GDOT
Georgia Department of Transportation

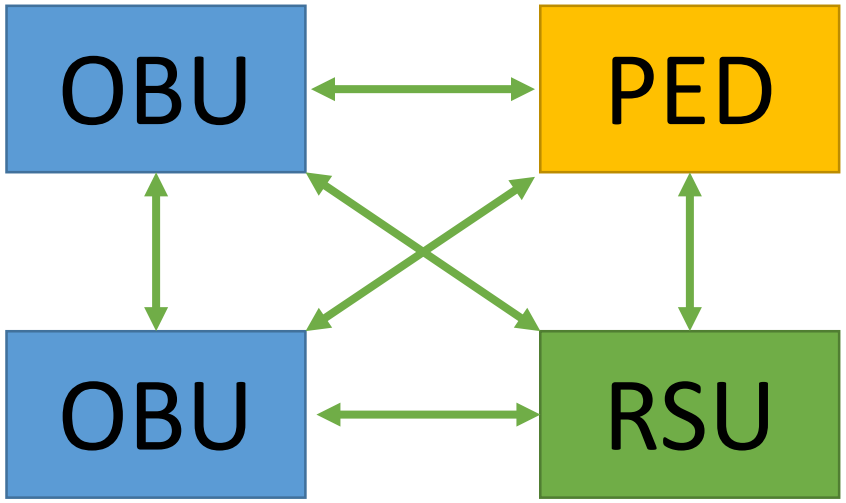
# Georgia Connected Vehicles

## Progress and Plans

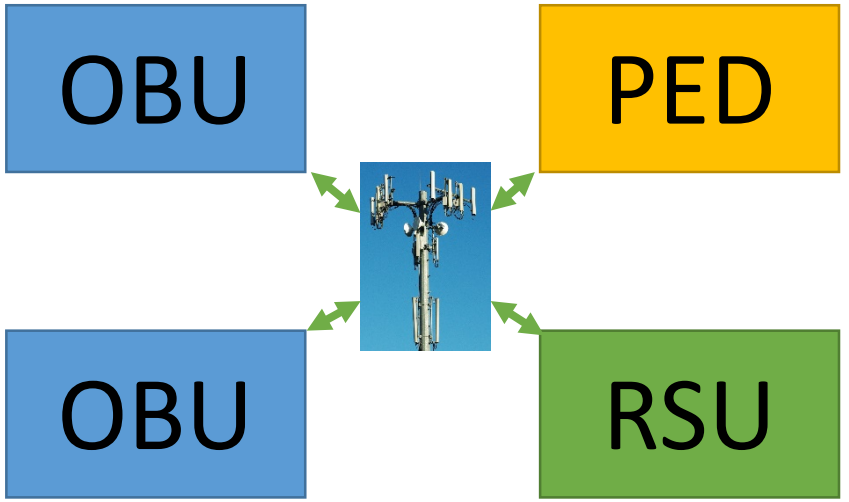
# The Definitions

## Point – to – point communications

### V2X is this:




### Not this:

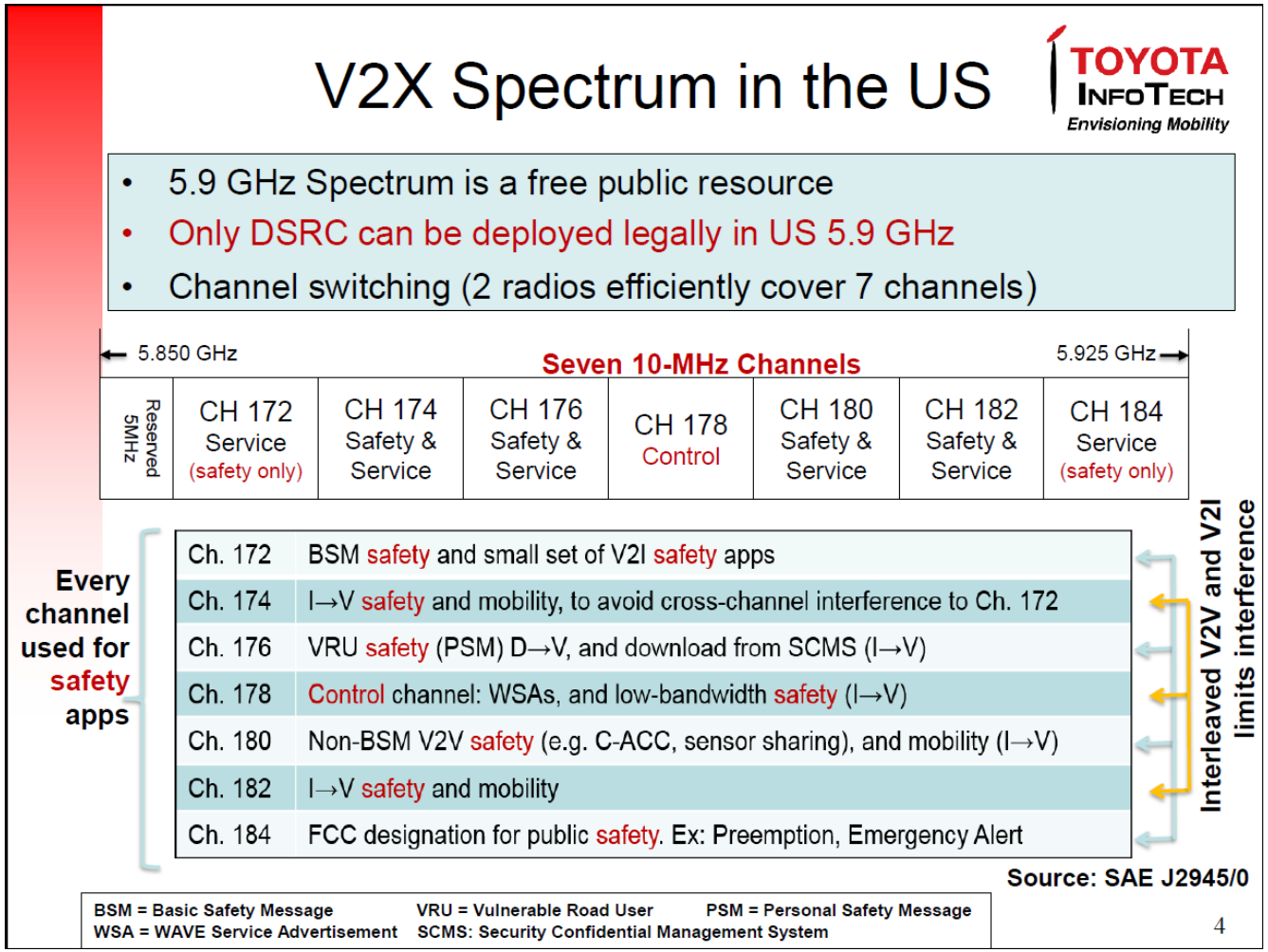



Infotainment vs. Safety Critical

# The Definitions

## Spectrum

- Free public resource
- Interoperability
- Research led to creation
  - Allocated by FCC in 1999
- Very low latency and high reliability
- Designed around IEEE 802.11protocols for interoperability and evolution
  - Dedicated Short Range Communications (DSRC)




