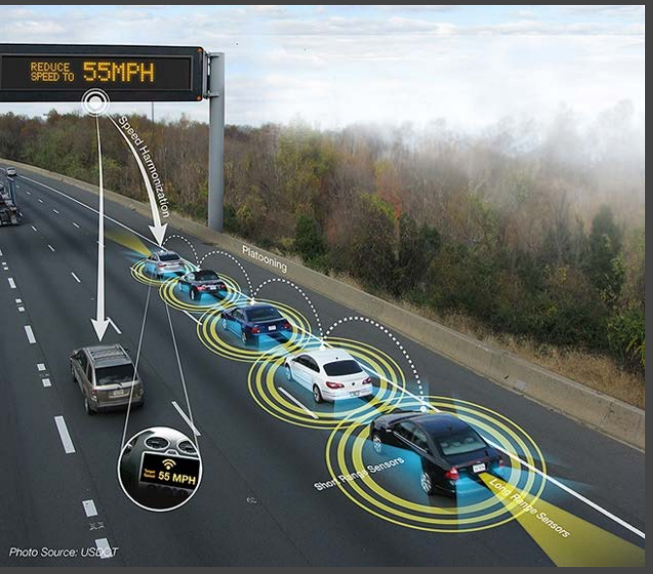


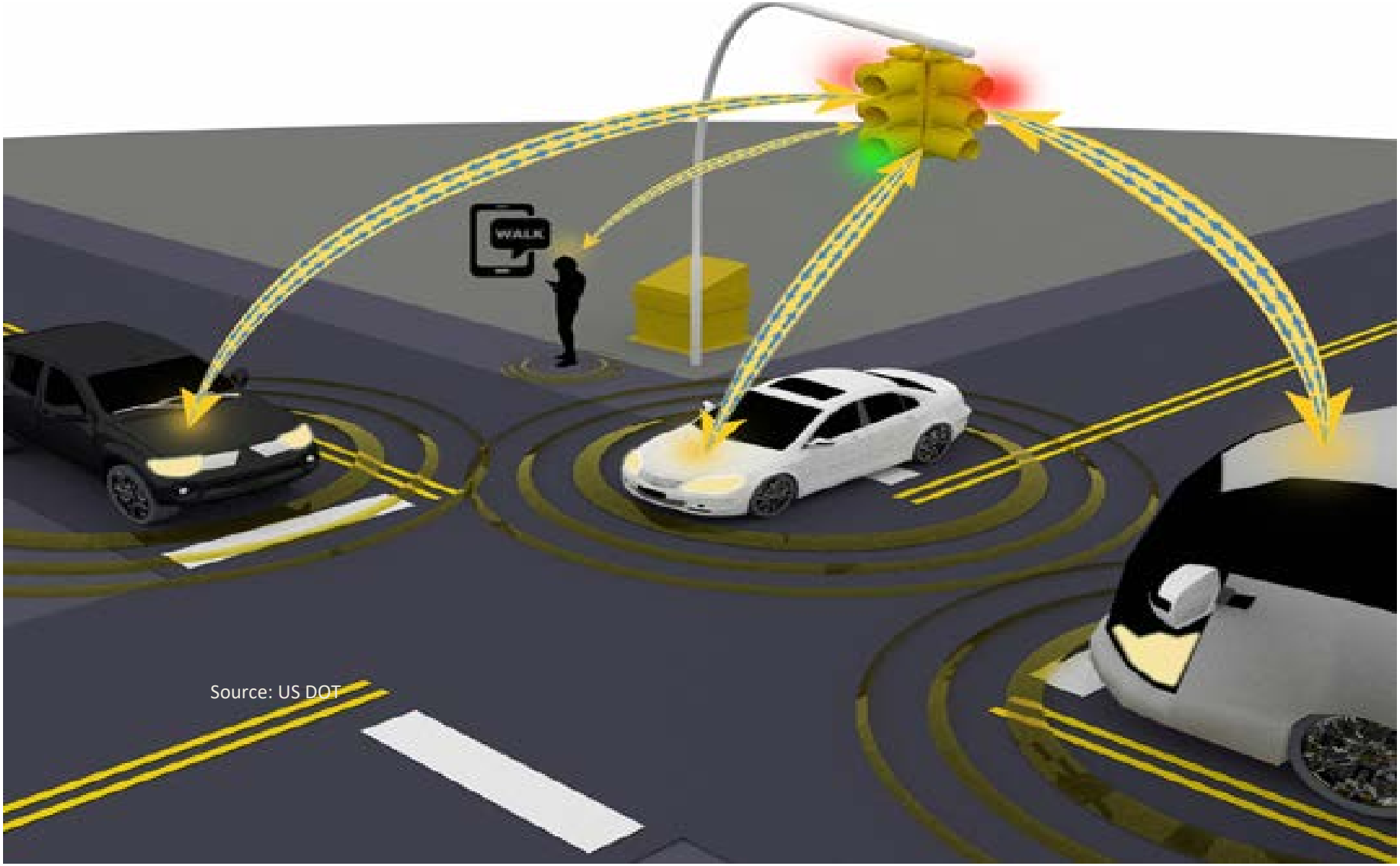
ODOT Connected Vehicle Applications

Presenters

Julie Kentosh, P.E., PTOE
Traffic Signal Engineer
Traffic-Roadway Section

Doug Spencer, P.E.
ITS Standards Engineer
Maintenance and Operations

Vehicle to Infrastructure Connectivity



Source: US DOT

Industry Status: DSRC Adoption

FUTURE CARS

Toyota, Lexus to launch 'talking' vehicles in 2021

It wants V2X tech on most of its lineup by the mid-2020s.

