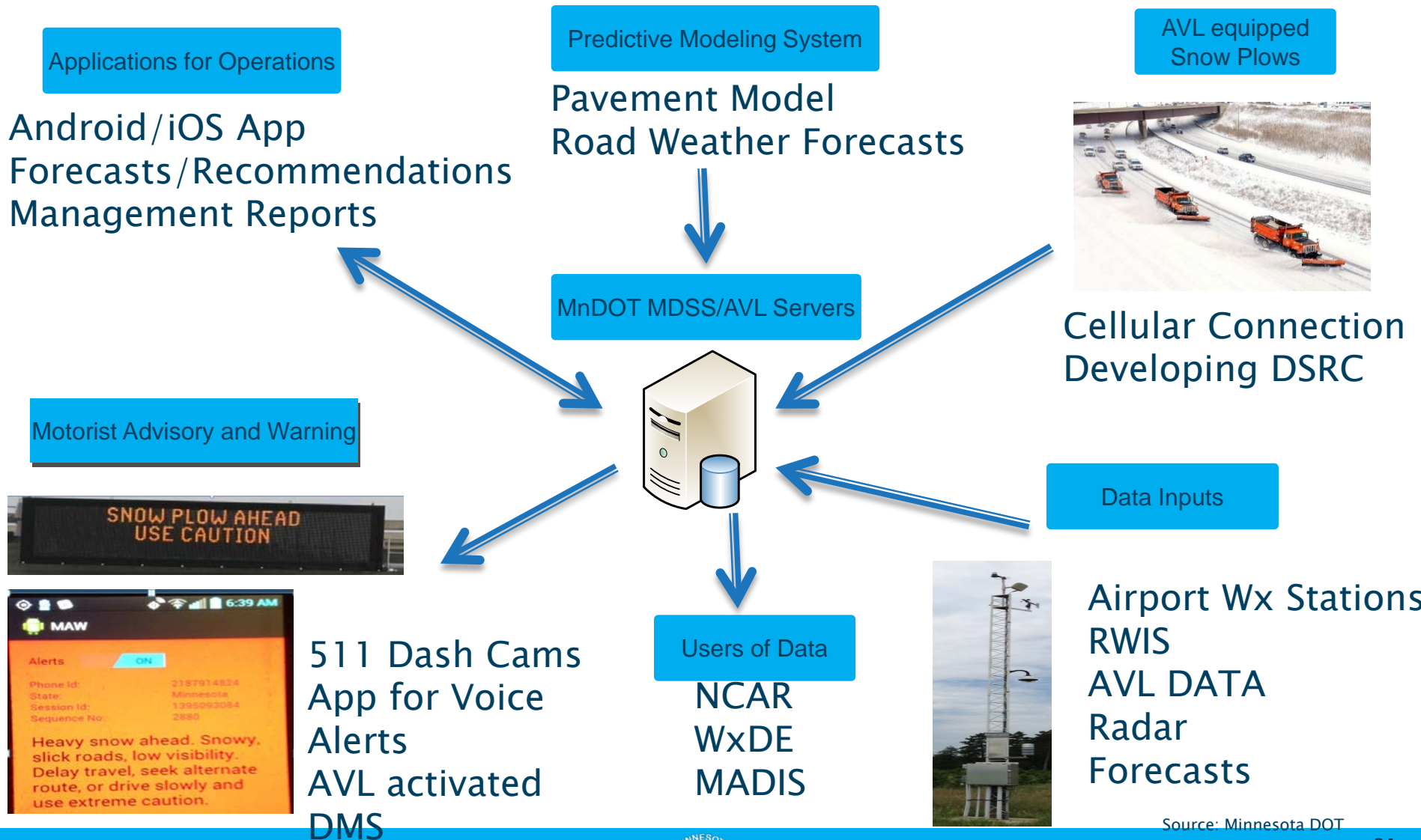
- Number of signal controllers currently running CV applications: 0

- Number of signal controllers planned to run CV applications by 2020: 700*

- Do your current procurement specifications for traffic signal hardware (e.g., controllers) include language for SPM support? No*. (In new specification, requiring