Source: Toyota InfoTech

# The Definitions

## The Standards

- IEEE 802.11p
- IEEE 1609.2, 1609.3, 1609.4
- SAE J2735 2016-03
- SAE J2945/1
- USDOT RSU 4.1

- Enabling technology for broad applications
- Designed around interoperability
- Tested and demonstrated use cases

Source: By John Trumbull - US Capitol, Public Domain

# The Definitions

## The Applications

- APPROACHING EMERGENCY VEHICLE (WARNING) ASSISTANT
- EMERGENCY VEHICLE SIGNAL PREEMPTION
- ROAD CONDITION WARNING
- LOW BRIDGE WARNING
- WORK ZONE WARNING
- IMMINENT COLLISION WARNING
- CURVE SPEED ASSISTANCE [ROLLOVER WARNING]
- INFRASTRUCTURE BASED – STOP LIGHT ASSISTANT
- INTERSECTION COLLISION WARNING/AVOIDANCE
- HIGHWAY/RAIL [RAILROAD] COLLISION AVOIDANCE
- COOPERATIVE COLLISION WARNING [V-V]
- GREEN LIGHT - OPTIMAL SPEED ADVISORY
- COOPERATIVE VEHICLE SYSTEM – PLATOONING
- COOPERATIVE ADAPTIVE CRUISE CONTROL [ACC]
- VEHICLE BASED PROBE DATA COLLECTION
- INFRASTRUCTURE BASED PROBE DATA COLLECTION
- INFRASTRUCTURE BASED TRAFFIC MANAGEMENT – [DATA COLLECTED from] PROBES
- TOLL COLLECTION
- TRAFFIC INFORMATION
- TRANSIT VEHICLE DATA TRANSFER (gate)
- TRANSIT VEHICLE SIGNAL PRIORITY
- EMERGENCY VEHICLE VIDEO RELAY
- MAINLINE SCREENING
- BORDER CLEARANCE
- ON-BOARD SAFETY DATA TRANSFER
- VEHICLE SAFETY INSPECTION
- DRIVER'S DAILY LOG

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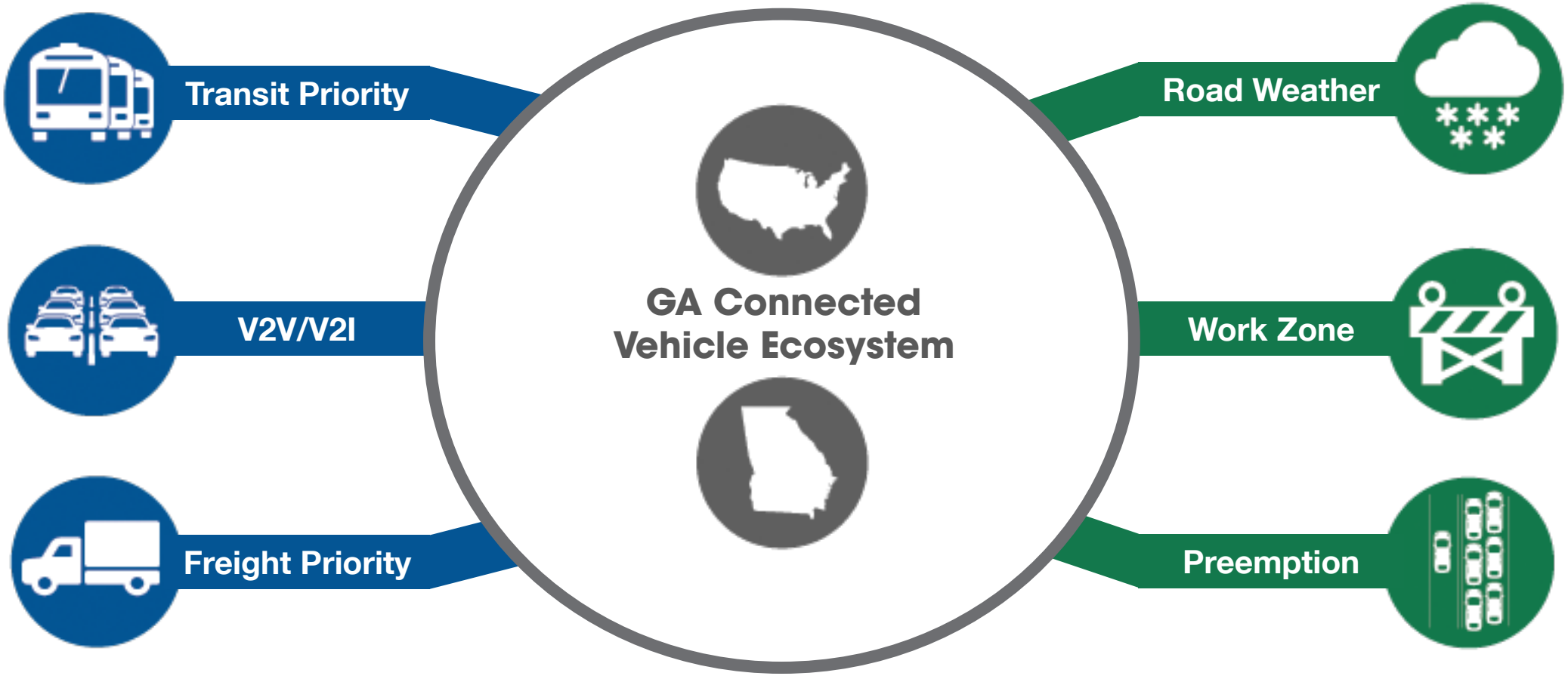
# Interoperable Ecosystem



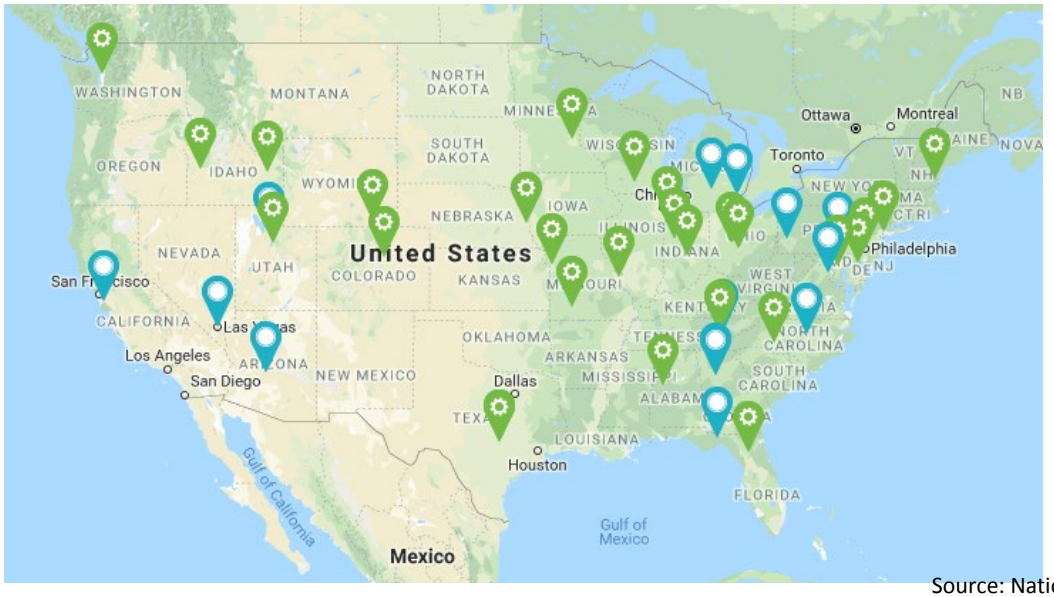

**Regional interoperability through standards-based, non-proprietary technology deployments**

# GDOT Deployments

## AASHTO SPaT Challenge

To challenge state and local public sector transportation Infrastructure Owners and Operators (IOOs) to deploy DSRC infrastructure with SPaT (and MAP) broadcasts in at least one corridor or network (approximately 20 signalized intersections) in each state by January 2020