BY **ANDREW KROK** / APRIL 16, 2018 1:01 PM PDT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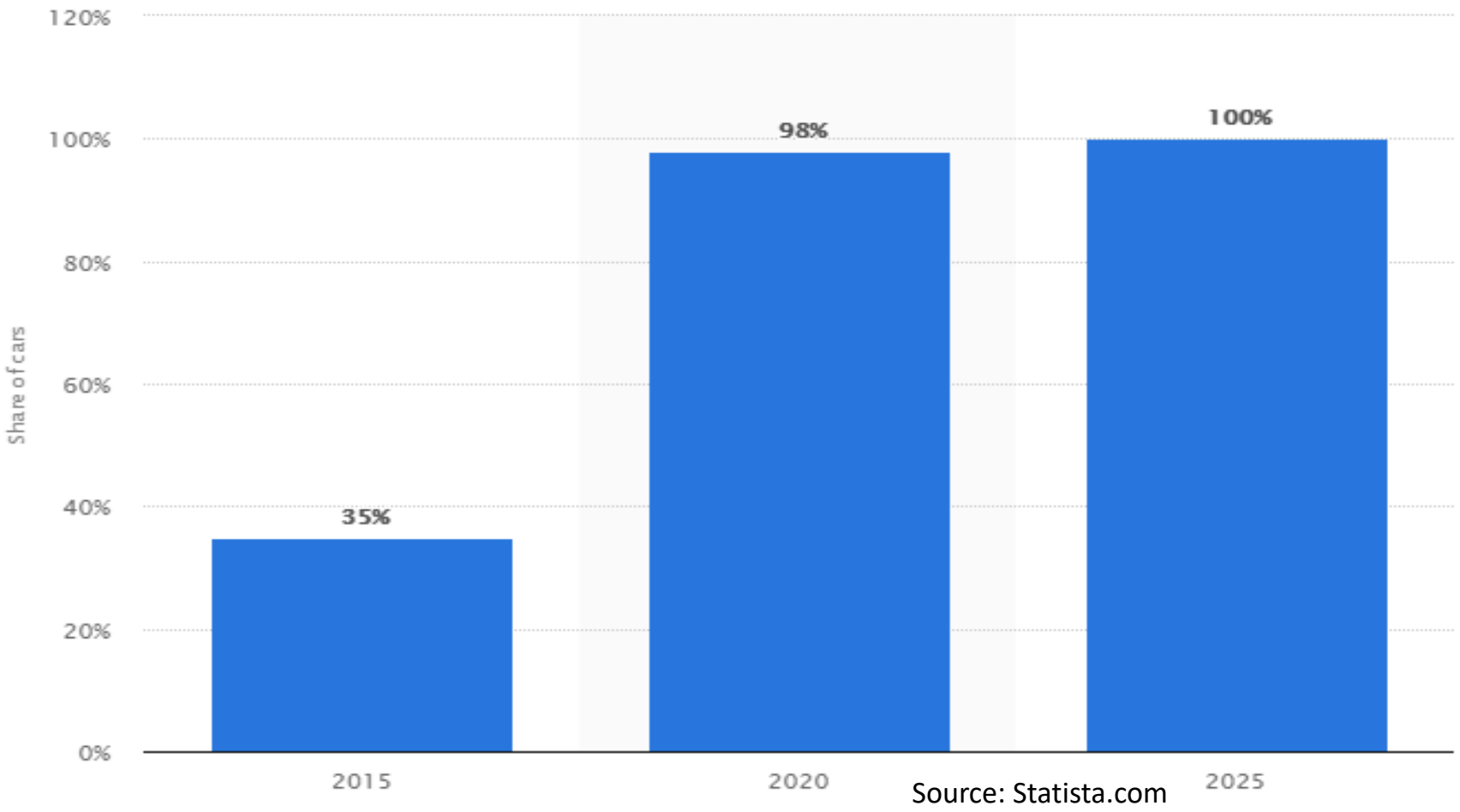
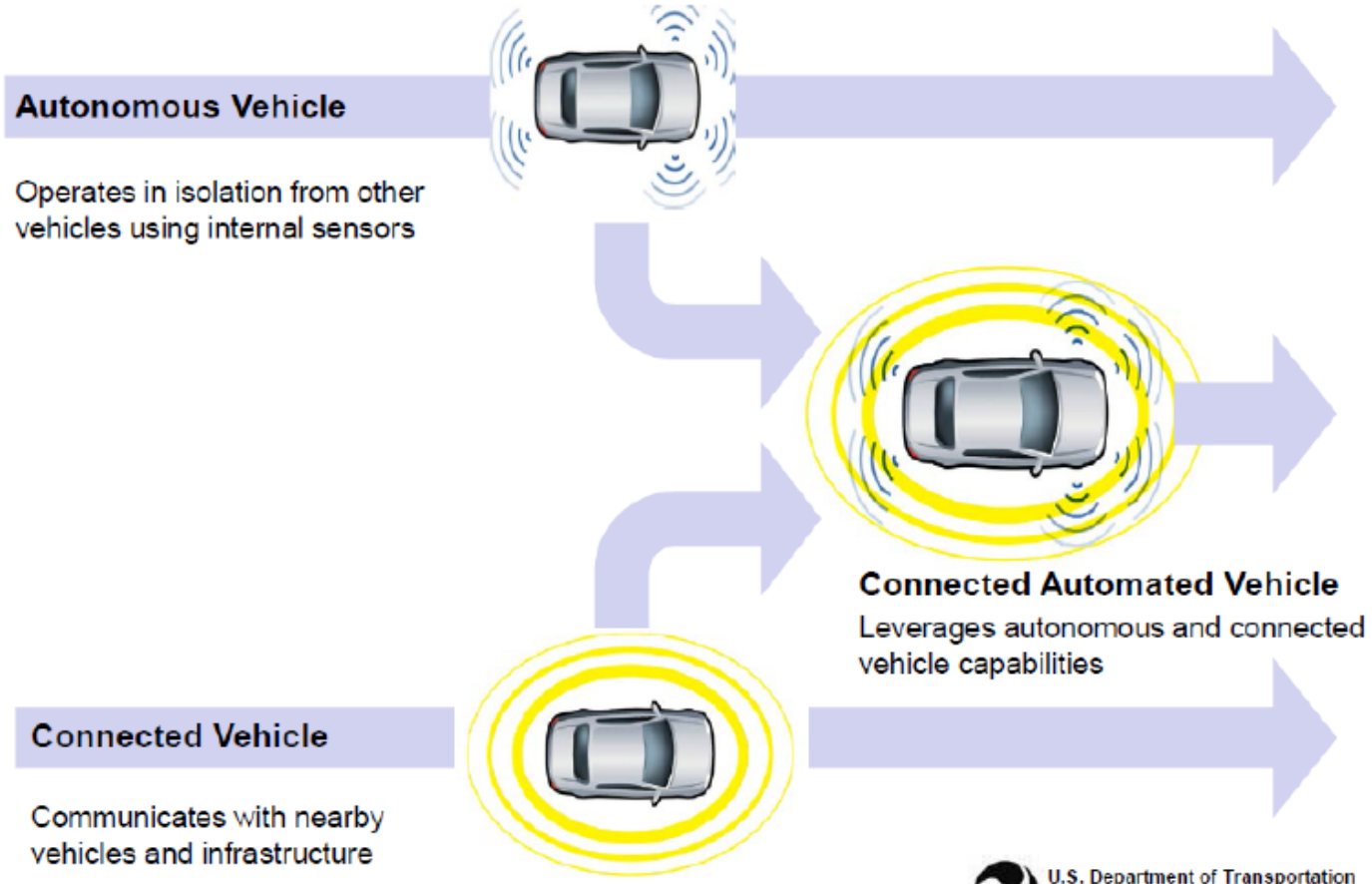


Source: Statista.com

Connected Automation for Greatest Benefits



U.S. Department of Transportation
ITS Joint Program Office

AASHTO SPaT Challenge

SPaT deployment underway

SPaT deployment operational

Purpose of the SPaT Challenge

- Provide state and local departments of transportation with a tangible first step for deploying V2I technology and operations.
- To show a commitment to DSRC based V2I deployments for the automotive industry.
- To enable some level of testing and validation and expanding the understanding of applications.
- To bring the V2I community together to foster cooperation and coordination.

Signal Phase and Timing (SPaT)

- SPaT means Signal Phase and Timing.
- Informs the driver about the current status of the traffic signal, how long this state will persist for each approach, and the next signal state change.
- Provides information about approaching traffic to optimize the signal.

SPaT Data Example

```
SPaT Message
    Msg id =  0x0c  (indicates a SPaT message)
    SPaT id = TBD   (indicates a unique value for this intersection)
    States
            State #1
                    Lane Set                (list of lanes this applies to)
                            1, 2
                    Movement State (signal state or pedestrian state)
                            SignalState  = Green light
                    TimeToChange         =  12.3 seconds
                    YellowSignalState    =



          State #2
                    Lane Set u(list of lanes this applies to)
                            3,4.5.6, etc...
                    Movement State (signal state or pedestrian state)
                            SignalState  = Red light
                    TimeToChange         =  Indeterminate for this state
                    YellowSignalState    =
  Preempt   = none present
```

MAP

- Map data describes the physical geometry of the intersection.
- Includes lane geometry and the allowable movements for each lane.
- Can include barriers, pedestrian walkways, shared roadways, and rail lines.

Connected Vehicle Tool Library - ISB Message Creator

Connected Vehicles Support

Tool Library Using SAE J2735 3/2016

We highly recommend that all users register for a free unlimited support account by clicking "Support" on the top right. This will allow submitting support and demonstration requests, reporting and tracking bugs, requesting new features, and providing feedback.

ISD Message Creator

Intersection MAP and SPaT

This tool allows a user to define the lanes and approaches of an intersection using a graphical interface. Once designed, the user can encode an ISD, MAP, or SPaT message as an ASN.1 UPER Hex string.

View Tool ›

Connected Vehicle Tool Library – TIM Message Creator

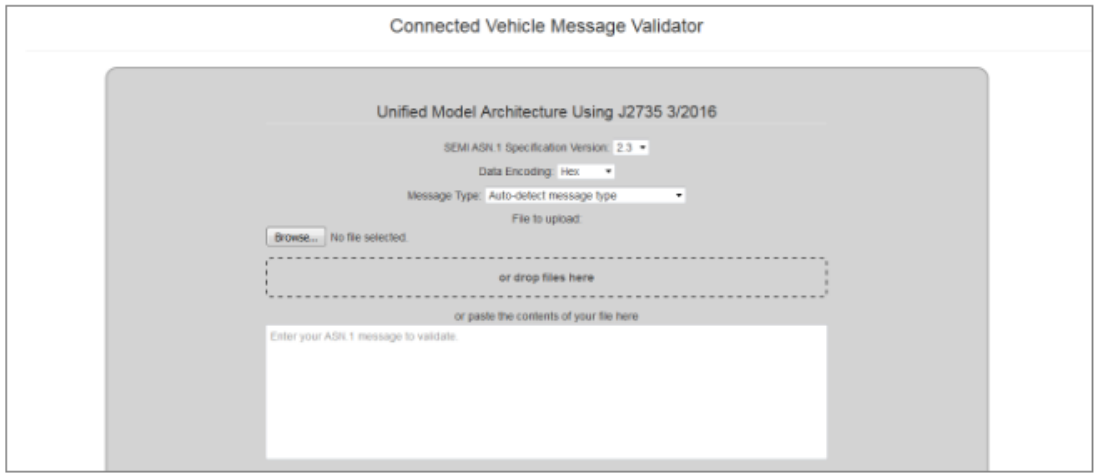
TIM Message Creator

Traveler Information

This tool allows users to build traveler information messages regarding sign and work zone details using a graphical interface. Once designed, the user can encode a TIM message as an ASN.1 UPER Hex string and deposit it to the SDW warehouse.

View Tool ›

Connected Vehicle Tool Library – Message Validator



Message Validator

for SDC/SDW messages

Use this tool to check versions of messages for accuracy against the specifications and standards prior to depositing into a warehouse.

