

ODOT Connected Vehicle Applications



Presenters

Julie Kentosh, P.E., PTOE

Traffic Signal Engineer

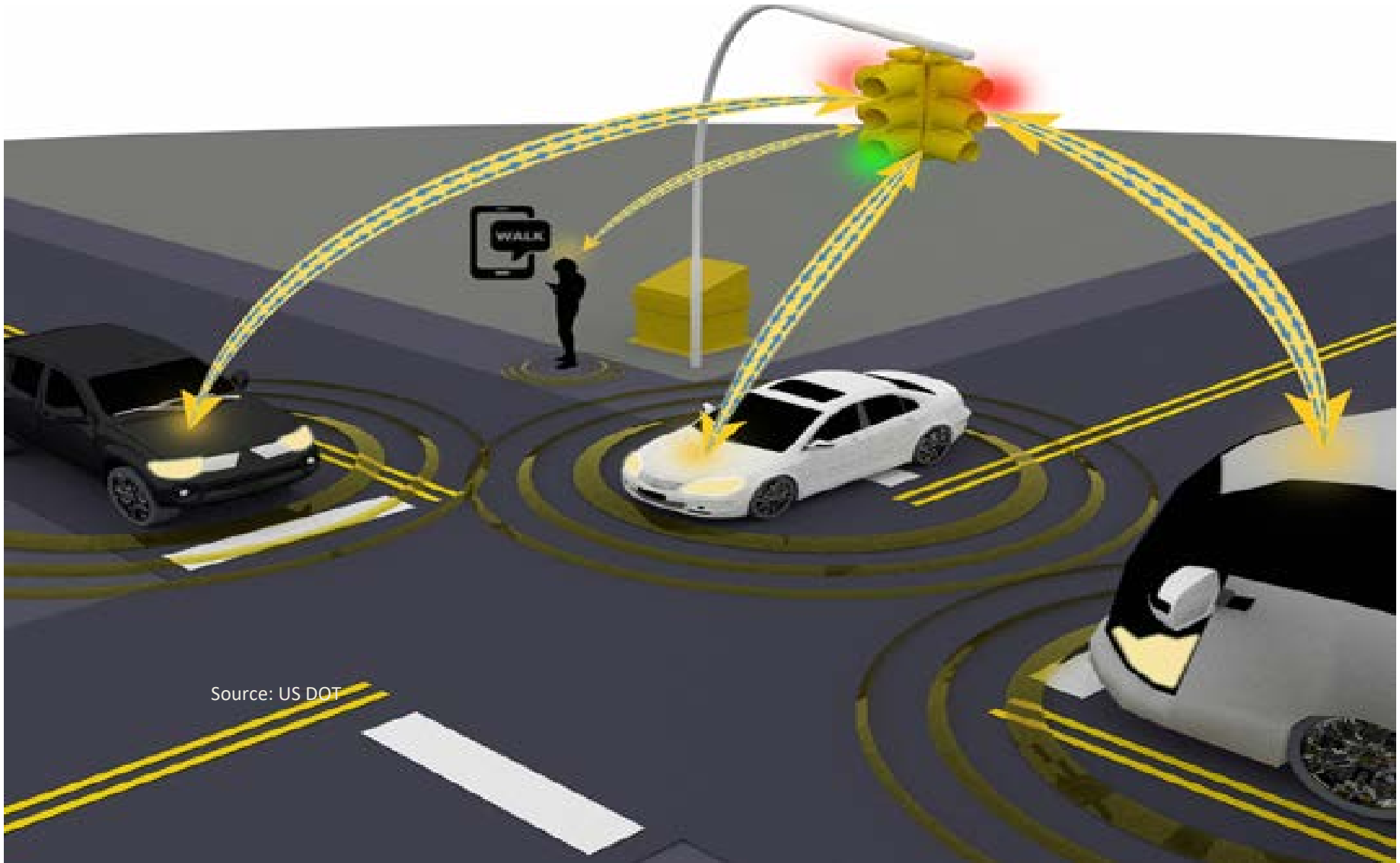
Traffic-Roadway Section

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





VEHICLES

OFFERS

SHOPPING TOOLS

Dealer Locator

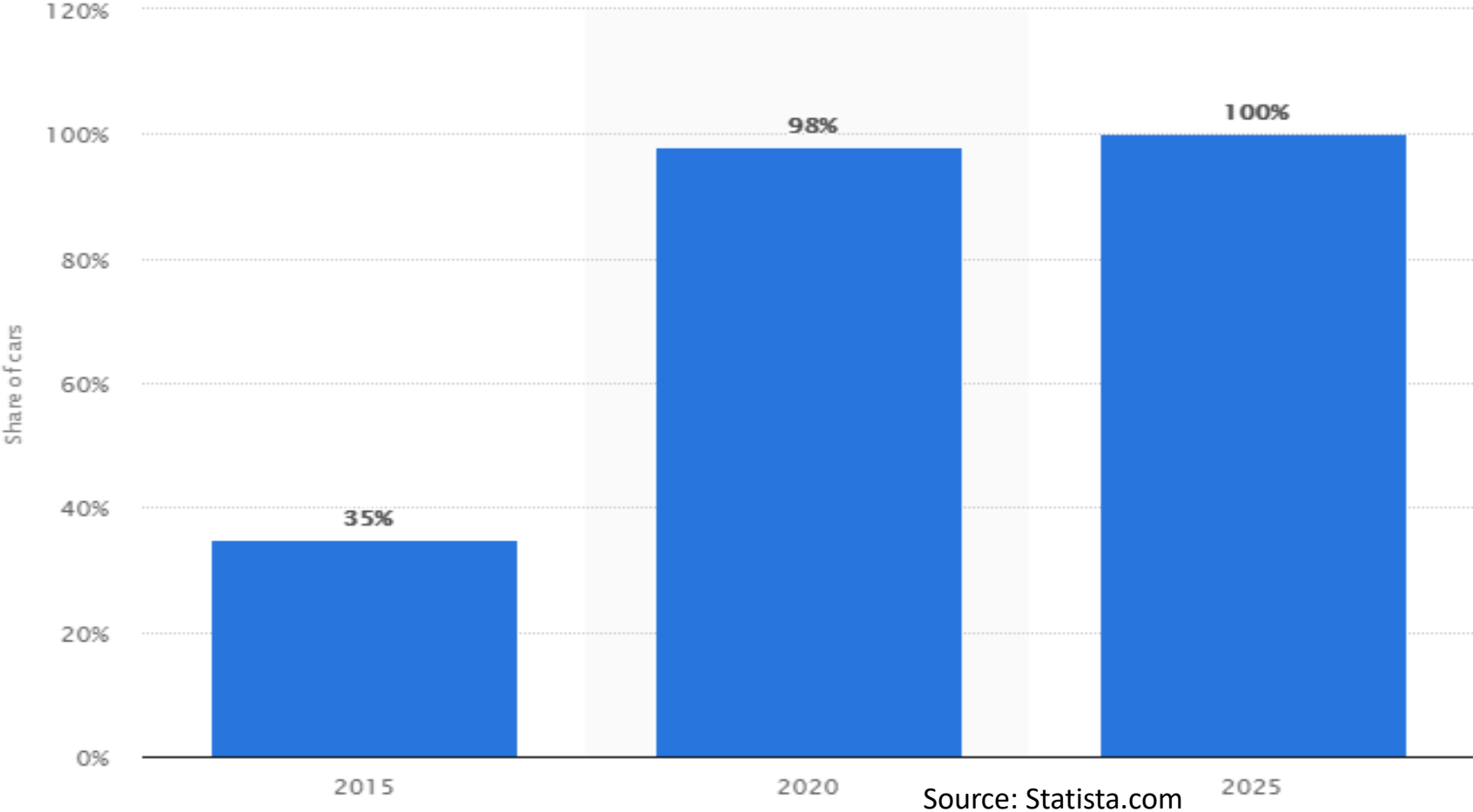
Owners

THE LARGEST 4G LTE Wi-Fi® VEHICLE LINEUP #1

Make Your Strongest Connections On The Road



Share of New Cars with Internet Connectivity



Connected Automation for Greatest Benefits

Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors



Connected Vehicle

Communicates with nearby vehicles and infrastructure



Connected Automated Vehicle

Leverages autonomous and connected vehicle capabilities



U.S. Department of Transportation
ITS Joint Program Office

AASHTO SPaT Challenge



Delivering resources to save time, lives, and money

LOG IN

REGISTER

[Knowledge Center](#)

[Why TSMO?](#)

[Calendar](#)

[News](#)

[About Us](#)



Search ...



[SPaT Home](#)

[Resources](#)

[Webinar Series](#)

[Contact Us](#)

SPaT Challenge Overview

The SPaT Challenge