**20 intersections in 50 states by 2020!**




**26**
States Committed

**450+**
Signals Operating

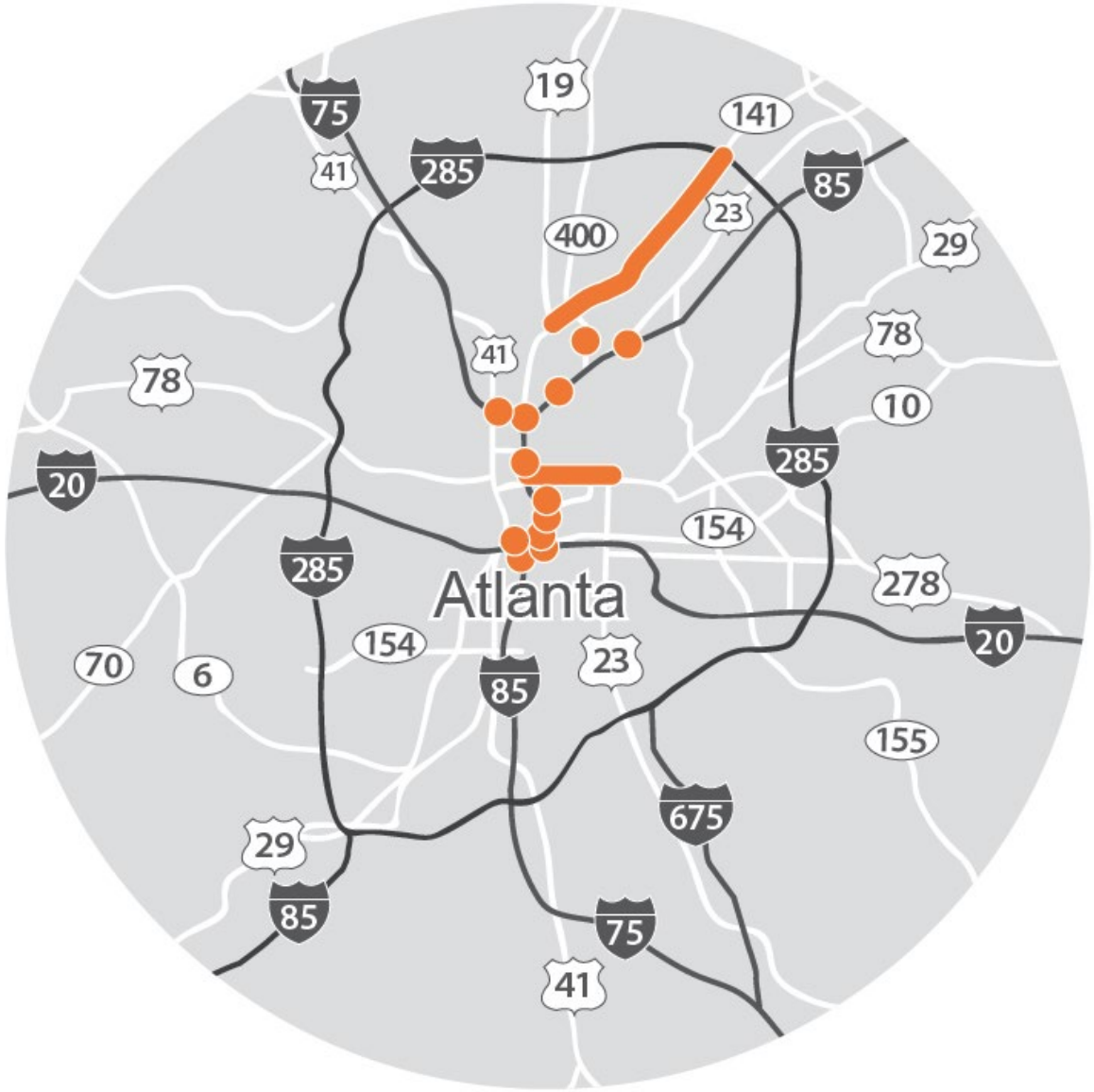
**3,800+**
Signals Planned

Source: National Operations Center of Excellence

# GDOT Deployments

## Pilot Deployment

- SR 141 (Peachtree) from SR 9 to I-285
- SR 8 (Ponce de Leon) from Peachtree to SR 42
- 54 traffic signals
- 12 ramp meters (in development)
- Signal Phasing and Timing (SPaT)
  - Red light warning
  - Pedestrian in signalized crosswalk (in development)
  - Phase termination/next signal phase
  - Green-band speed (Green light optimal speed)



# GDOT Deployments

## Phase 1 Applications

| | | |
|---|---|---|
| Red light warning | → | Safety for drivers – alerts of inability to safely clear intersection |
| Pedestrian in crosswalk | → | Safety for drivers and pedestrians – turning vehicles have additional awareness of other users |
| Phase service remaining | → | Efficiency for drivers – alert drivers for safe intersection passage or efficient stopping |
| Green speed for coordinated signals | → | Efficiency for drivers – inform drivers of the optimal driving speed through coordinated signals to minimize stops |