View Tool ❯

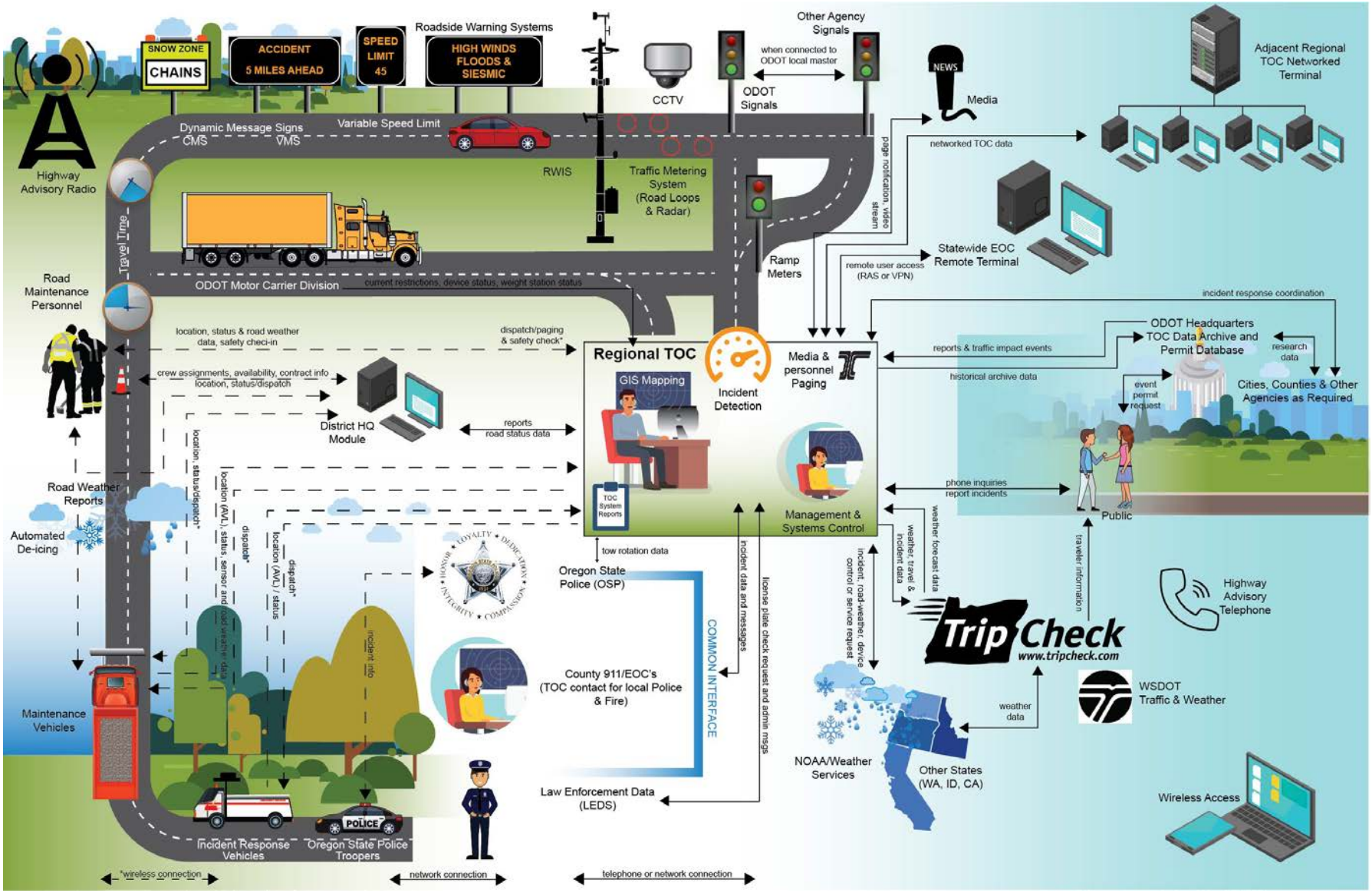
TripCheck API Project

The Vision:

An automated transportation data portal that provides a platform for sharing agency data with a connected environment.

TripCheck API Project

ODOT Regional TOC Con Ops View



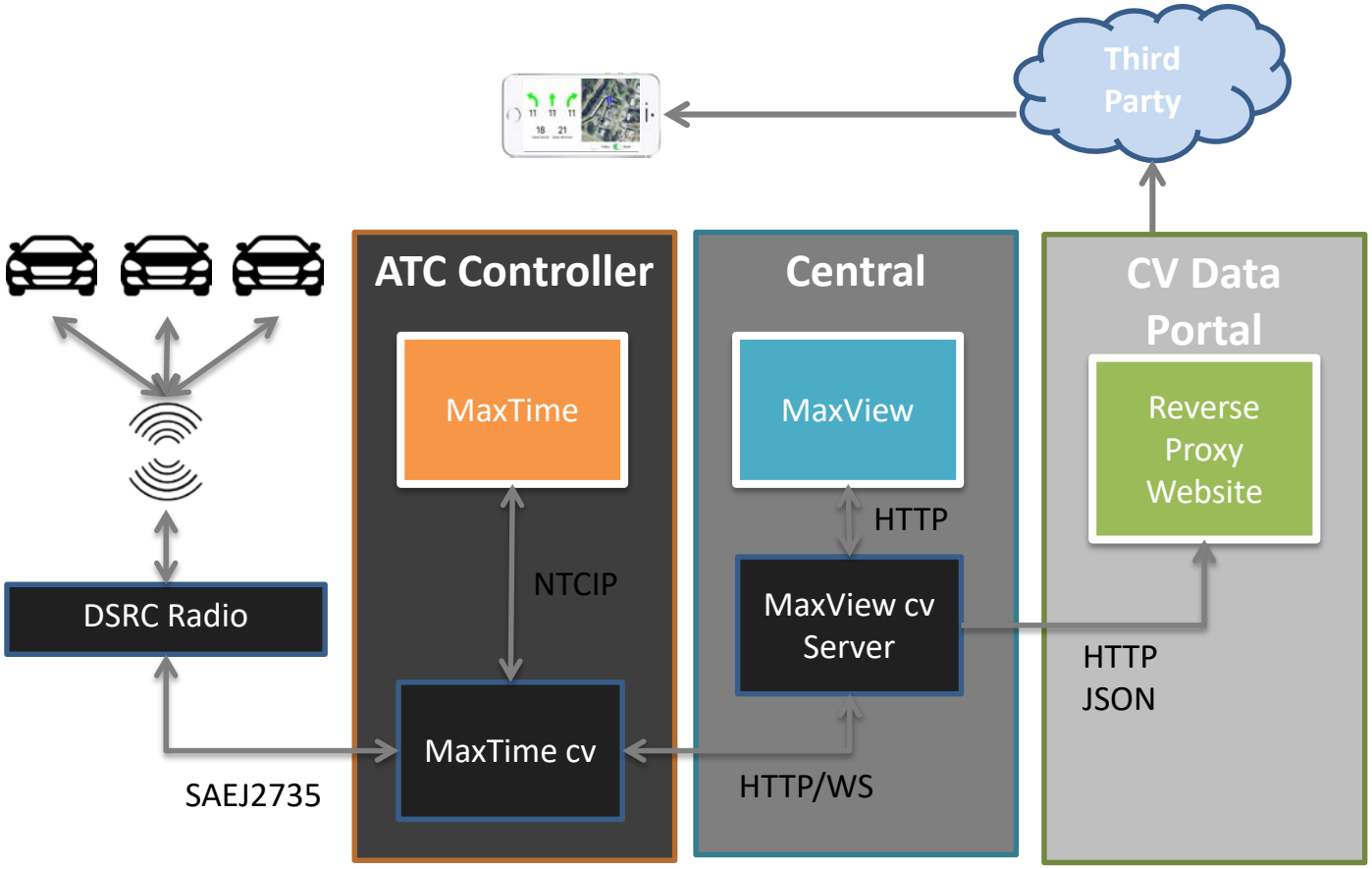
ODOT's Connected Vehicle Strategy

- Address CV centrally first since we have an IT project to update TripCheck's API.
- Standardize on the signal data that we provide to other parties thru the Internet.
- Gets the agency experience with CV without having to install RSU/DSRC in the field.