A challenge to state and local public sector transportation infrastructure owners and operators to cooperate together to achieve deployment of DSRC infrastructure with SPaT broadcasts in at least one corridor or network (approximately 20 signalized intersections) in each of the 50 states by January 2020. SPaT broadcasts are expected to be accompanied by MAP and RTCM broadcasts.



Map Satellite



 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

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

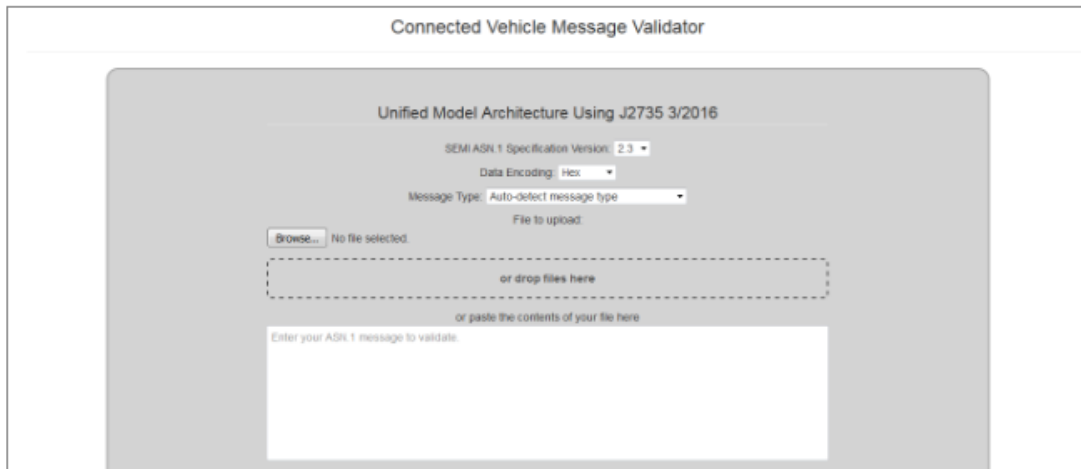
Traveler Information

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



The screenshot shows the 'Connected Vehicle Message Validator' interface. At the top, it says 'Unified Model Architecture Using J2735 3/2016'. Below this, there are several configuration options: 'SEMI ASN 1 Specification Version' set to '2.3', 'Data Encoding' set to 'Hex', and 'Message Type' set to 'Auto-detect message type'. There is a 'File to upload' section with a 'Browse...' button and the text 'No file selected.'. Below this is a dashed box containing the text 'or drop files here' and 'or paste the contents of your file here'. At the bottom, there is a text input field with the placeholder text 'Enter your ASN 1 message to validate.'

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 >](#)

