THE NARWHAL GROUP

UDOT Keeping Utah Moving
TRANSPORTATION TECHNOLOGY

Deploying Connected Vehicle Technology

Additional Roadside and Onboard Equipment

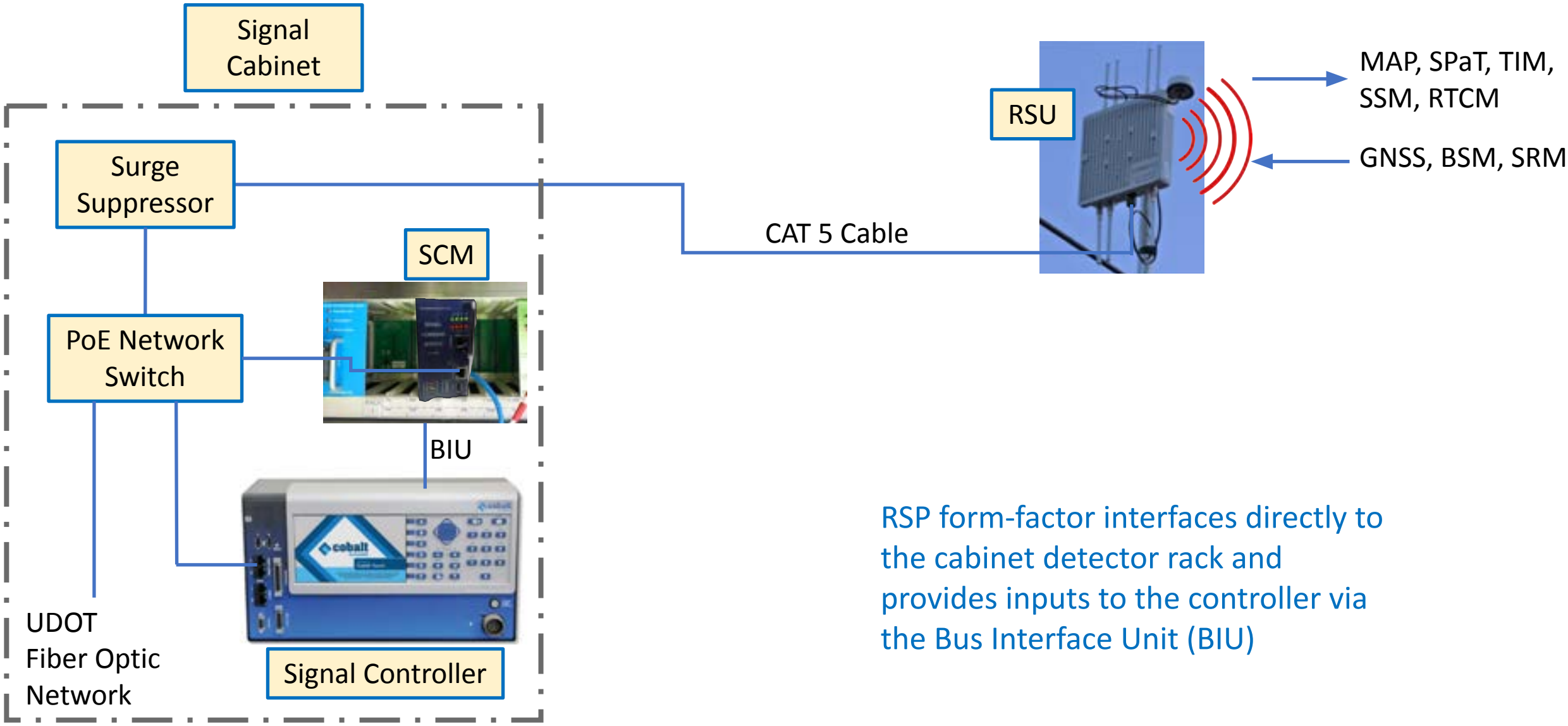
Merging Technology with Human Intellect

Additional Hardware / Software

- Roadside - RSE
  - Roadside Unit (RSU)
  - Roadside Processor (RSP) or Signal Command Module (SCM)
  - Traffic Signal Controller
  - PoE Injector or Switch

- Vehicle - OBE
  - On-board Unit (OBU)
  - On-board Processor (OBP)
  - Other circuitry or interface elements