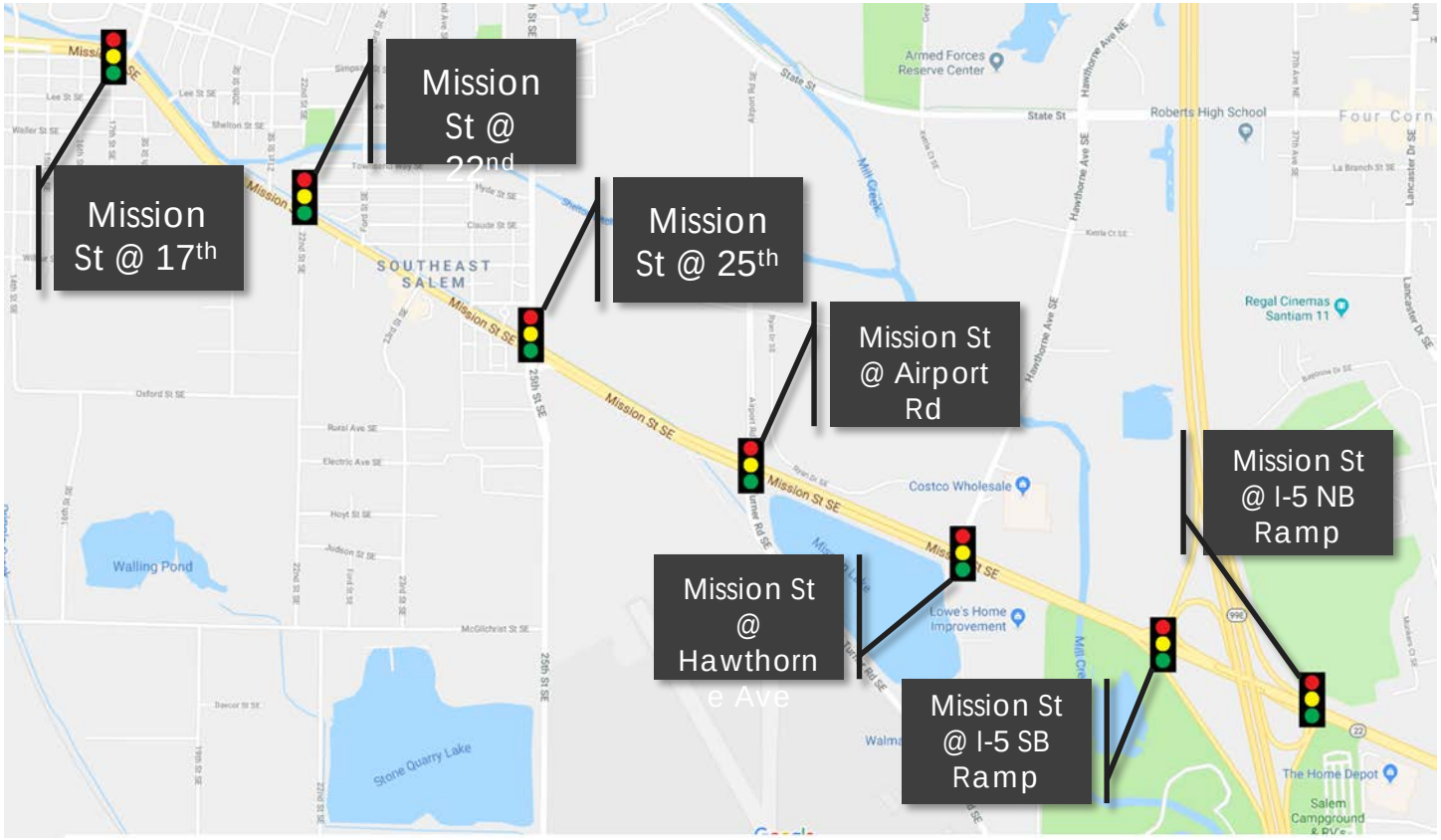
ODOT's Connected Vehicle Strategy-Continued

- Central CV does not satisfy AASHTO SPaT challenge.
- Roadside CV applications have more issues with standards development, safety messages, vehicle data, security, and DSRC vs 5G.
- Work with ODOT's traffic signal software vendor for the development of their central CV applications. ODOT has a price agreement contract for traffic signal software applications that includes CV. Contract has a work order mechanism for development work.

Traffic Signal Connected Vehicle Strategy

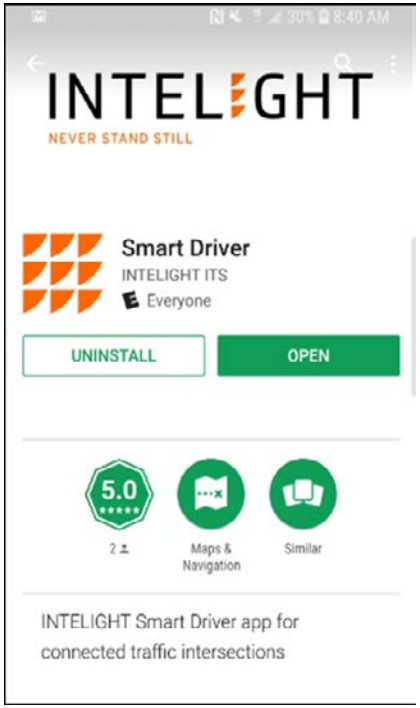


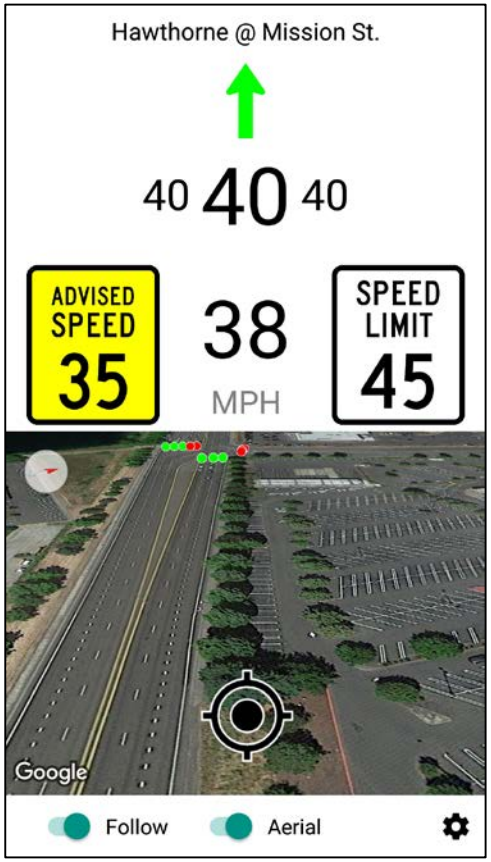
Connected Vehicle Pilot Project-Central: Mission St, Salem Oregon

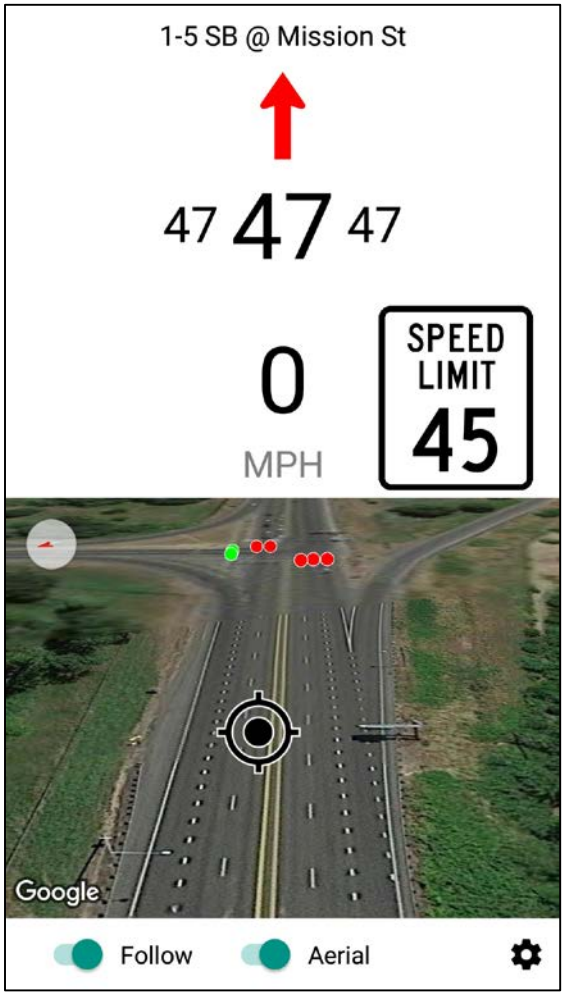


Mission Street Pilot

- Active August 24th 2018
- Test Environment

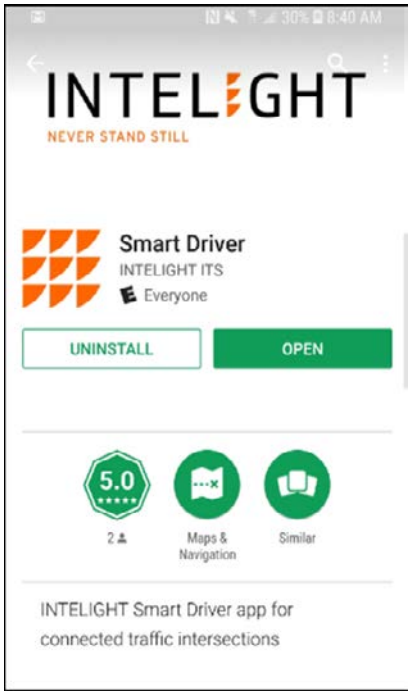






Intelight In Car Reference App

- Native IOS/Android Reference car app.
- Connected to MaxTime CV – DSRC/SAE J2735
- Connected to MaxView CV – JSON CV
- Allows hybrid DSRC/5G radio and central approach
- In car scenarios
  - Realtime position and lane tracking
  - Time to green/time to red
  - Actual/Suggested speed
  - Preempt/EV notification
  - Traveler Information Message notification
  - Priority Request/Priority Status (Future)