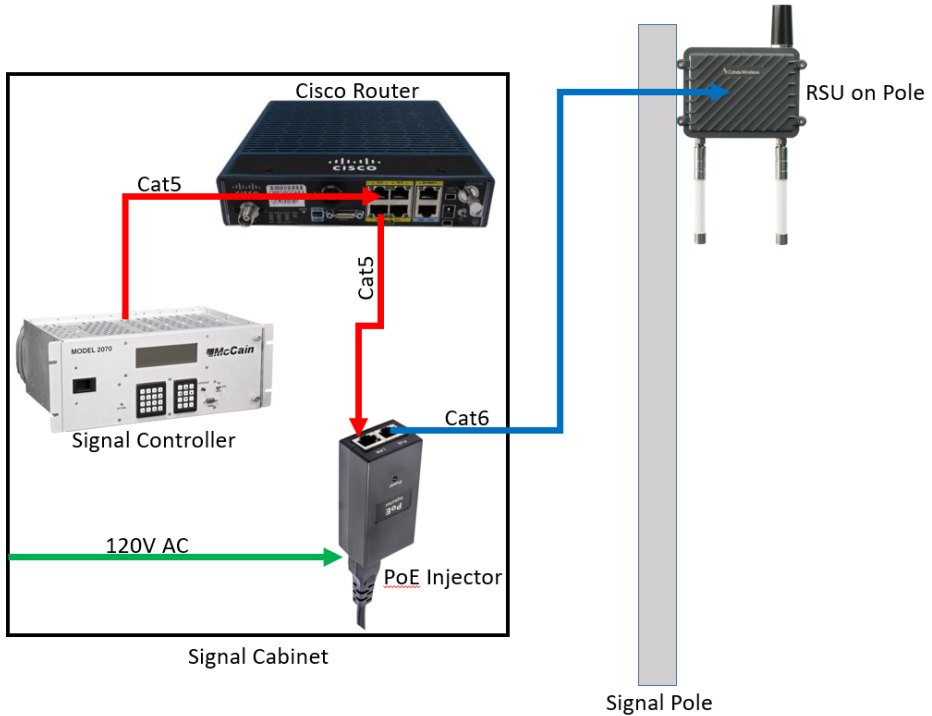
## ACTIVE RSUs IN METRO ATLANTA

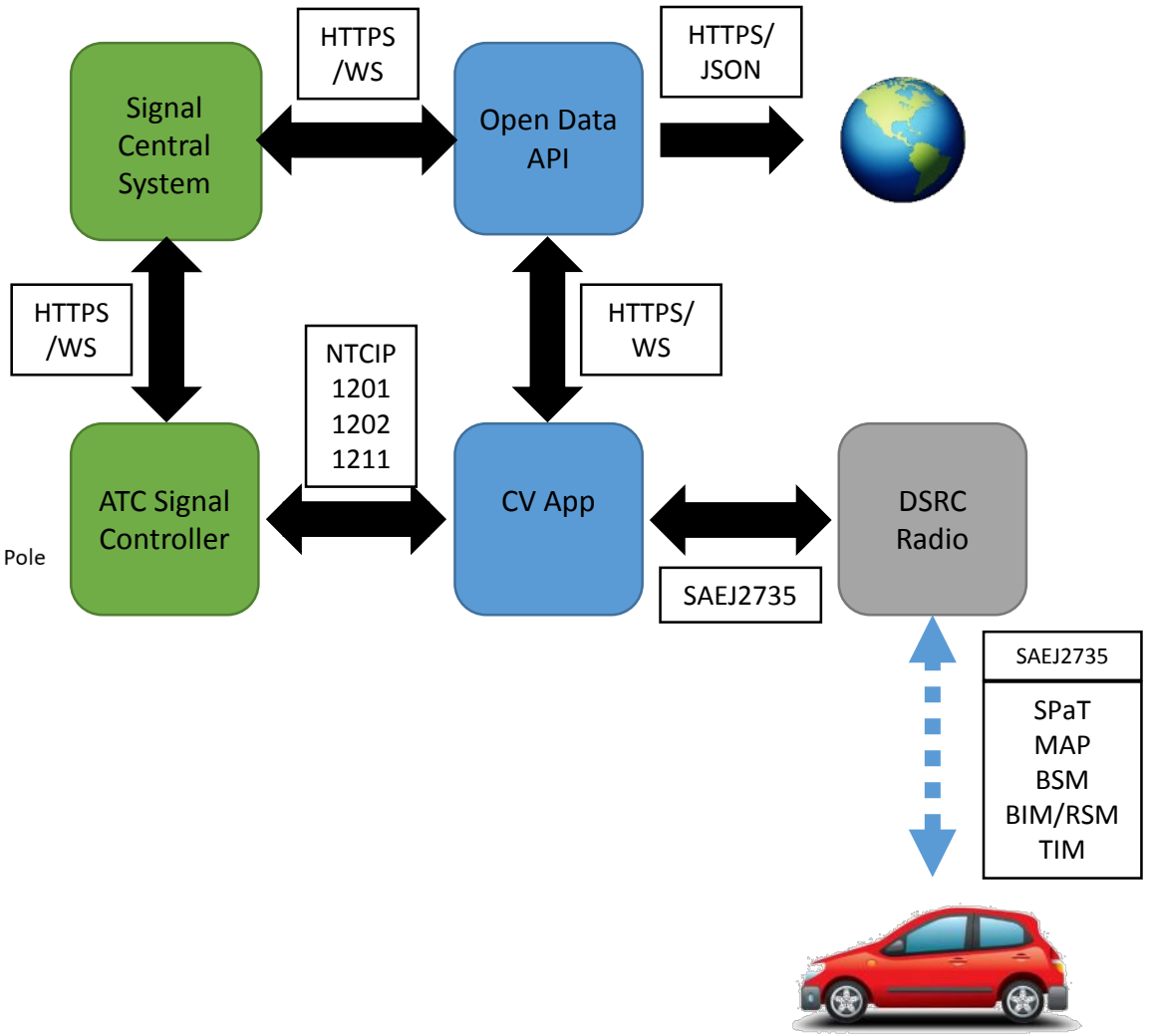
- SR 141 (Peachtree) – 39 intersections
- SR 8 (Ponce de Leon) – 15 intersections
- North Ave – 22 intersections (Renew)

# GDOT Deployments

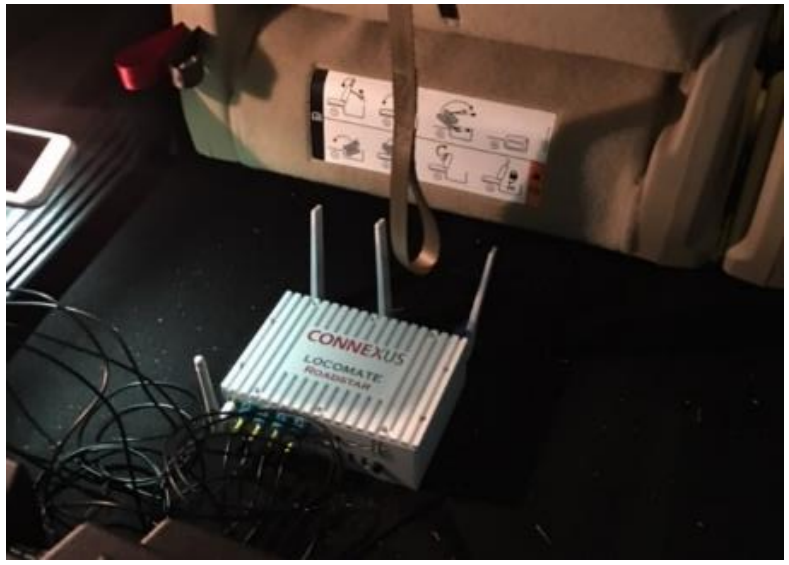
## CV Architecture

- CV Application resides on signal controller
- No additional hardware (outside of RSU) required
- Open access to third parties
- **Conformity to national standards and open access**



# GDOT Deployments



## MAXTIME CV

Search

Home

Status

Connected Devices

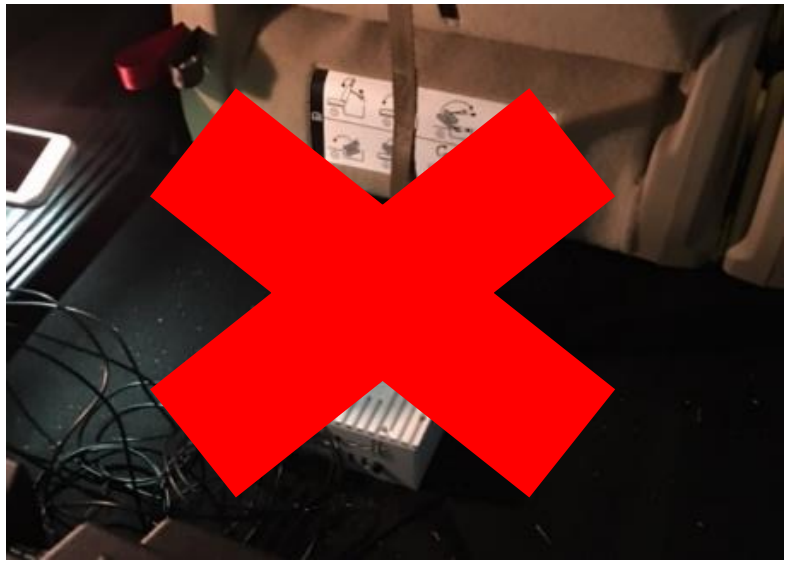
SPaT Message

**Connected Devices Status**

Show All Devices

| Device | Device Type | Peer ID | Connection Status |
|---|---|---|---|
| 1 | MaxTime | 1 | Connected |
| 2 | RSU 4.1 SPAT UDP | 2 | Connected |
| 3 | RSU 4.1 MAP UDP | 3 | Connected |
| 4 | RSU 4.1 TIM UDP | 4 | Connected |