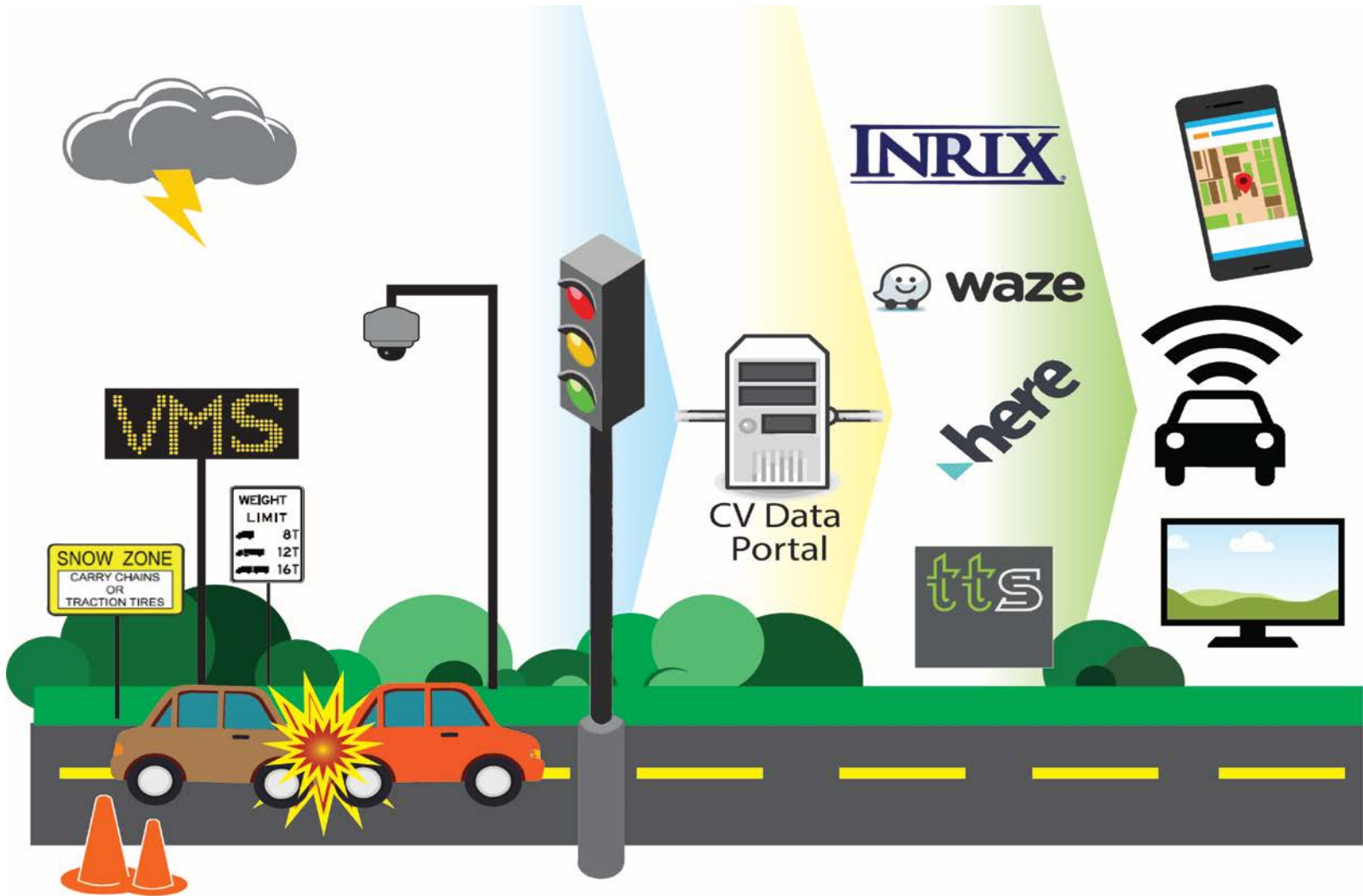


TripCheck API Project

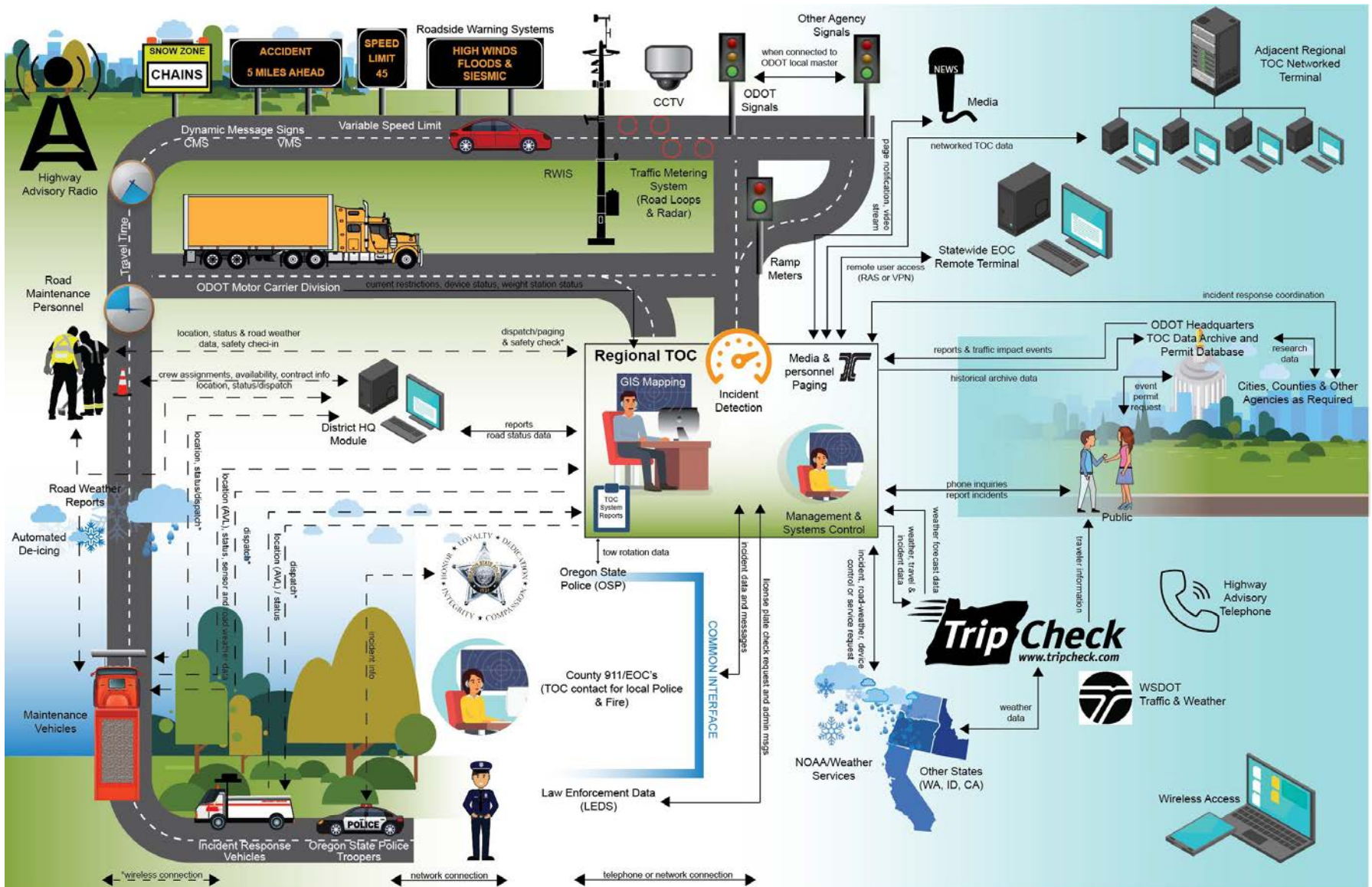
The Vision:

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.