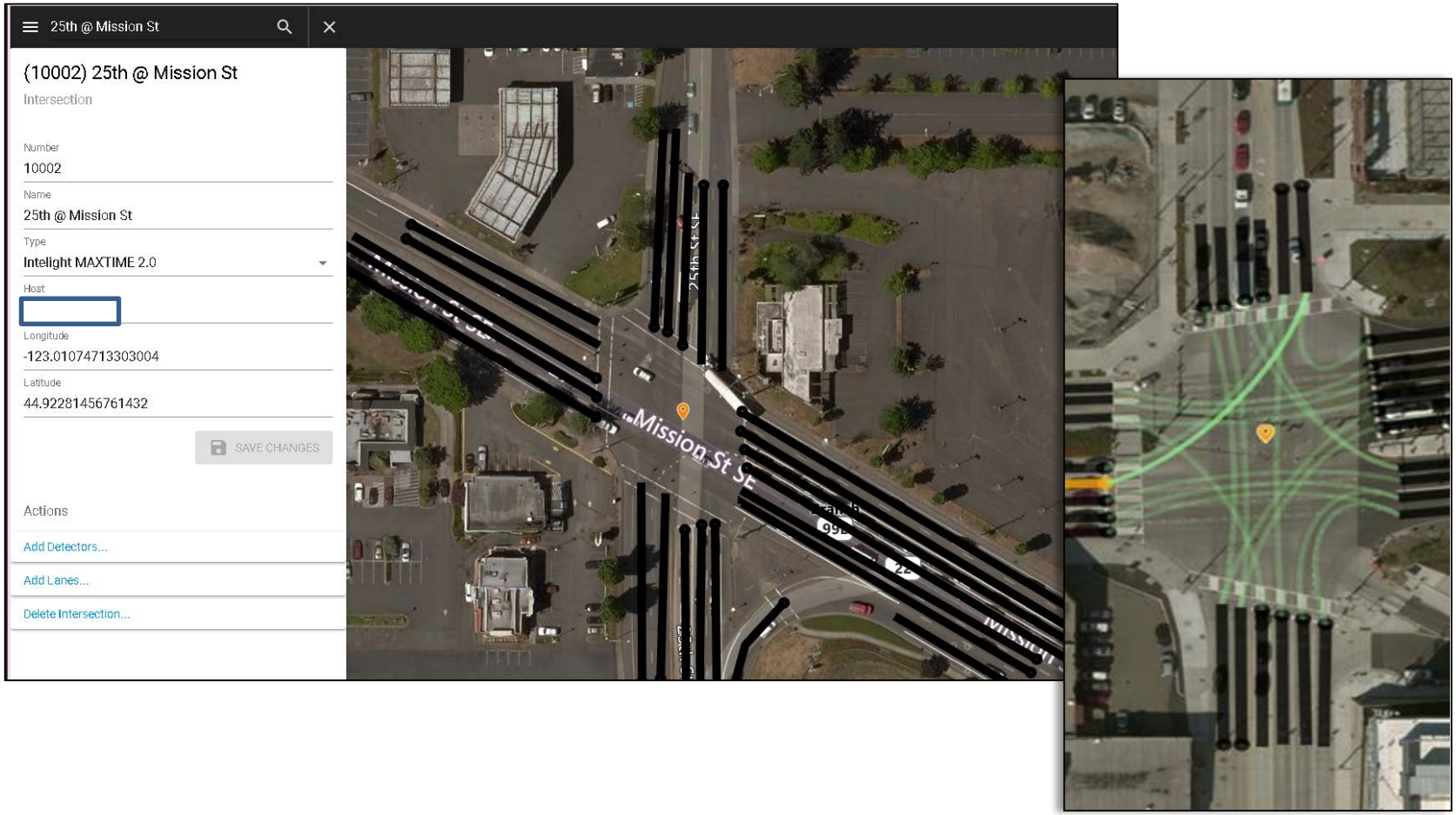


Hardware Requirements: ATC Controllers

Mission St Signal Pilot Project - Video

- https://www.youtube.com/watch?v=f49V4Toykjk&feature=youtu.be

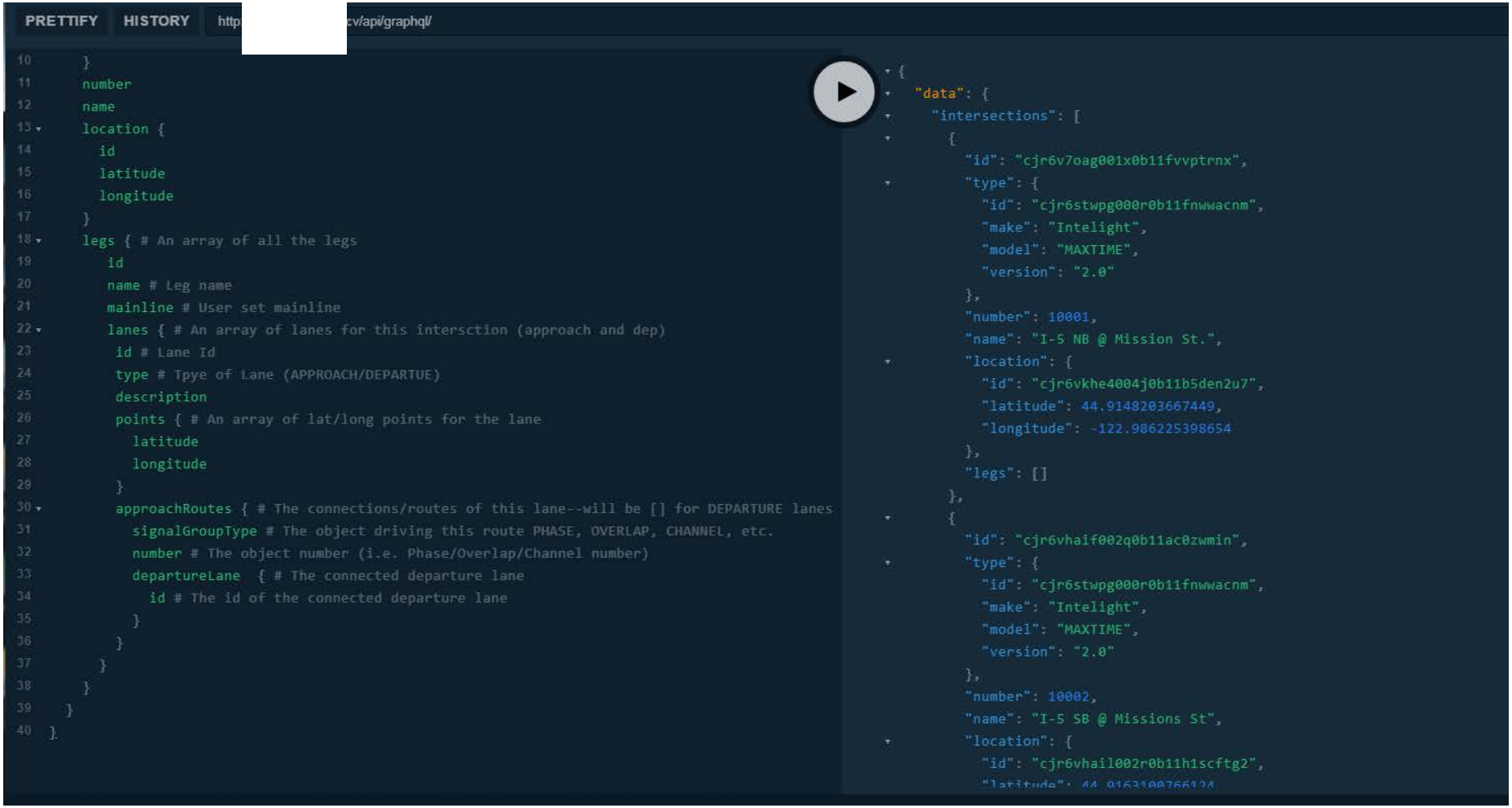
MAXVIEW Configuration Tool



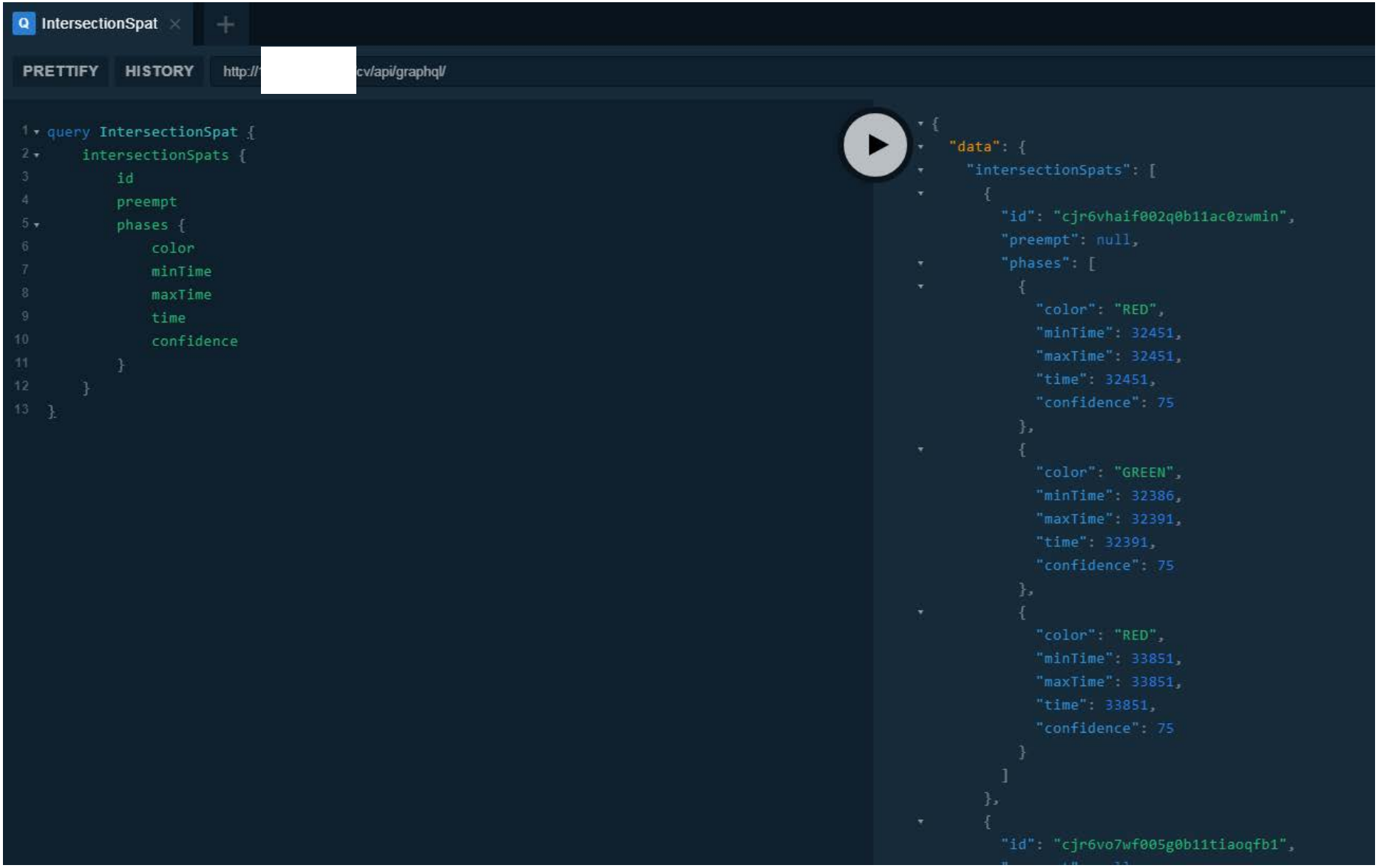
MAP and SPaT Verification

- ODOT IS created a tool to verify data going out.
- Currently using GraphQL Playground.
- Queries MaxConnect Central API