# GDOT Deployments

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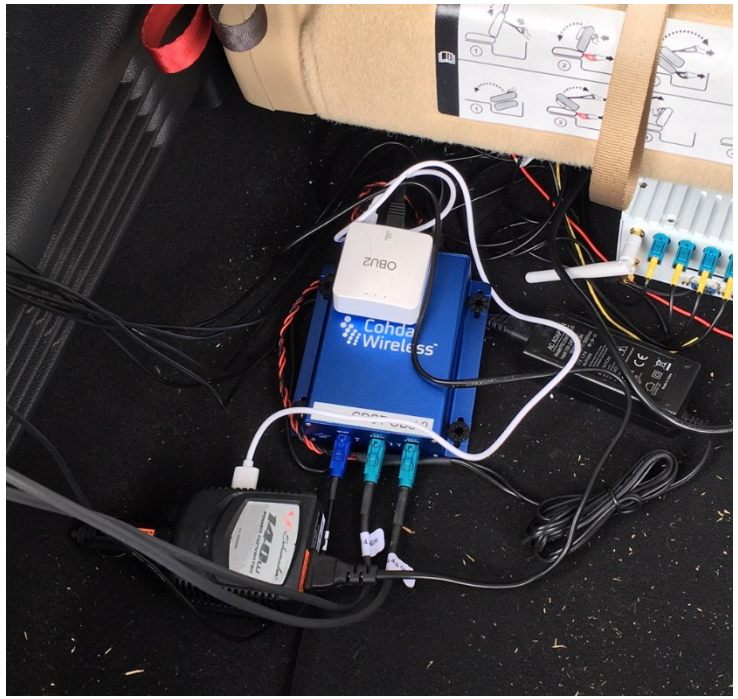
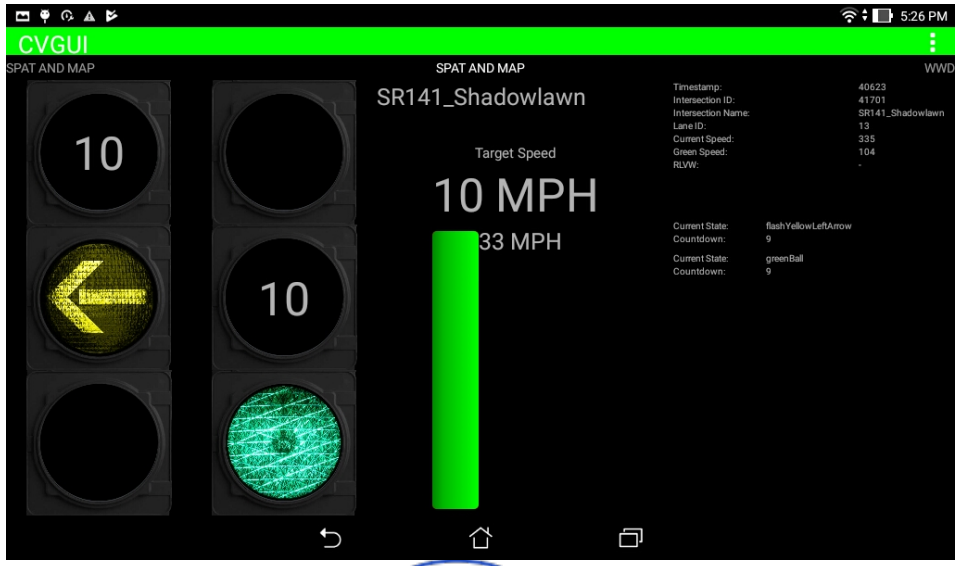
# Deployment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SOUTHWEST RESEARCH INSTITUTE