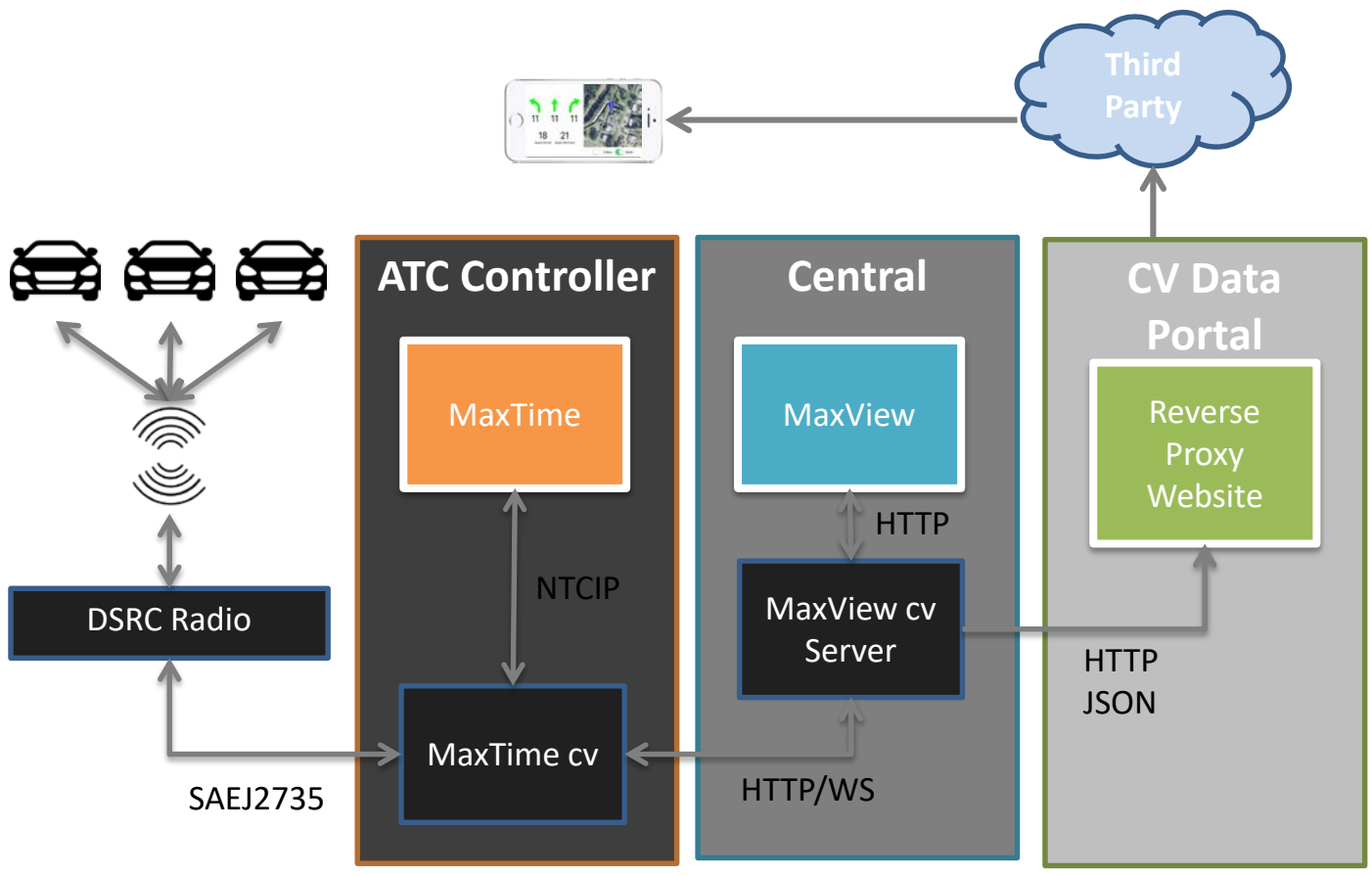


ODOT's Connected Vehicle Strategy-Continued

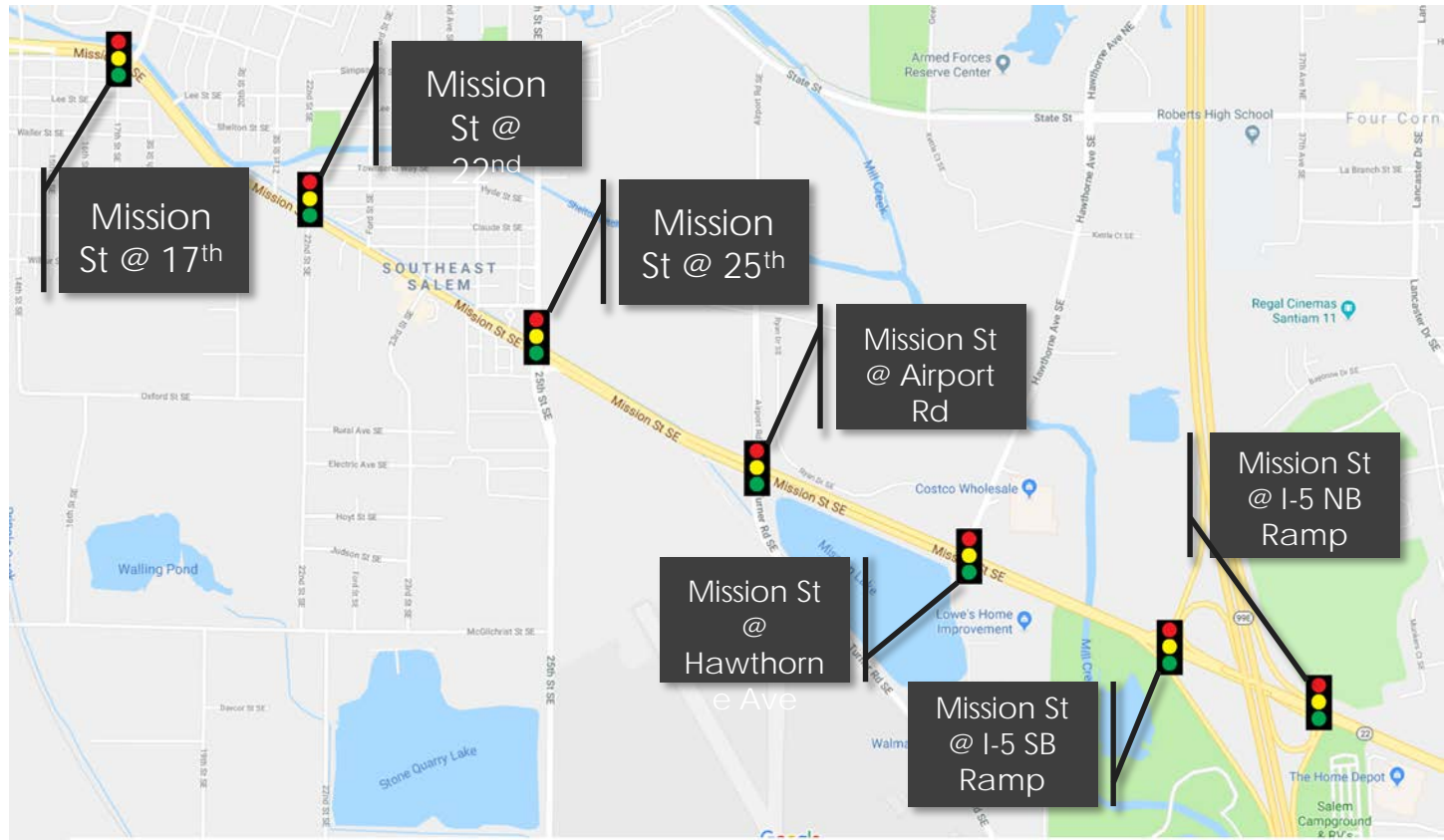
- Central CV does not satisfy AASHTO SPaT challenge.
- Roadside CV applications have more issues with standards development, safety messages, vehicle data, security, and DSRC vs 5G.
- Work with ODOT's traffic signal software vendor for the development of their central CV applications. ODOT has a price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