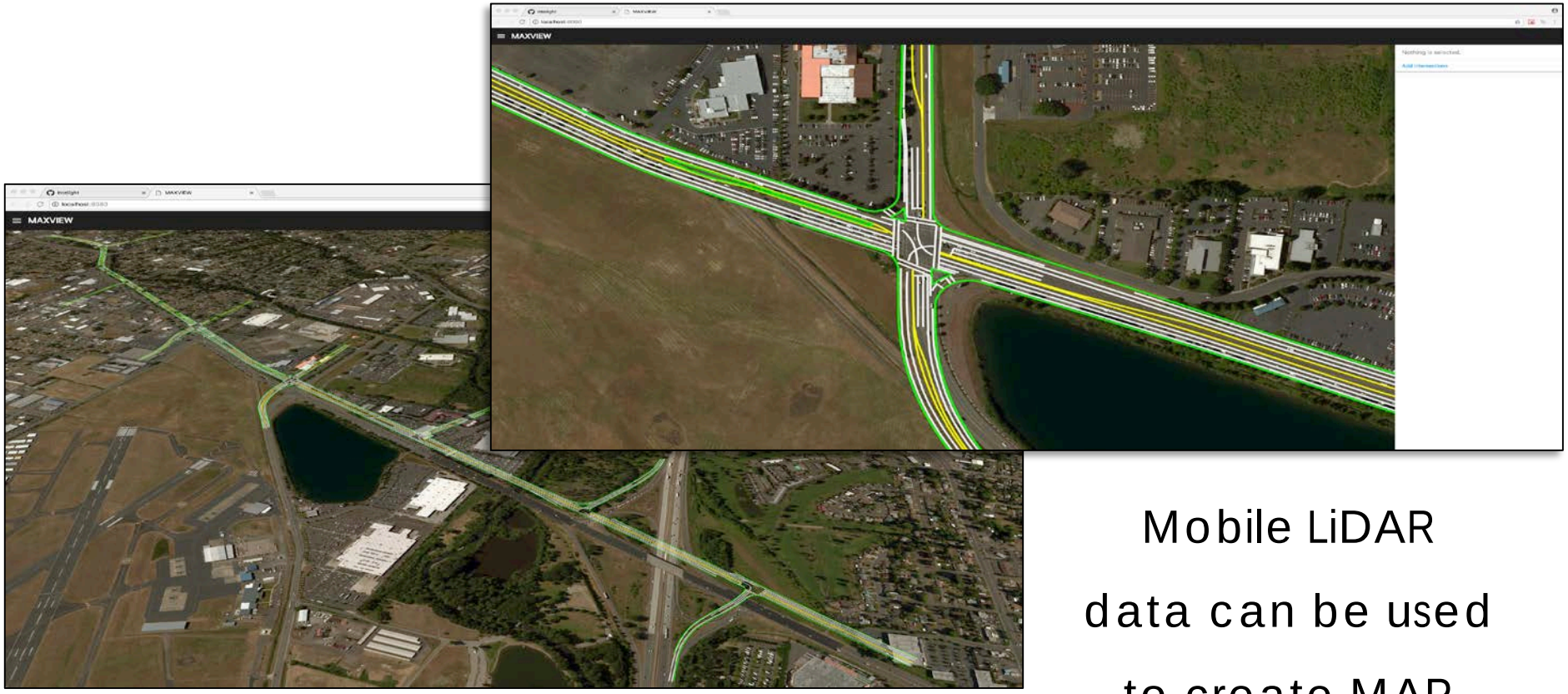
MAP Data Verification



SPaT Data Verification



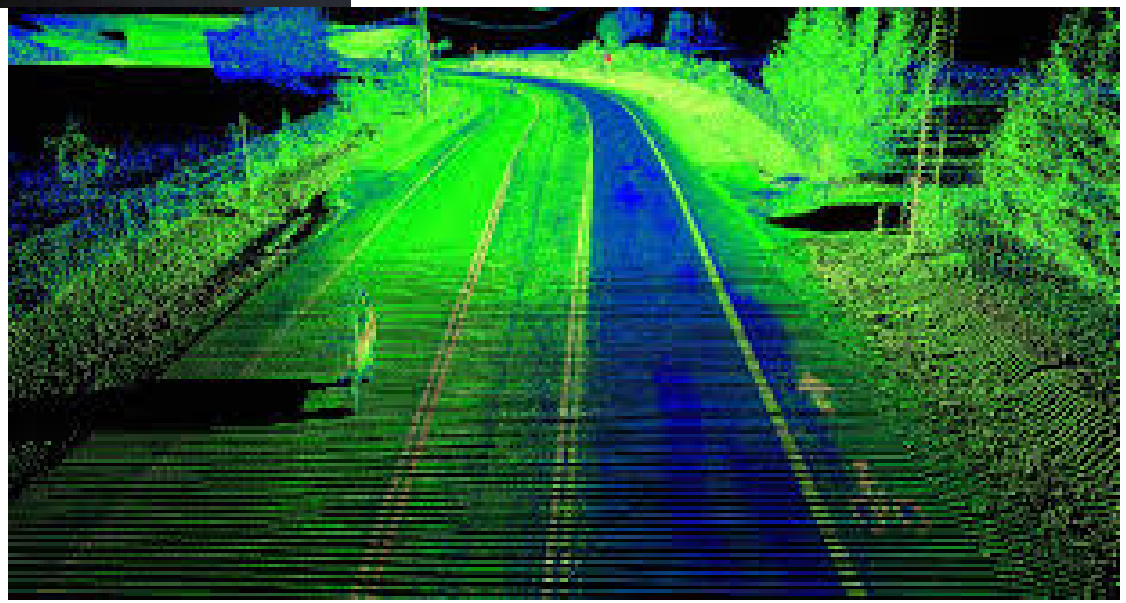
Basemap Data



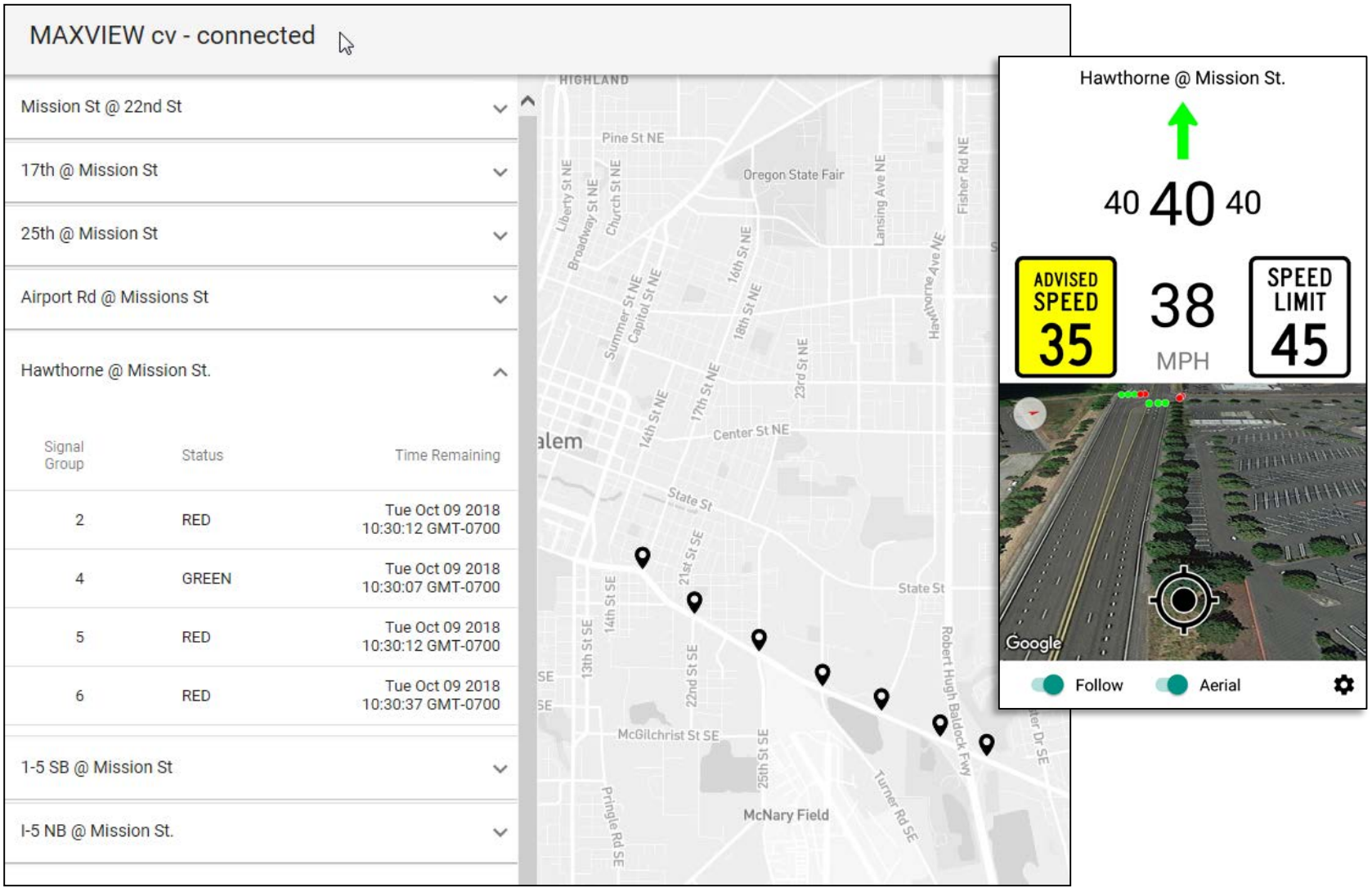
Mobile LiDAR data can be used to create MAP data

ODOT LiDAR

Can use ODOT LiDAR for new signalized intersections not in Google Map, Bing, etc.



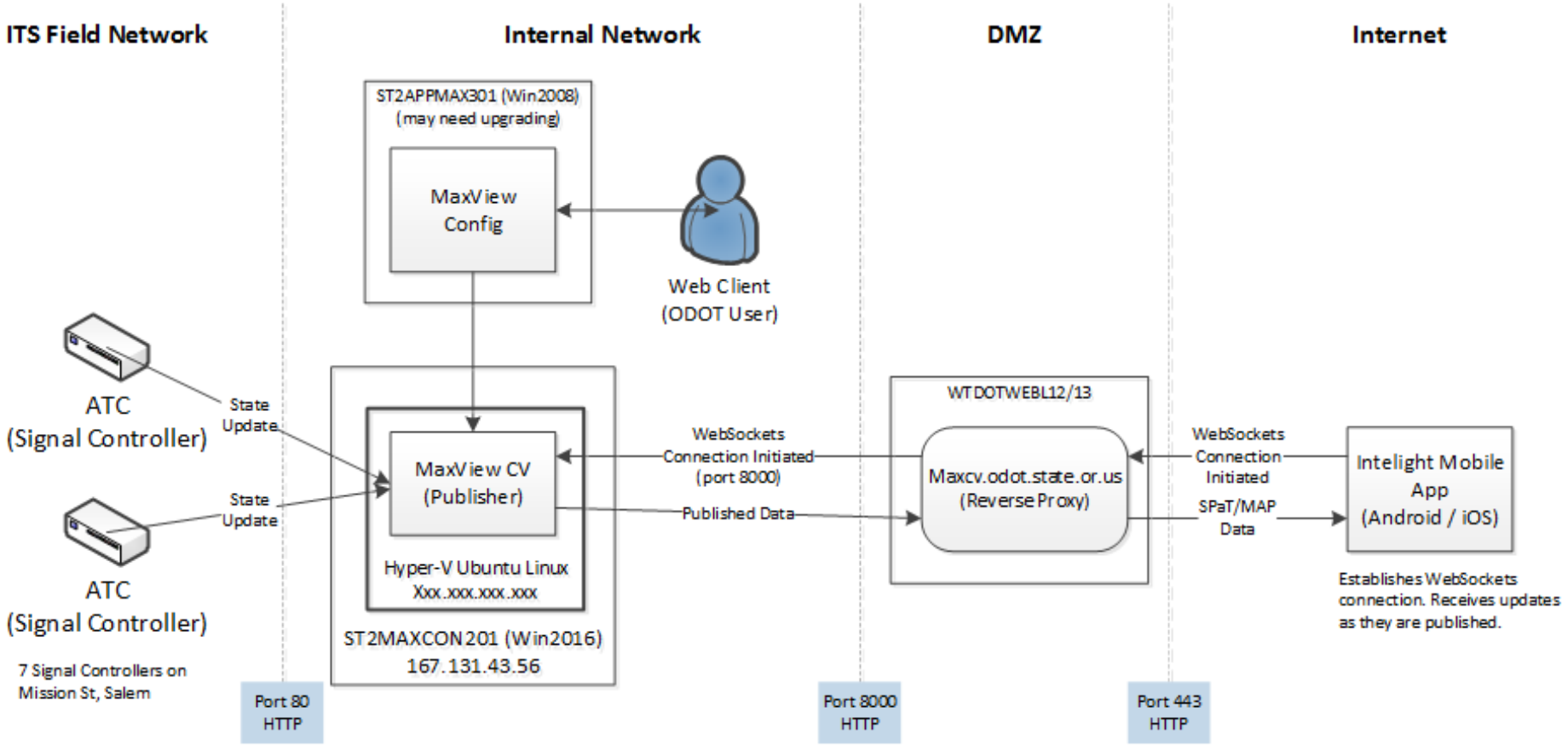
CV Status


MAXVIEW cv - connected
Mission St @ 22nd St
17th @ Mission St
25th @ Mission St
Airport Rd @ Missions St
Hawthorne @ Mission St.
Signal Group
Status
Time Remaining
2
RED
Tue Oct 09 2018 10:30:12 GMT-0700
4
GREEN
Tue Oct 09 2018 10:30:07 GMT-0700
5
RED
Tue Oct 09 2018 10:30:12 GMT-0700
6
RED
Tue Oct 09 2018 10:30:37 GMT-0700
1-5 SB @ Mission St
I-5 NB @ Mission St.
HIGHLAND
Pine St NE
Oregon State Fair
Center St NE
State St
McGilchrist St SE
McNary Field
Hawthorne @ Mission St.
40 40 40
ADVISED SPEED 35
38
MPH
SPEED LIMIT 45
Google
Follow
Aerial

In Car Scenarios

MaxView CV - Pilot

Server Infrastructure



MaxView Connected Vehicle

- Signal controllers are calculating SPaT prediction and pushing that data to MaxView CV application.
- MaxView CV aggregates the intersections together and sends out a data payload at most once a second (can be less often).
- API with subscription for MAP and SPaT data.
- Data is pushed to the subscriber who has a persistent connection
- Uses Websockets protocol.

MaxConnect Connected Vehicle

- Data is only pushed when status changes at each intersection or when MAP configuration changes are made.

- Using a reverse proxy website, ODOT exposes the API to the external users without needing to create a firewall exception for each consumer.

Current Traffic Technology Services, Inc. Data Feed

- ODOT pushes MAP data to TTS once a day out of TransSuite server.
- ODOT pushes status data to them every second.
- TTS creates SPaT predictions from status data.