- Do your current procurement specifications for any ITS hardware (including signal controllers) include language for CV application support? In Process

Current Minnesota CV Activities

▸ Deployment project – MnDOT Maintenance Lead
  ◦ Integrating Mobile Observations

▸ Research Projects – University of Minnesota
  ◦ Freeway Queue Warning and BSM Emulation
  ◦ Snowplow "Gang" plowing
  ◦ I – 94 St. Paul Work Zone
  ◦ Duluth Work zone worker safety – DSRC
  ◦ In–Vehicle Messaging

▸ USDOT Proposals
  ◦ ATCMTD (Advanced Transportation & Congestion Management Deployment Grant)
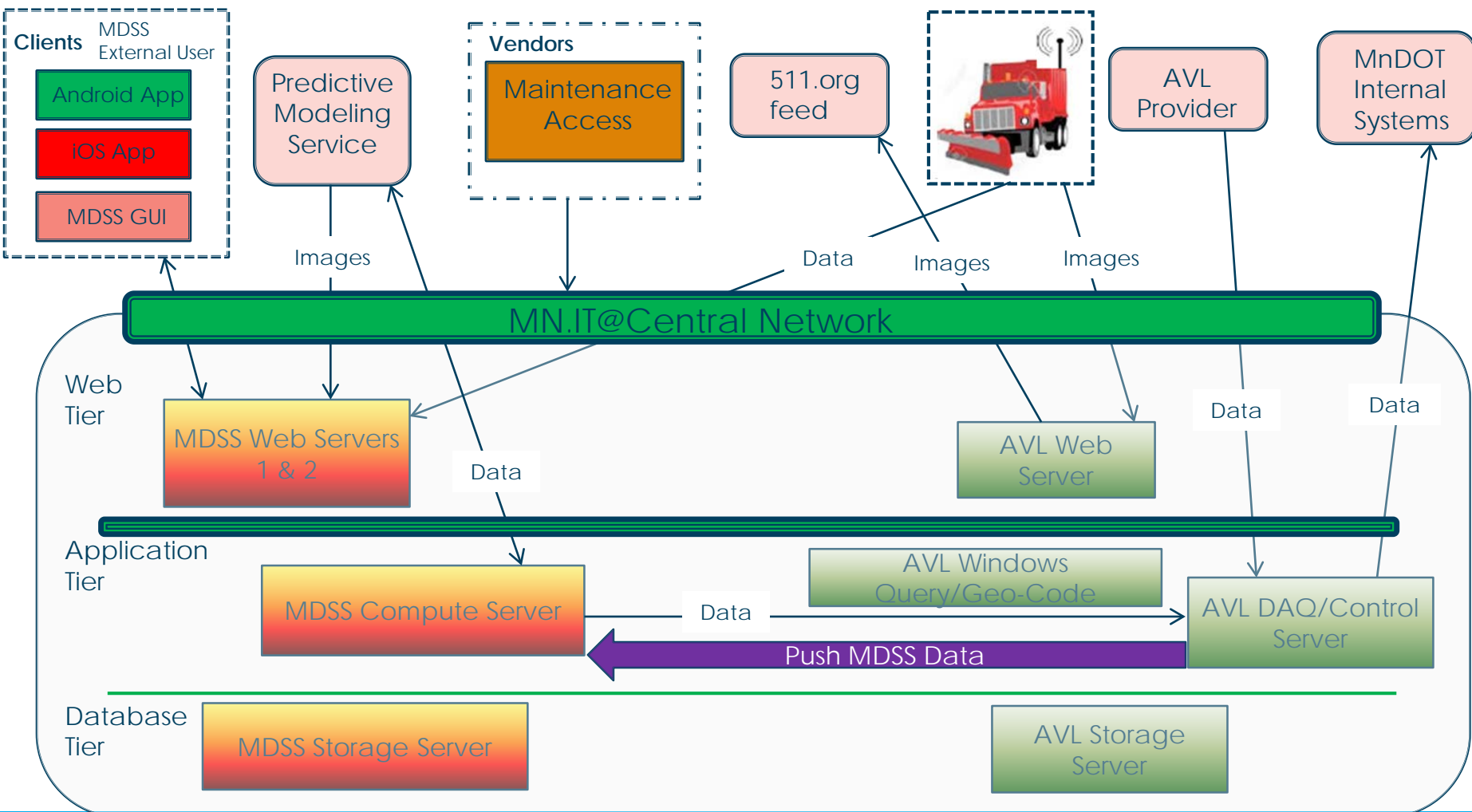
Minnesota IMO System Framework