Traffic Signal Connected Vehicle Strategy

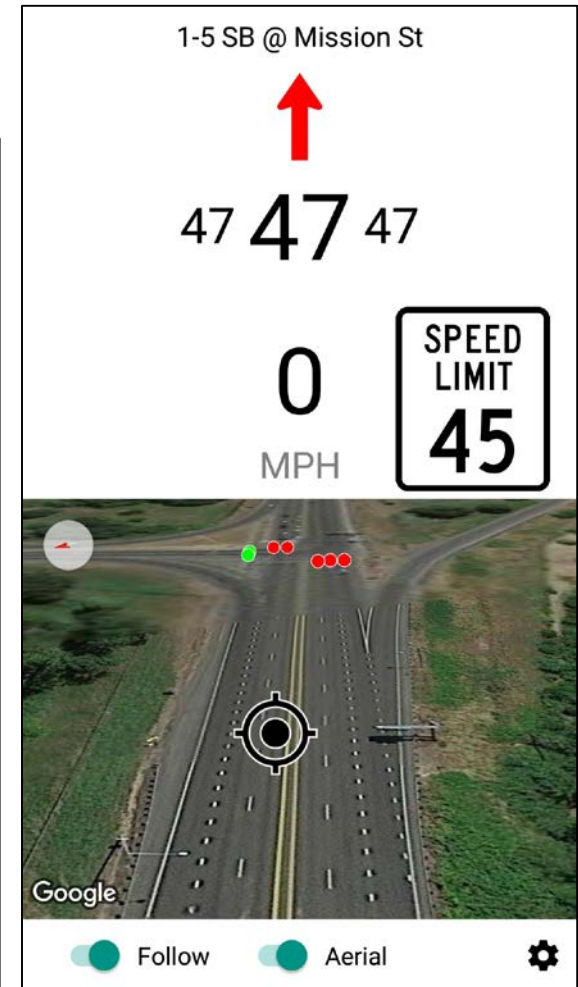
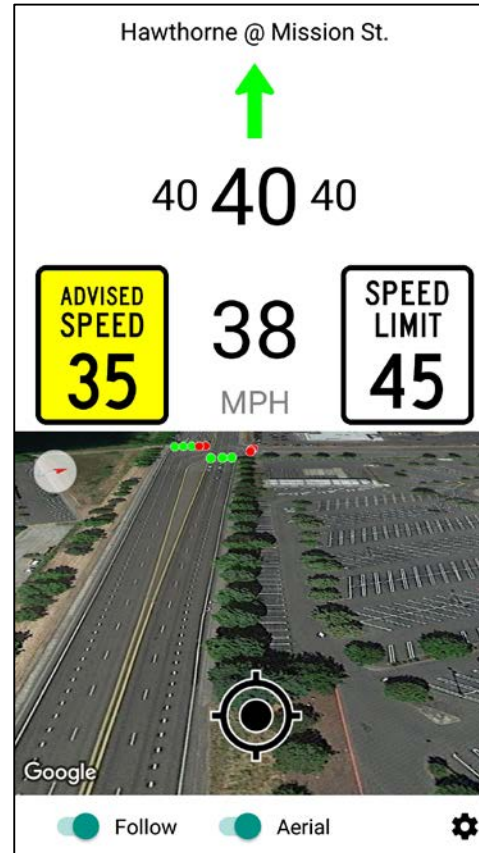
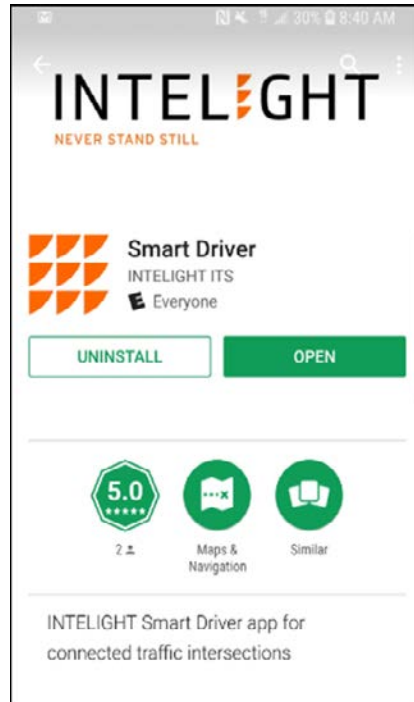


Connected Vehicle Pilot Project-Central: Mission St, Salem Oregon



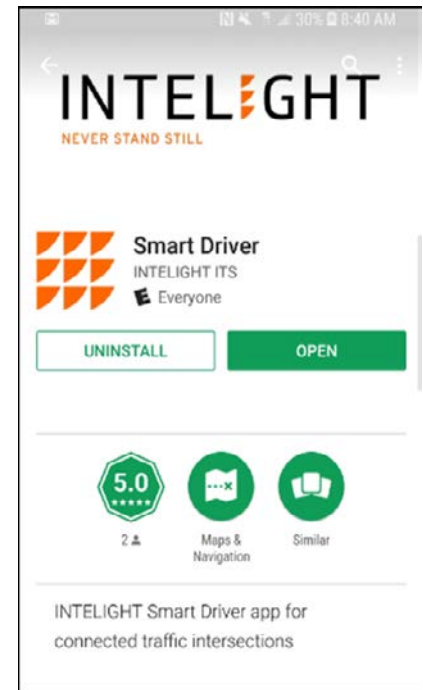
Mission Street Pilot

- 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

The screenshot displays the MAXVIEW Configuration Tool interface. On the left is a configuration panel for the intersection '(10002) 25th @ Mission St'. The panel includes the following fields and options:

- Number:** 10002
- Name:** 25th @ Mission St
- Type:** Intelight MAXTIME 2.0
- Host:** (Empty field with a blue border)
- Longitude:** -123.01074713303004
- Latitude:** 44.92281456761432
- Actions:**
 - [Add Detectors...](#)
 - [Add Lanes...](#)
 - [Delete Intersection...](#)

A 'SAVE CHANGES' button is located below the configuration fields. The right side of the interface shows two overlapping aerial views of the intersection. The background view shows the physical intersection with black lane markings. The foreground view shows the same intersection with green lines representing the virtual lane configuration overlaid on the satellite imagery.