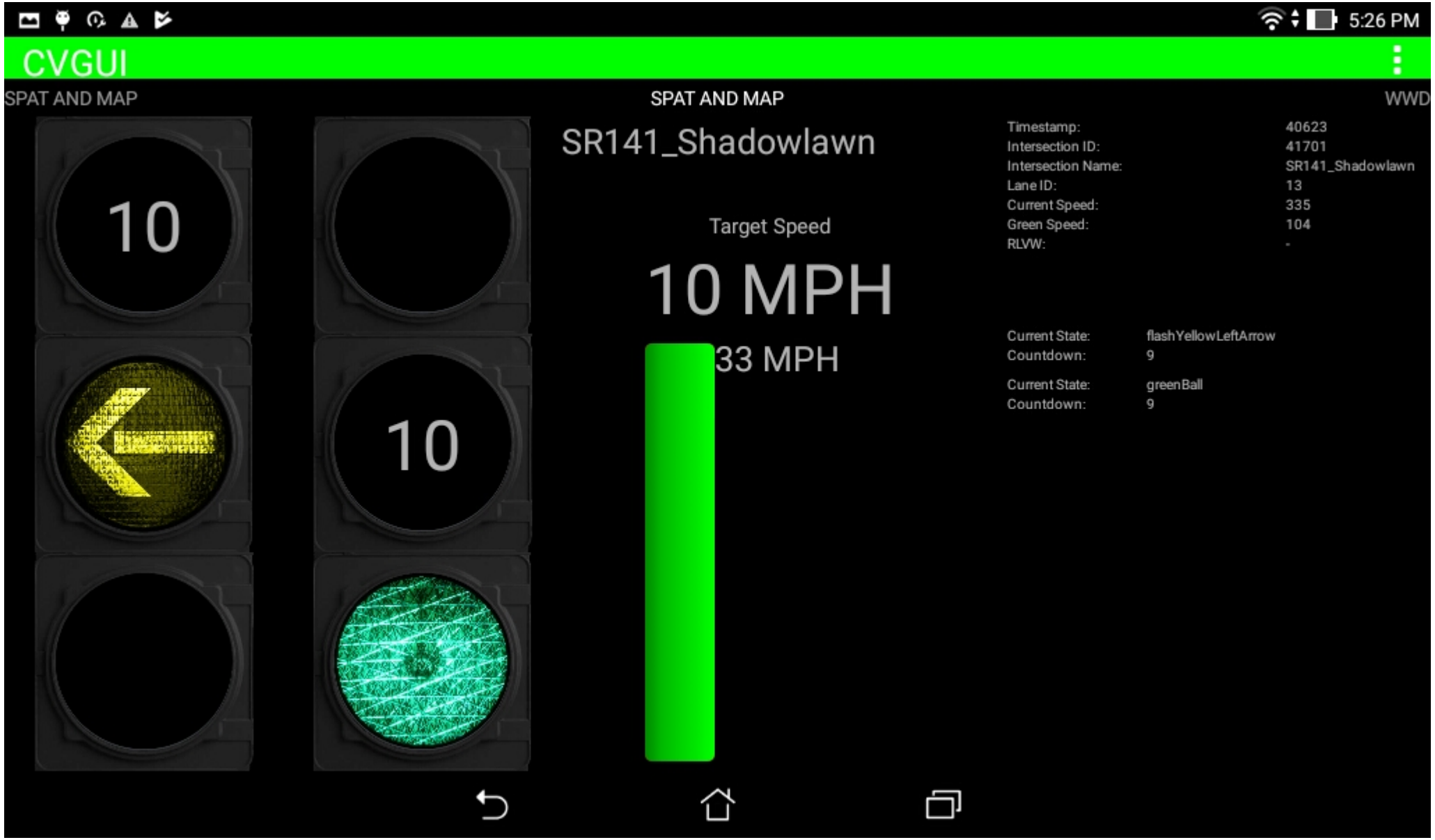
## MAXTIME CV

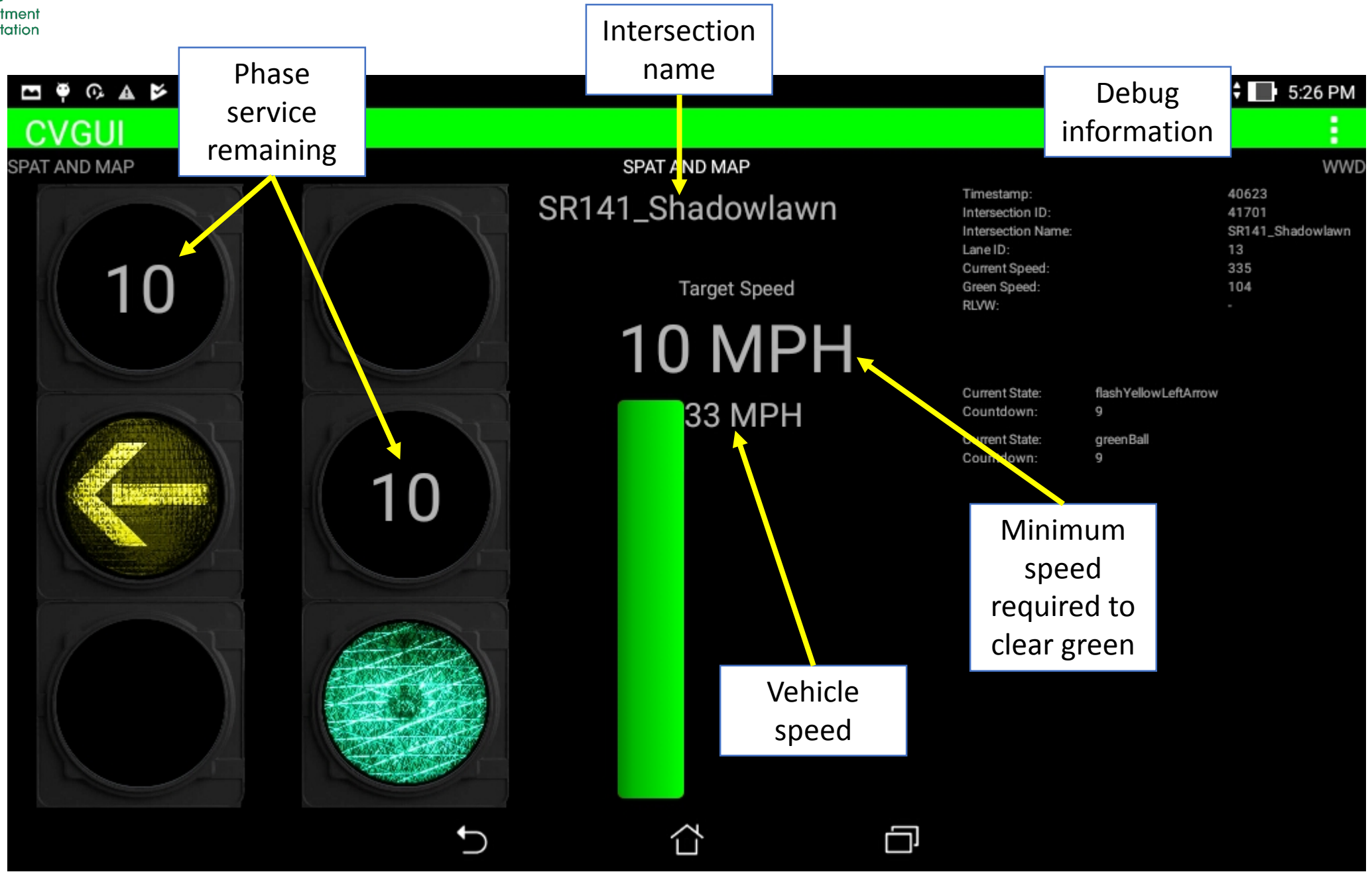
Search
Home
Status
Connected Devices
SPaT Message
MAP Message