Applications for Operations

Android/iOS App
Forecasts/Recommendations
Management Reports

Predictive Modeling System

Pavement Model
Road Weather Forecasts

AVL equipped
Snow Plows

Cellular Connection
Developing DSRC

MnDOT MDSS/AVL Servers

Motorist Advisory and Warning

SNOW PLOW AHEAD
USE CAUTION

511 Dash Cams
App for Voice
Alerts
AVL activated
DMS

Users of Data

NCAR
WxDE
MADIS

Data Inputs

Airport Wx Stations
RWIS
AVL DATA
Radar
Forecasts

Source: Minnesota DOT

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Minnesota IMO System Framework

MnDOT MDSS/AVL Production Server

Clients — MDSS External User
- Android App
- iOS App
- MDSS GUI

Predictive Modeling Service

Vendors
Maintenance Access

511.org feed

AVL Provider

MnDOT Internal Systems

Images

Data

Images

Images

MN.IT@Central Network

Web Tier

Data

MDSS Web Servers 1 & 2

Data

AVL Web Server

Application Tier

MDSS Compute Server

Data

AVL Windows Query/Geo-Code

AVL DAQ/Control Server

Push MDSS Data

Database Tier

MDSS Storage Server

AVL Storage Server

Minnesota DOT's System Framework

◦ Maintenance Decision Support System (MDSS) Unique forecasts for all 810 MnDOT plow routes

◦ Automated Vehicle Location (AVL) 590+ units now installed and reporting in Snow plows

◦ Cameras installed in 240 plows

- Images will be used internally and sent to 511 for public info

◦ Additional 43 AVL's installed and collecting data in Mower tractors and Light Duty Vehicles

First
Advanced
Sustainable
Transportation

"**MnDOT's** goal with the **FAST** initiative is to create the first major metro area in the nation with full **DSRC** coverage for Connected Vehicles deployments on the state network."