MAP and SPaT Verification

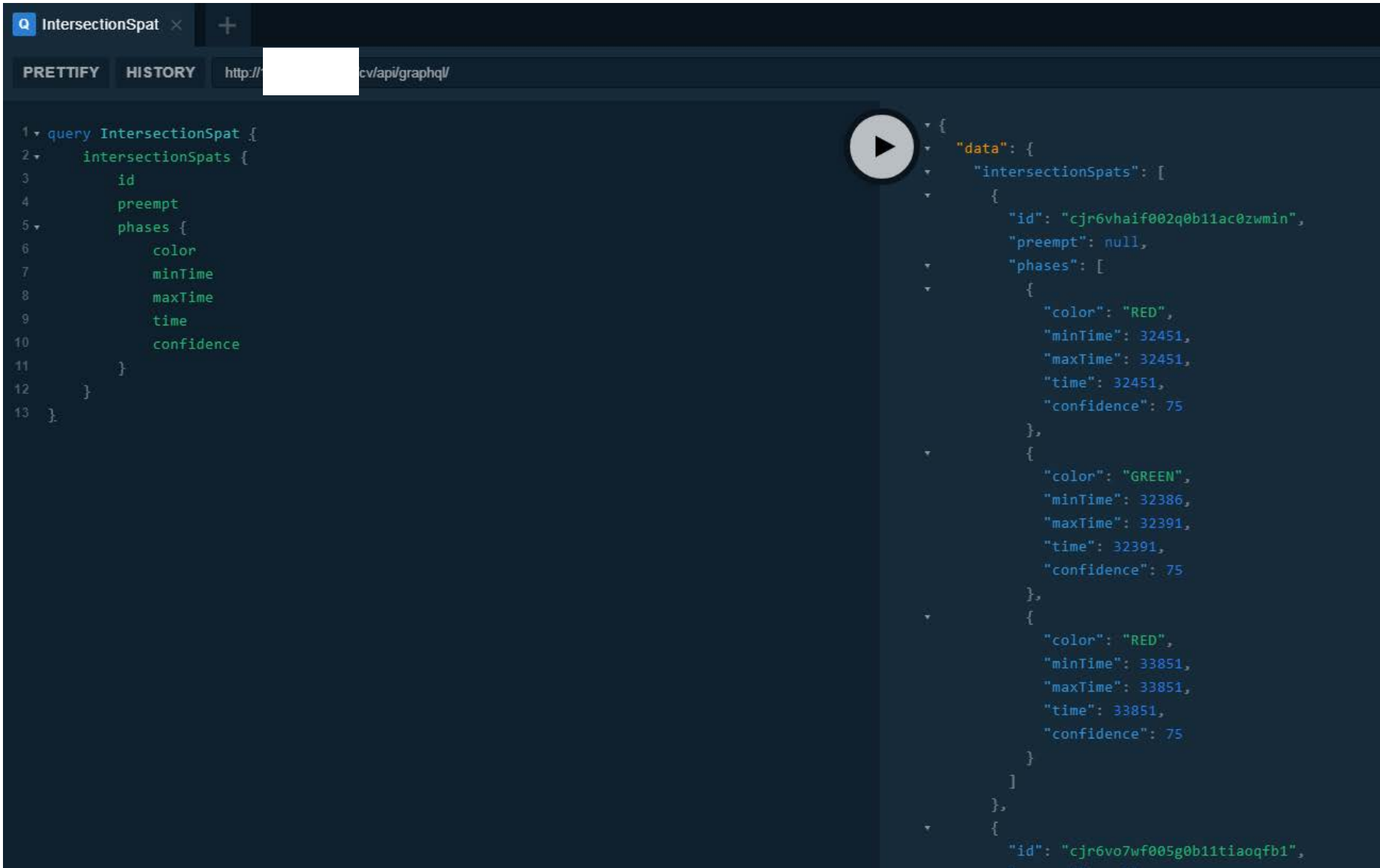
- ODOT IS created a tool to verify data going out.
- Currently using GraphQL Playground.
- Queries MaxConnect Central API

MAP Data Verification

```
PRETTIFY HISTORY http://api/graphql/
10 }
11 number
12 name
13 location {
14   id
15   latitude
16   longitude
17 }
18 legs { # An array of all the legs
19   id
20   name # Leg name
21   mainline # User set mainline
22 lanes { # An array of lanes for this intersection (approach and dep)
23   id # Lane Id
24   type # Type of Lane (APPROACH/DEPARTUE)
25   description
26   points { # An array of lat/long points for the lane
27     latitude
28     longitude
29   }
30 approachRoutes { # The connections/routes of this lane--will be [] for DEPARTURE lanes
31   signalGroupType # The object driving this route PHASE, OVERLAP, CHANNEL, etc.
32   number # The object number (i.e. Phase/Overlap/Channel number)
33   departureLane { # The connected departure lane
34     id # The id of the connected departure lane
35   }
36 }
37 }
38 }
39 }
40 }
```

```
{
  "data": {
    "intersections": [
      {
        "id": "cjr6v7oag001x0b11fvvptrnx",
        "type": {
          "id": "cjr6stwpq000r0b11fnwwacnm",
          "make": "Intelight",
          "model": "MAXTIME",
          "version": "2.0"
        },
        "number": 10001,
        "name": "I-5 NB @ Mission St.",
        "location": {
          "id": "cjr6vkhe4004j0b11b5den2u7",
          "latitude": 44.9148203667449,
          "longitude": -122.986225398654
        },
        "legs": []
      },
      {
        "id": "cjr6vhaif002q0b11ac0zwmn",
        "type": {
          "id": "cjr6stwpq000r0b11fnwwacnm",
          "make": "Intelight",
          "model": "MAXTIME",
          "version": "2.0"
        },
        "number": 10002,
        "name": "I-5 SB @ Missions St",
        "location": {
          "id": "cjr6vhail002r0b11h1scftg2",
          "latitude": 44.9143100766104
        }
      }
    ]
  }
}
```