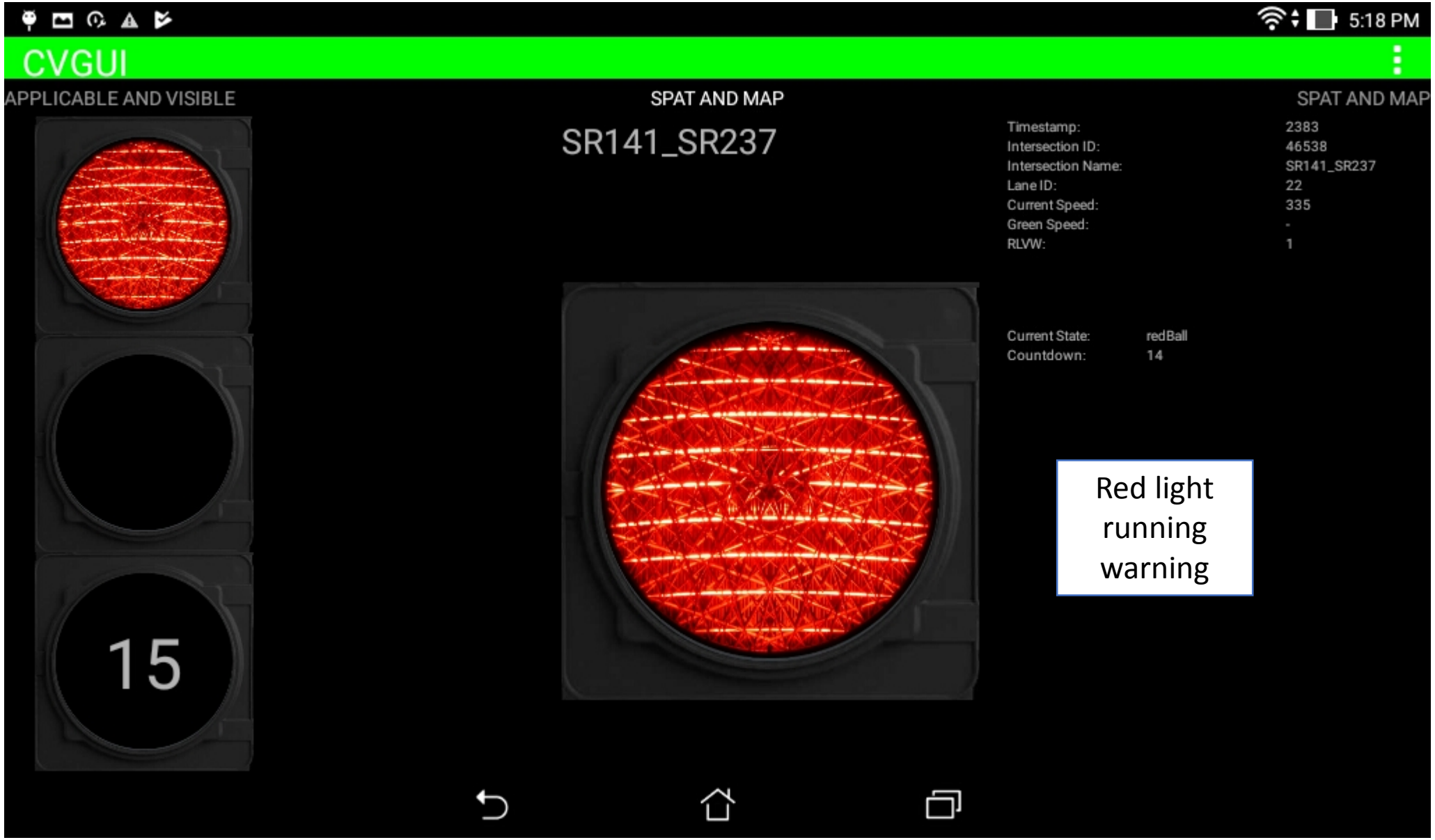
### Connected Devices Status

Show All Devices

| Device | Device Type | Peer ID | Connection Status |
|---|---|---|---|
| 1 | MaxTime | 1 | Connected |
| 2 | RSU 4.1 SPAT UDP | 2 | Connected |
| 3 | RSU 4.1 MAP UDP | 3 | Connected |
| 4 | RSU 4.1 TIM UDP | 4 | Connected |
| 5 | Generic RSU UDP | 5 | Connected |


5:26 PM
CVGUI
SPAT AND MAP
SPAT AND MAP
WWD
10
10
SR141_Shadowlawn
Target Speed
10 MPH
33 MPH
Timestamp: 40623
Intersection ID: 41701
Intersection Name: SR141_Shadowlawn
Lane ID: 13
Current Speed: 335
Green Speed: 104
RLVW: -
Current State: flashYellowLeftArrow
Countdown: 9
Current State: greenBall
Countdown: 9

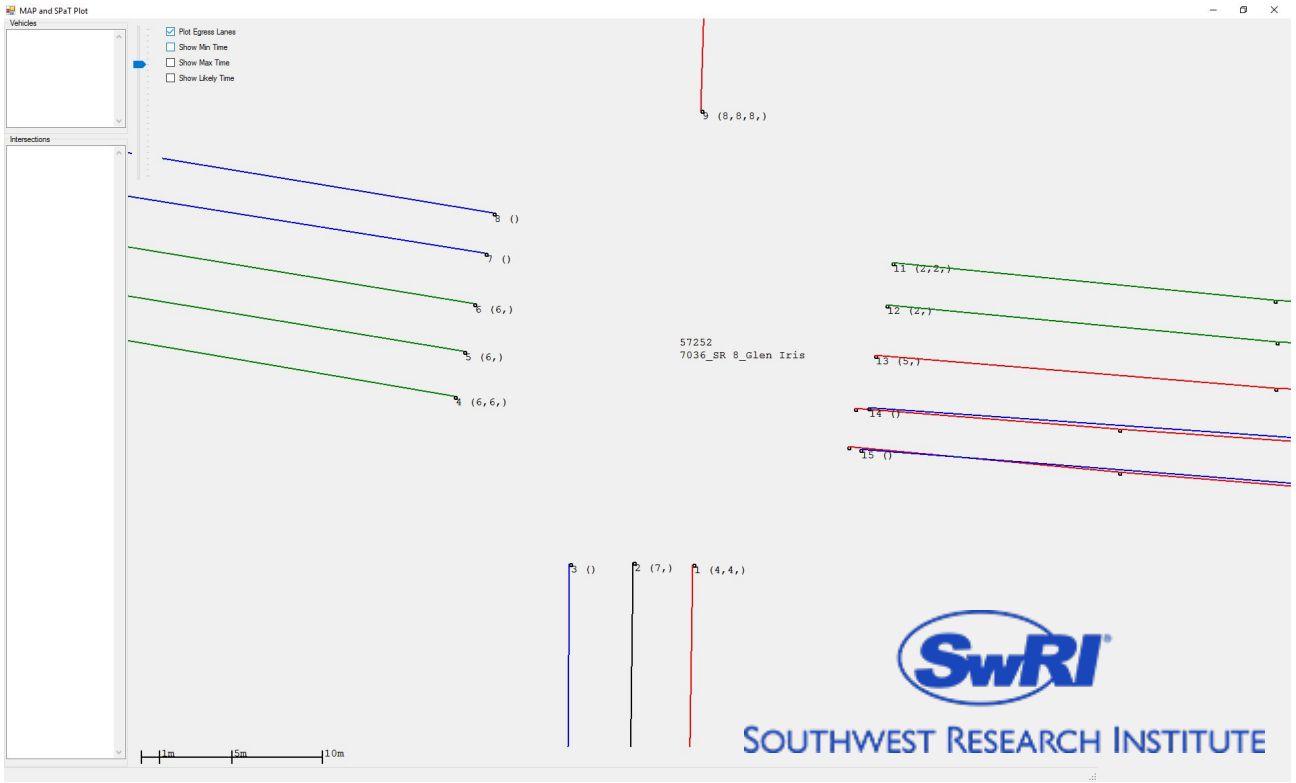

Intersection name
Phase service remaining
Debug information
5:26 PM
CVGUI
SPAT AND MAP
SPAT AND MAP
WWD
SR141_Shadowlawn
Timestamp: 40623
Intersection ID: 41701
Intersection Name: SR141_Shadowlawn
Lane ID: 13
Current Speed: 335
Green Speed: 104
RLVW: -
10
10
Target Speed
10 MPH
33 MPH
Current State: flashYellowLeftArrow
Countdown: 9
Current State: greenBall
Countdown: 9
Minimum speed required to clear green
Vehicle speed


5:18 PM
CVGUI
APPLICABLE AND VISIBLE
SPAT AND MAP
SR141_SR237
SPAT AND MAP
Timestamp: 2383
Intersection ID: 46538
Intersection Name: SR141_SR237
Lane ID: 22
Current Speed: 335
Green Speed: -
RLVW: 1
Current State: redBall
Countdown: 14
15
Red light running warning

# GDOT Deployments

## Validation and Testing

- Properly formatted, J2735-compliant messages
- Ingress lanes that include a ConnectsTo but that egress lane is not defined (or is not defined as an egress)
- Ingress lanes that do not include a ConnectsTo
- Ingress lanes that do not include a signal phase/approachId
- Incorrect or missing ingress/egress definitions for each approach
- Overlap/underlap of lanes and widths
- Incorrect ‘ConnectsTo’ lanes
- General layout and structure of lane paths/geometries
- Signal phases being reported as “dark” or “unavailable”
- Correctness of the time remaining values
- Inconsistency of the reported minTime and maxTime (ie. min greater than max)
- Unexpected changes in minTime and maxTime
- Accuracy of the reported phase vs the actual signal
- Transmit rate of each message type