We all have a stake in A to B

MnDOT's FAST Initiative

▸ MnTEL – ATC Controller Upgrade
      (building on existing fiber communications backbone with DSRC tech)
▸ Active Traffic Management
▸ Snow/Ice & Maintenance Operations
   ◦ Snow plow traffic signal priority
   ◦ Maintenance vehicle warning
   ◦ Short-term construction work zone warning
▸ Integrated Corridor Management
   ◦ FATPOT World for C-2-C CAD communication
   ◦ TIM Planning & Operations
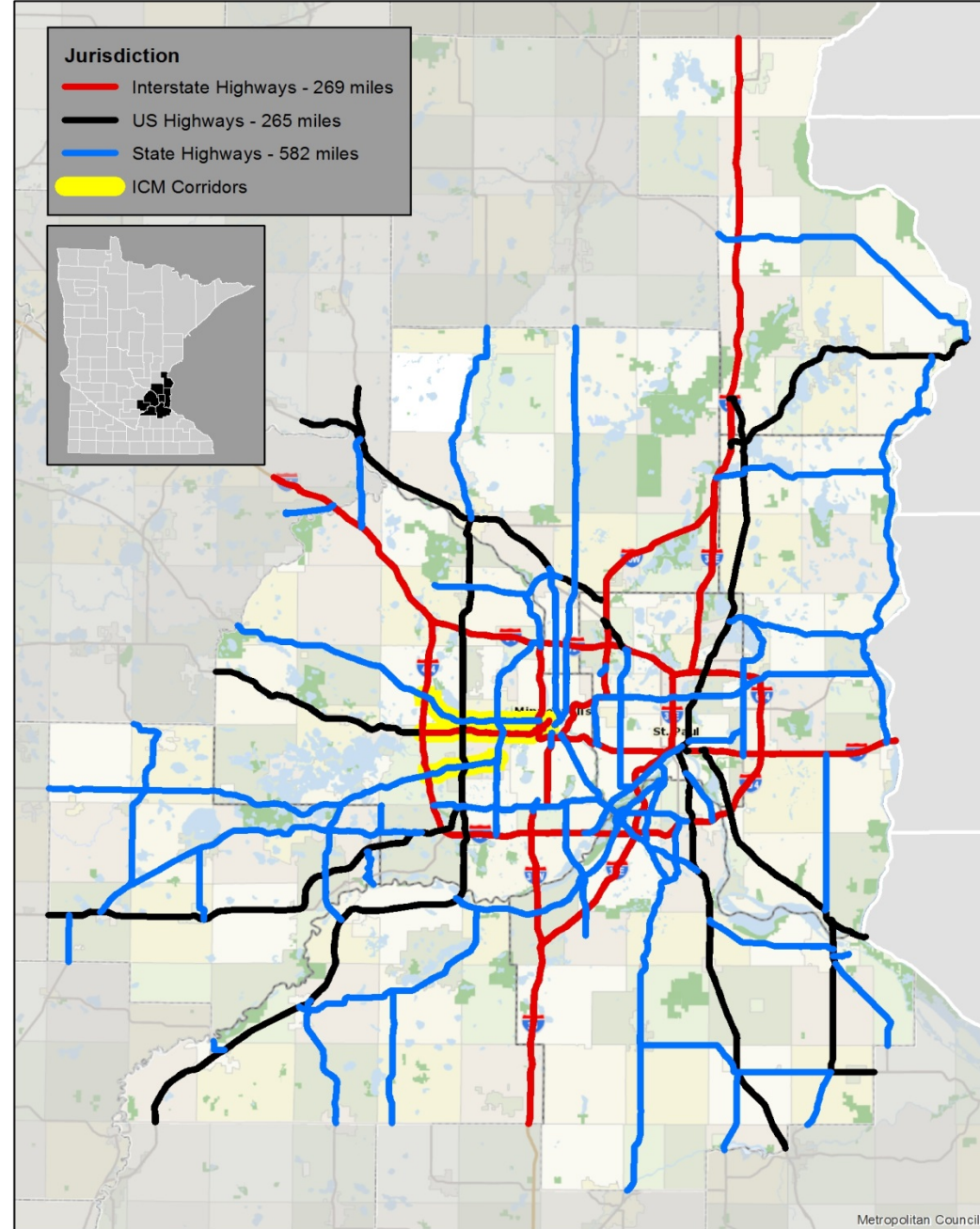   ◦ Arterial – Freeway comparative travel times
▸ Traveler Information – API
▸ MnPASS Interoperability

Metro Coverage

- ▸ 1116 total miles

- ▸ 680 miles of fiber

- ▸ 675 signals

- ▸ 482 ramps
  (675 controllers including detector stations)

Active Traffic Management

- ▸ ATC Controller Upgrade
  - ◦ More frequent polling
  - ◦ Reduced latency
- ▸ More accurate ATM messages
  - ◦ Variable speed limits
  - ◦ Lane control
- ▸ DSRC radios at controller locations
  - ◦ First major metro area in the nation with full DSRC coverage for Connected Vehicles deployments
  - ◦ Ability to receive data from vehicles transmitting BSM

Snow/Ice & Maintenance Operations

▸ Snow Plow Signal Priority
  ◦ MnDOT traffic signals (675)
  ◦ Ramp meters (482)
  ◦ Communication via DSRC

▸ Benefits
  ◦ Faster plowing times
  ◦ Less snow left behind at traffic signals and ramp meters
  ◦ Improved gang plowing operations (ability for ramp plow to stay in-sync)