SPaT Data Verification

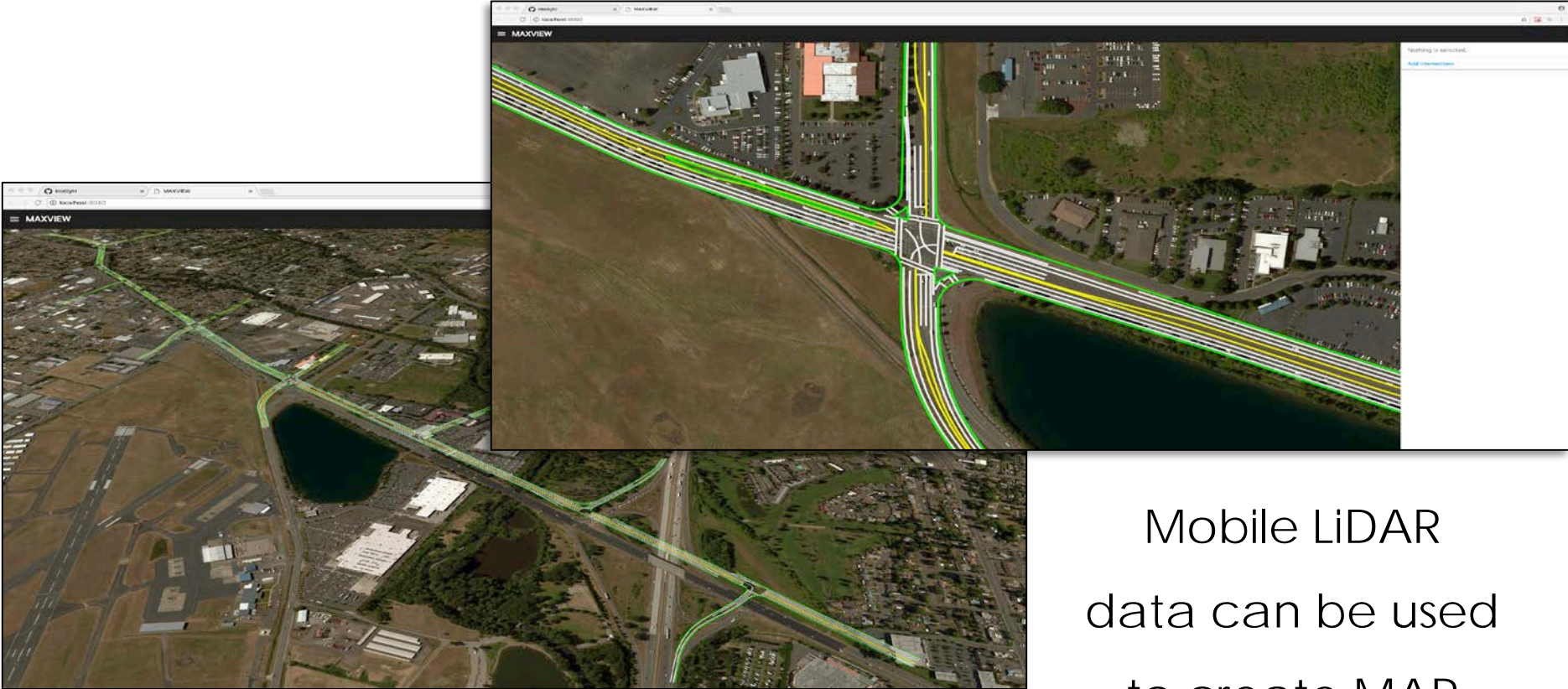


The screenshot shows a GraphQL IDE interface with a query on the left and its JSON response on the right. A play button icon is visible between the query and response.

```
1 query IntersectionSpat {
2   intersectionSpats {
3     id
4     preempt
5     phases {
6       color
7       minTime
8       maxTime
9       time
10      confidence
11    }
12  }
13 }
```

```
{
  "data": {
    "intersectionSpats": [
      {
        "id": "cjr6vhaif002q0b11ac0zwmin",
        "preempt": null,
        "phases": [
          {
            "color": "RED",
            "minTime": 32451,
            "maxTime": 32451,
            "time": 32451,
            "confidence": 75
          },
          {
            "color": "GREEN",
            "minTime": 32386,
            "maxTime": 32391,
            "time": 32391,
            "confidence": 75
          },
          {
            "color": "RED",
            "minTime": 33851,
            "maxTime": 33851,
            "time": 33851,
            "confidence": 75
          }
        ]
      },
      {
        "id": "cjr6vo7wf005g0b11tiaofb1",
        "preempt": null,
        "phases": [
          {
            "color": "RED",
            "minTime": 33851,
            "maxTime": 33851,
            "time": 33851,
            "confidence": 75
          }
        ]
      }
    ]
  }
}
```

Basemap Data

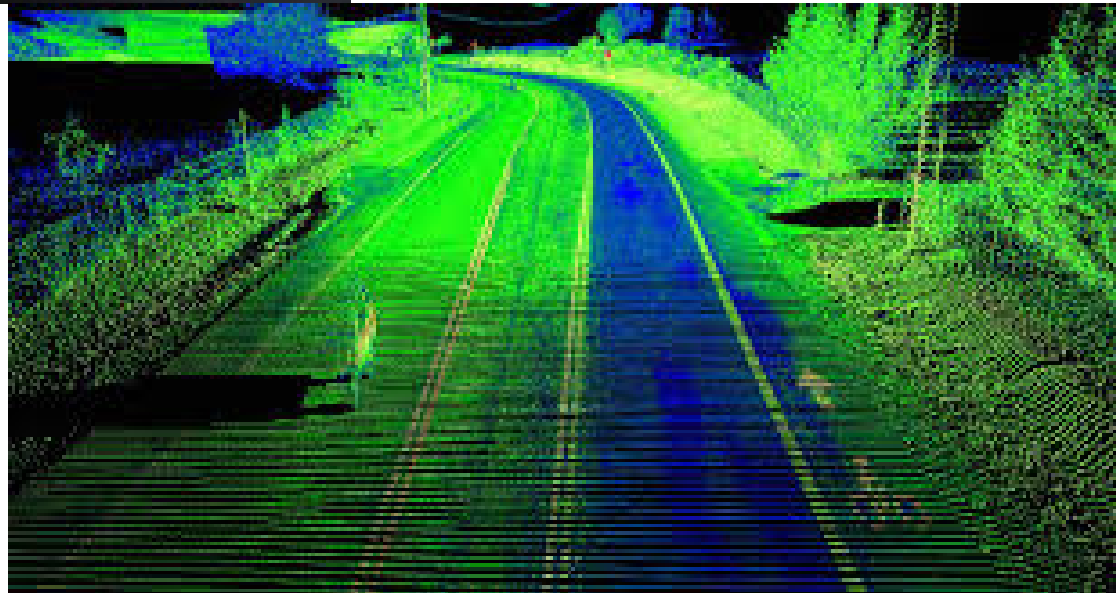


Mobile LiDAR data can be used to create MAP data


ODOT LiDAR








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





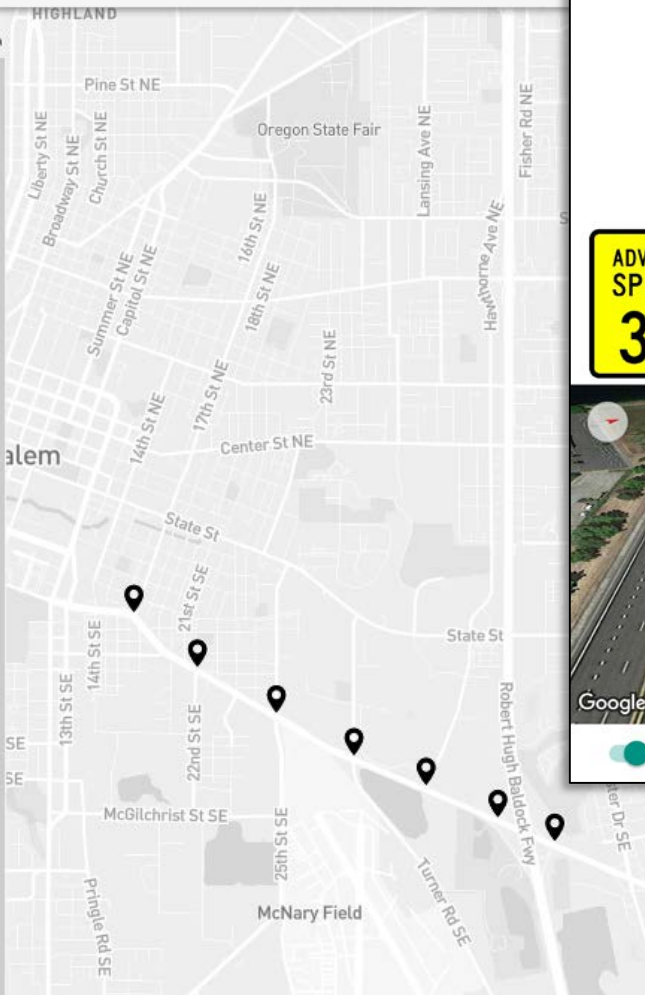
CV Status

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. 