Traffic Technology Services, Inc. - Audi Traffic Light Information

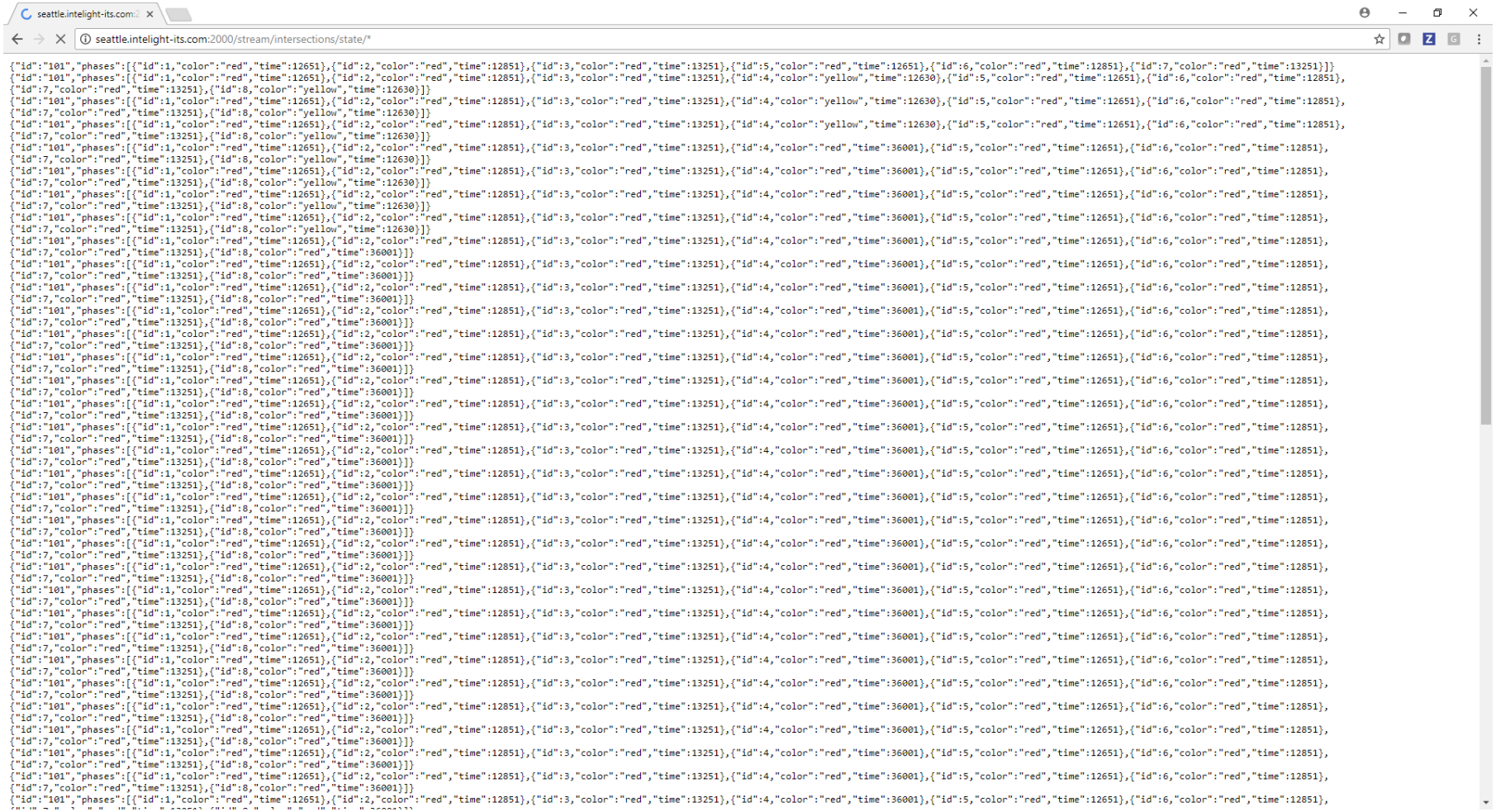
- https://www.traffictechservices.com/

- Now available in 13 metro areas.

New Process Using MaxView Connected Vehicle

- TTS subscribes to SPaT data stream and updates are pushed when changes occur at each intersection.
- Each data push will be smaller since it will only be the intersections that have changed.
- TTS subscribes to MAP data stream and updates are pushed when configuration changed.
- When Traffic staff make an update to an intersection configuration, that update will be pushed to TTS.

What Does the Data Look Like?



MaxView CV

- Central based CV vehicle data aggregator for any NTCIP 1202v3 signal firmware.
- Supports public scalable and cloud hostable API with authentication.
- Log and analyze incoming BSM/SRM when using MaxTime CV.
- 3rd party realtime access to aggregated JSON CV (SPaT, MAP, etc. with less than 1 sec. latency).
- Direct realtime communication with signal firmware
  - MaxTime over HTTP/Websocket for fast exchange

INTELIGHT
NEVER STAND STILL

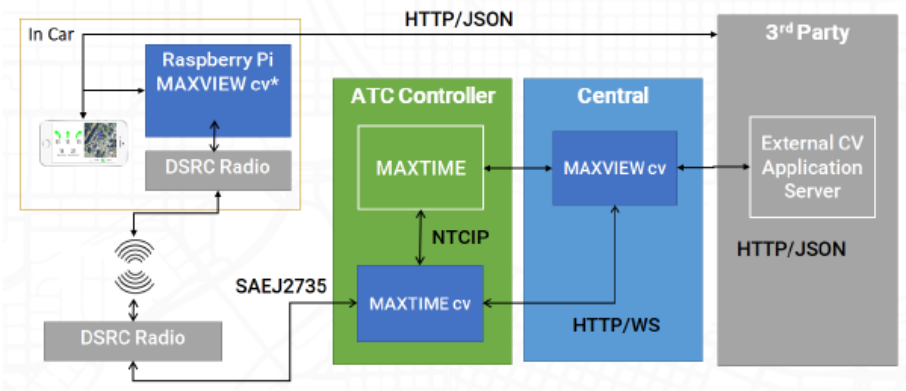
INTELIGHT CV

end-to-end connected vehicle solution

Overview

Intelight's Connected Vehicle applications, MAXTIME cv and MAXVIEW cv, are built upon the latest ATC, NTCIP and DSRC J2735 standards. MAXTIME cv is built as a stand-alone embedded firmware application designed to run on ATC 5.2b or above compliant controller hardware. In addition, by leveraging the Linux kernel and the ATC API Standard v2.06b, MAXTIME cv can run on the same physical ATC engine board as the existing MAXTIME intersection firmware, thereby reducing the overall hardware cost of the connected vehicle deployment.

MAXTIME cv communicates directly with the signal firmware utilizing NTCIP 1201, 1202 and 1211 message sets. MAXTIME cv then creates valid J2735 messages including SPaT, MAP, and SSM to be broadcast on a connected DSRC radio or via a connected MAXVIEW cv server application over the internet. Intelight's in-car CV App (Android and Apple devices supported) provides real-time connected vehicle data from MAXVIEW cv (Cellular) or MAXTIME cv (DSRC Radio). The application currently displays: real-time position and lane tracking, time to green/time to red, actual/suggested speed, preempt/EV notification, and traveler information messages.



MAXTIME CV

- Runs on the same ATC intersection controller as MAXTIME signal controller software
- Uses ATC API specification for shared interface
- Full web browser with rich status and configuration view
- Web-based configuration of MAP data — shared across MAXTIME, MAXVIEW, and other apps
- Broadcast SPaT, MAP, SRM/SSM to connected DSRC or web service
- Connect with a broad set of DSRC radio or external services vehicle services
- Connected Vehicle Application Platform
- Supports subset of NTCIP 1202 v.3 connected vehicle objects

MAXVIEW CV

- Central based connected vehicle data aggregator
- Direct real time communication with MaxTime CV over HTTP/Web socket for fast exchange
- Log and analyze incoming SPaT, MAP, SRM/SSM messages
- Provides third-party real-time access to aggregate SPaT, MAP, etc. data with <1 sec latency.

Vendor offers software as a product now. MaxView CV.

Local Connected Vehicle

- March 2019 ODOT's ITS decides to move forward with local CV for AASHTO SPaT challenge.
- Use same 7 intersections along Mission St in Salem. Mission St corridor becomes test bed for traffic signal operations for the agency.
- April 2019 – Toyota releases public announcement that it will not deploy V2X technology on vehicles in the US in 2021 as previously planned.
- 5G or DSRC?
- RSU – ATC 1C CPU engine board or Raspberry Pi?
- Vehicle Equipment – OBU Kit from Intelight

Dedicated Short-Range Communications

- 5.9 GHz, FCC reserved since 1999
- IEEE 802.11p Wireless Access in Vehicular Environment (WAVE)
- IEEE 1609.2 Security Services
- IEEE 1609.3 Networking Services
- IEEE 1609.4 Multi-channel operations
- SAE J2735 message set dictionaries
- SAE J2945 for DSRC performance requirements

C-2VX 5G

- 5G (C-V2X) Cellular Vehicle to Everything
  - Peer to Peer
  - 5.9 GHz ITS spectrum, unlicensed, low latency
  - Compatible with 5G networks
  - ODOT's visit to Colorado DOT and Panasonic, Lear 5G/DSRC radios
  - Early in the market space. Where's the radios? Where's the standards?

C-2VX Continued

- **Device to device**
  - V2V and V2I, direct communication without relying on the cellular network provider.
- **Device to cell tower**
  - Another V2I communication link which enables network resources and scheduling and utilizes existing operator infrastructure.
- **Device to network**
  - V2N solution using traditional cellular links to enable cloud services to be part and parcel of the end to end solution.

Roadside Unit (RSU)

- Raspberry Pi Computer

- ATC 1C CPU

Vehicle Equipment

Other CV Topics

- Security Credential Management Systems (SCMS)
- Real-Time Correct Message (RTCM)
- NTCIP 1218 Roadside Unit

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Smart Mobility
NETWORK

VOLUME I
TECHNICAL APPLICATION

Keeping **People**, **Goods**, and **Ideas** Moving in a Growing Region

June 18, 2018
Advanced Transportation and Congestion
Management Technologies Deployment Initiative
Notice of Funding Opportunity No. 693JJ318NF00010

Oregon Department of Transportation

In Partnership With...

PBOT
TRIMET
Metro
Multnomah County
DAIMLER
WAVETRONIX
INTELIGHT
FLIR

Oregon Smart Mobility Network Projects with Connected Vehicle

- OR212/224 Arterial Corridor Management (ODOT)
- NE Airport Way Arterial Corridor Management (PBOT)
- Cornelius Pass Road Arterial Corridor (WA County)

QUESTIONS?

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