Snow/Ice & Maintenance Operations

▶ Maintenance Vehicle Warning
- WZARD expansion
- Communication via DSRC
- Utilizing existing DMS

▶ Incidents w/ Maintenance Vehicles (Metro only)
- 2013 – 106 (45 from plowing/sanding)
- 2014 – 143 (60 from plowing/sanding)
- 2015 – 90 (15 from plowing/sanding)

MnDOT's ATCMTD Proposal Budget

| Phase		Application	Total Cost	Total Federal Reimbursement	Total State Funding Match
Planning			$1,100,000	$550,000	$550,000
Design/Build	Supporting Infrastructure	Supporting Infrastructure	$14,969,122	$7,384,561	$7,584,561
		Active Traffic Management	$610,000	$305,000	$305,000
		Snow /Ice and Maintenance Operations	$2,159,340	$1,079,670	$1,079,670
		Information Sharing	$1,220,000	$610,000	$610,000
		Integrated Corridor Management	$844,000	$322,000	$522,000
		Unified Payment Systems	$2,740,000	$1,320,000	$1,420,000
Total Project Cost			$23,642,462	$11,571,231	$12,071,231

CV and AV on a collision course

‣ Connectivity will provide benefits that autonomous vehicles cannot achieve on their own, leading to the *Connected Automated Vehicle*

Autonomous Automated Vehicle
- Operates in isolation from other vehicles using internal sensors
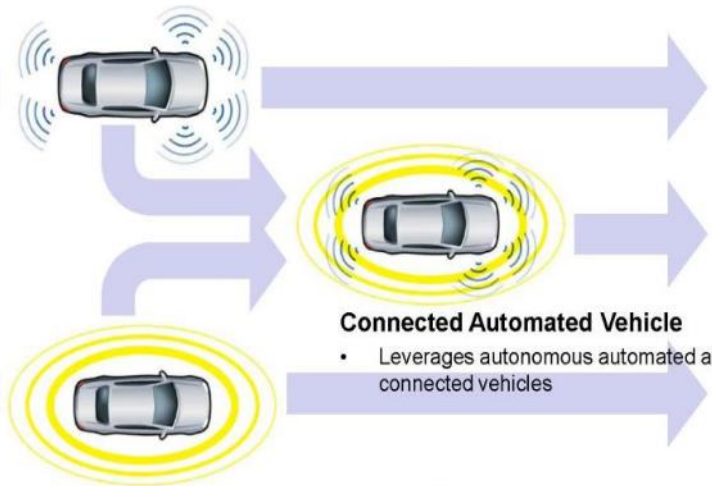
Connected Vehicle
- Communicates with nearby vehicles and infrastructure
- Not automated (level 0)

Connected Automated Vehicle
- Leverages autonomous automated and connected vehicles

U.S. Department of Transportation

Automated Vehicles

- Organize for Regulations
  - Testing and Operating
  - DOT and DPS
  - Strict or Lenient
- Signing / Marking Standards
  - Automation-Friendly
- Impacts on Planning
  - Less Need for Safety Infrastructure?

Where should we go?

1. ## Develop Partnerships
   - Pooled fund
     - Connected Vehicles Pooled Fund
     - Neighboring States (MN, WI, IA, etc. – Snow & Ice Operations)
   - Partnerships
     - AASHTO Subcommittee on Transportation System Management & Operations (STSM&O) TWG 5
     - MAASTO States (Truck Parking, CV ?)
     - V2I Deployment Coalition
     - Other Regional Agencies
2. ## CV Proposals for a ATCMTD Grants
3. ## MN CV Pilot Deployments
   - Innovative Ideas
   - Un-Funded Projects

CV Un-Funded Projects

▸ SPAT Challenge – $900 K
  ◦ Provide plows with extra green time, by extending green or shortening red phases along TH 55

▸ WZARD Expansion – $1.5 M
  ◦ Extend eastward into metro area using existing DMS and adding several new DMS

▸ Connected Gang Plowing – $1.8 M
  ◦ Instrument plows from Camden and Plymouth stations with DSRC, allowing for safer, more efficient gang plowing