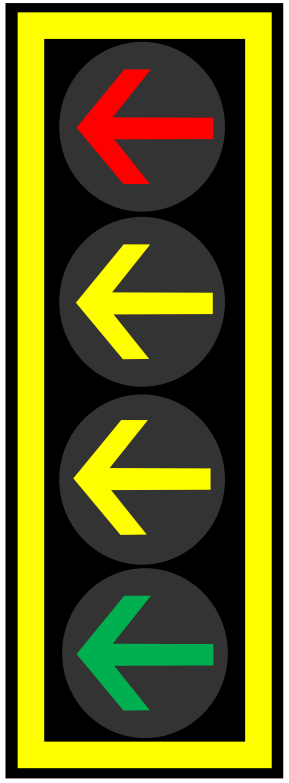



| | | | |
|---|---|---|---|
| 2019-05-29 20:57:38.1 | 72 | 82 | 23 |
| 2019-05-29 20:57:38.3 | 72 | 82 | 32 |
| 2019-05-29 20:57:38.3 | 72 | 82 | 26 |
| 2019-05-29 20:57:38.8 | 72 | 81 | 26 |
| 2019-05-29 20:57:39.2 | 72 | 81 | 23 |
| 2019-05-29 20:57:39.6 | 72 | 82 | 4 |

# GDOT Deployments

## Project Challenges

- Device interoperability
  - Controller to RSU
  - RSU to OBU
  - OBU to OBU
- MAP message creation and validation
- Protected/permissive left turns
- Application deployments
- Security credentialing
- Data
- Limited fleet
- Regional communications network
- **Technology risk and Spectrum Uncertainty**



# GDOT Deployments

## Phase 2: RTOP – June 2020

## GDOT Investment + USDOT ATCMTD Grant

- 1,600 traffic signals in metro Atlanta
- 185 ramp meter locations
- **Regional deployment**
  - **Not a pilot program: a deliberate inter-agency deployment across the entire metro Atlanta region**

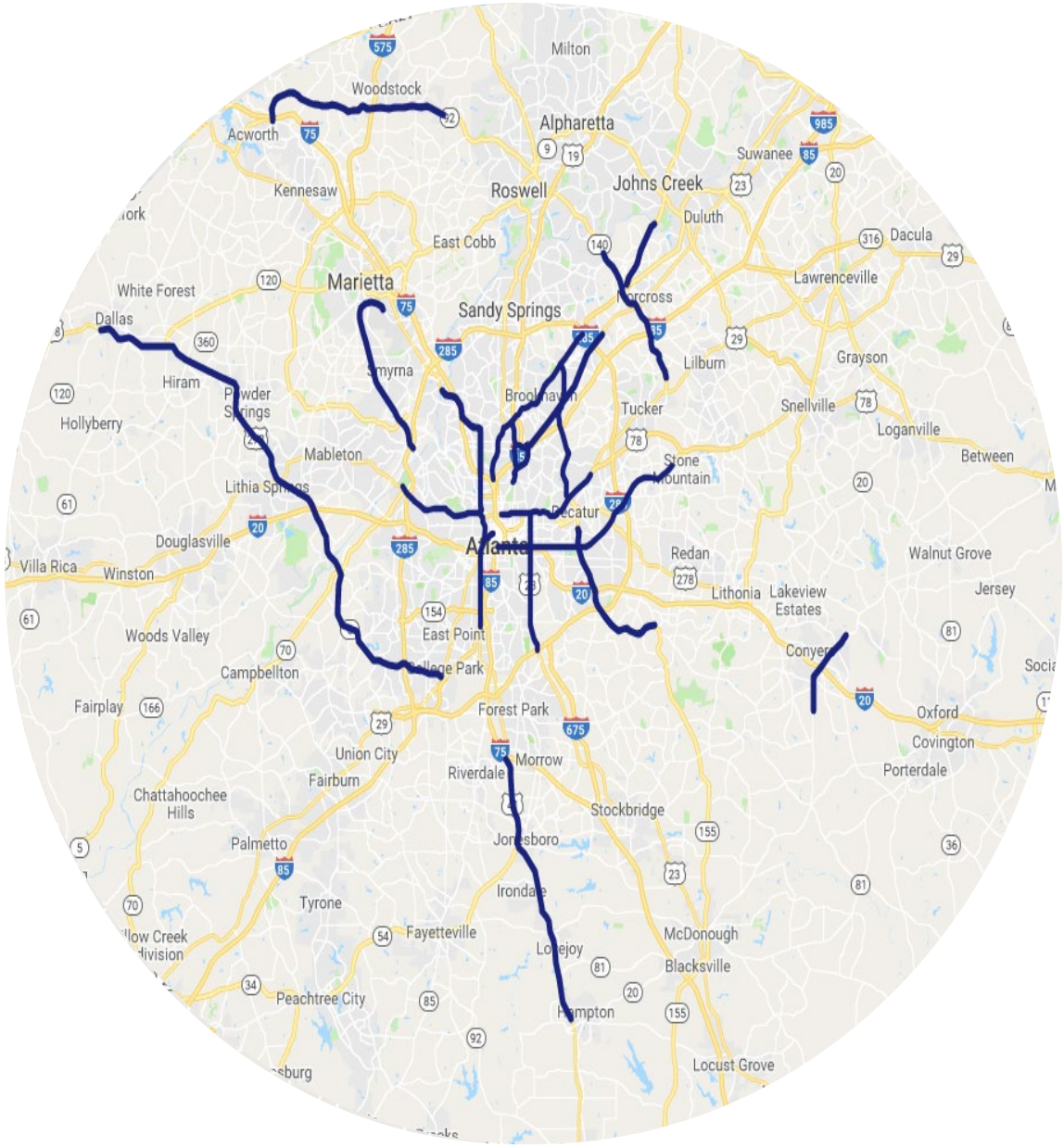
# GDOT Deployments

## Phase 2.1: RTOP – Fall 2019

- Additional 600 of FY 2019 to be installed by Fall 2019
- 305 RSUs operational as of July 2019
- Connectivity on every major arterial in metro Atlanta
- Open data stream to third parties also available

## ADDITIONAL APPLICATIONS

| | |
|---|---|
| Emergency vehicle preemption | Preemption at select signals to improve emergency vehicle response time |
| Transit signal priority | Priority requests to signal controllers for specific transit applications and routes |
| Freight signal priority | Signal priority for freight vehicles that are operating in cooperative platooning mode |



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# GDOT Deployments

ATCMTD 2018

| Phase 2 Deployment Est. | FY 2019 (600) | FY 2020 (1000) |
|---|---|---|
| RSU Equipment | $780,000 | $1,300,000 |
| RSU Deployment | $510,000 | $850,000 |
| RSU Configuration & Support | $1,200,000 | $2,000,000 |
| ATCMTD OBUs (1000) | - | $1,000,000 |
| TOTAL | $2,490,000 | $4,150,000 |

- 1,600 Roadside units at $1,300 per device.
- RSU deployment at $850 per location.
- RSU configuration at $2,000 per device.
- OBU costs at $1,000 per device (optional).

Total: $6,640,000

**654 RSUs to be operational by Fall 2019**

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# CV, AV, & CAV



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