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

ITS Field Network

ATC
(Signal Controller)

ATC
(Signal Controller)

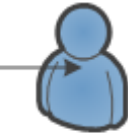
7 Signal Controllers on
Mission St, Salem

Port 80
HTTP

Internal Network

ST2APPMAX301 (Win2008)
(may need upgrading)

MaxView
Config



Web Client
(ODOT User)

MaxView CV
(Publisher)

Hyper-V Ubuntu Linux
Xxx.xxx.xxx.xxx

ST2MAXCON201 (Win2016)
167.131.43.56

WebSockets
Connection Initiated
(port 8000)

Published Data

Port 8000
HTTP

DMZ

WTDOTWEB12/13

Maxcv.odot.state.or.us
(Reverse Proxy)

WebSockets
Connection Initiated

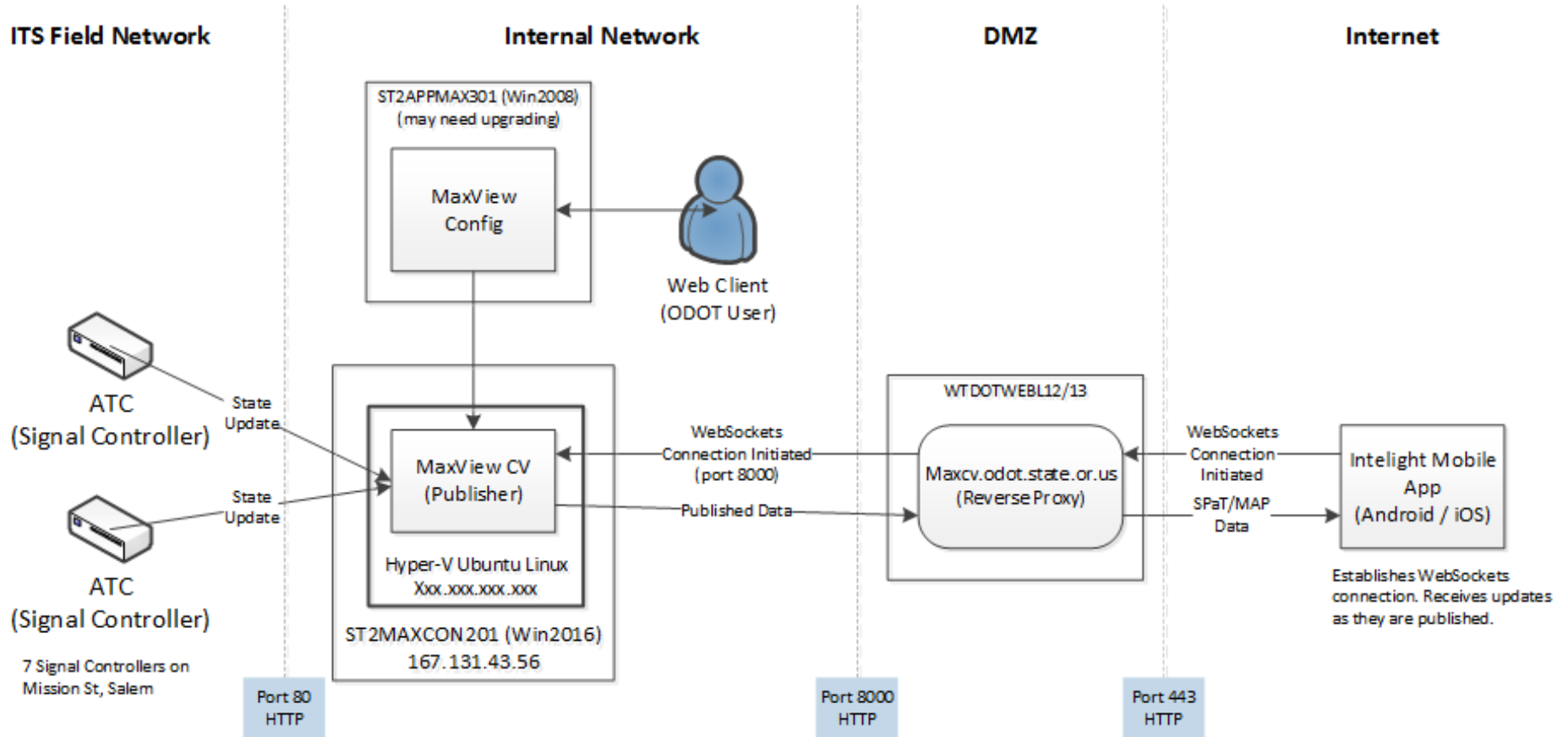
SPaT/MAP
Data

Port 443
HTTP

Internet

Intelight Mobile
App
(Android / iOS)

Establishes WebSockets
connection. Receives updates
as they are published.



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.



MaxView CV

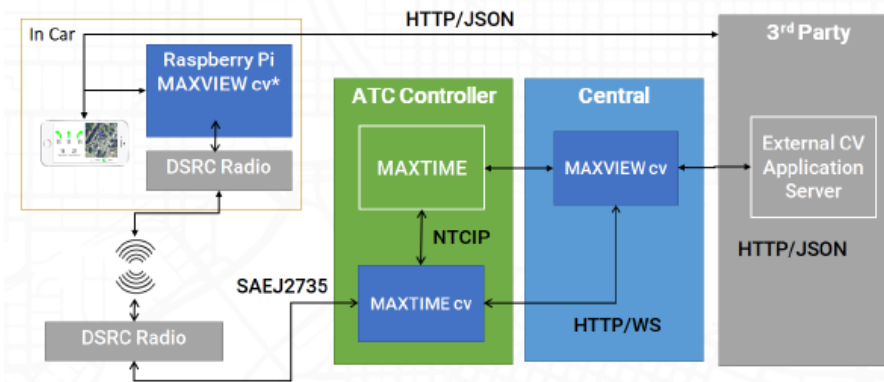
- Central based CV vehicle data aggregator for any NTCIP 1202v3 signal firmware.
- Supports public scalable and cloud hostable API with authentication.
- Log and analyze incoming BSM/SRM when using MaxTime CV.
- 3rd party realtime access to aggregated JSON CV (SPaT, MAP, etc. with less than 1 sec. latency).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



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



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



PREPARE



MANAGE



RECOVER

June 18, 2018

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



In Partnership With...



WAVETRONIX



DAIMLER



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?

Julie Kentosh, P.E., PTOE

(503) 986-3576

julie.l.kentosh@odot.state.or.us

Doug Spencer, P.E.

(541) 747-1276

doug.l.spencer@odot.state.or.us