Roadside Equipment Schematic



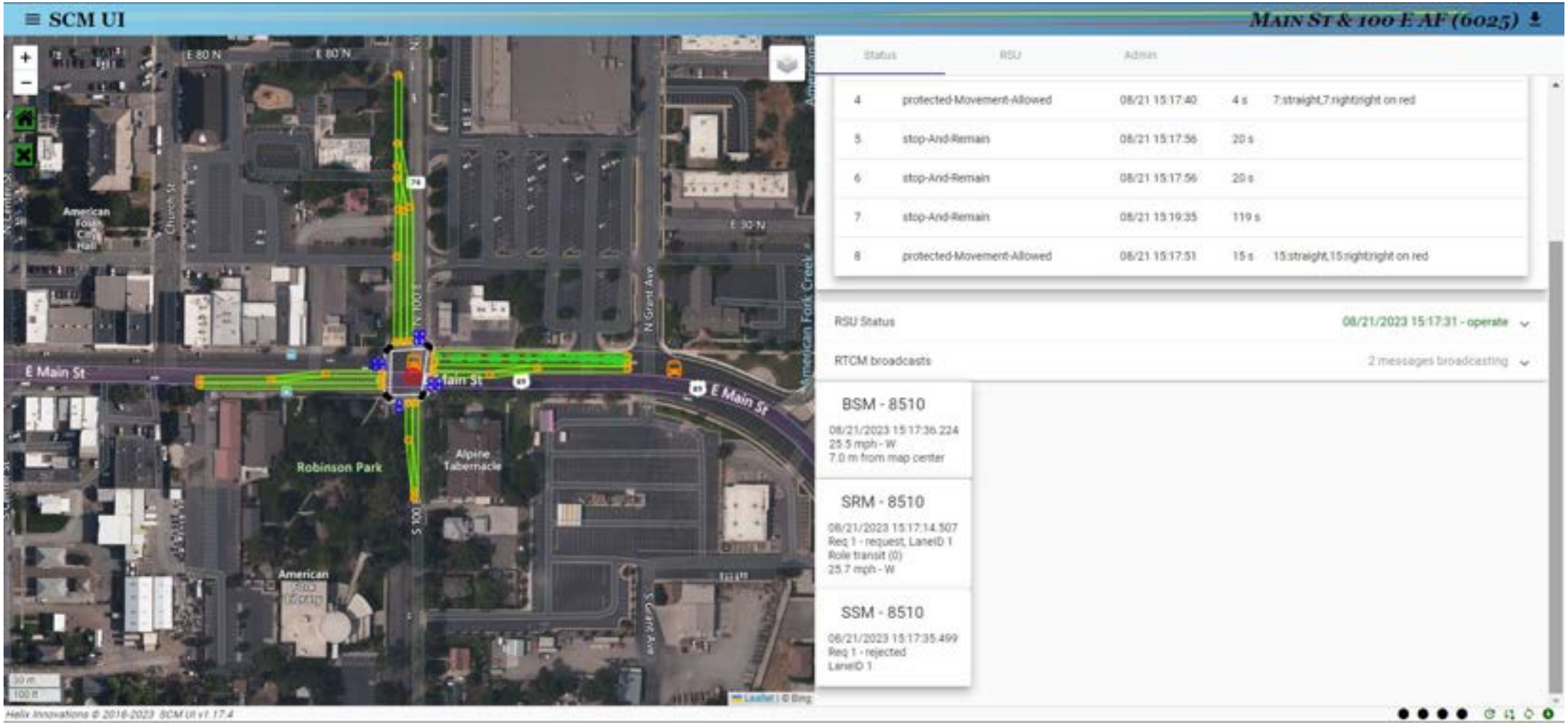
RSP form-factor interfaces directly to the cabinet detector rack and provides inputs to the controller via the Bus Interface Unit (BIU)

Signal Command Module (SCM)

Signal Command Module (SCM)

- Functions and Capabilities
  - Provides interface between RSUs and the Traffic Signal Controller Equipment
  - Ability to visualize the operation of V2X messages in both a software interface and faceplate indication including:
    - MAP
    - SPaT
    - RTCM
    - SRM
    - SSM
    - Electronic Relay Status
  - Off-the-shelf equipment to install an operational V2X application at intersections (TSP / Preemption) using generic V2X equipment
  - Interface between various signal controller types
  - Ability to directly interface with standards-based RSUs
  - Ability to assign 8 different outputs ina standard 4 Channel detection slot
  - Provide signal technicians the ability to program TSP / Preemption in an environment that they are accustomed to

SCM Software Interface



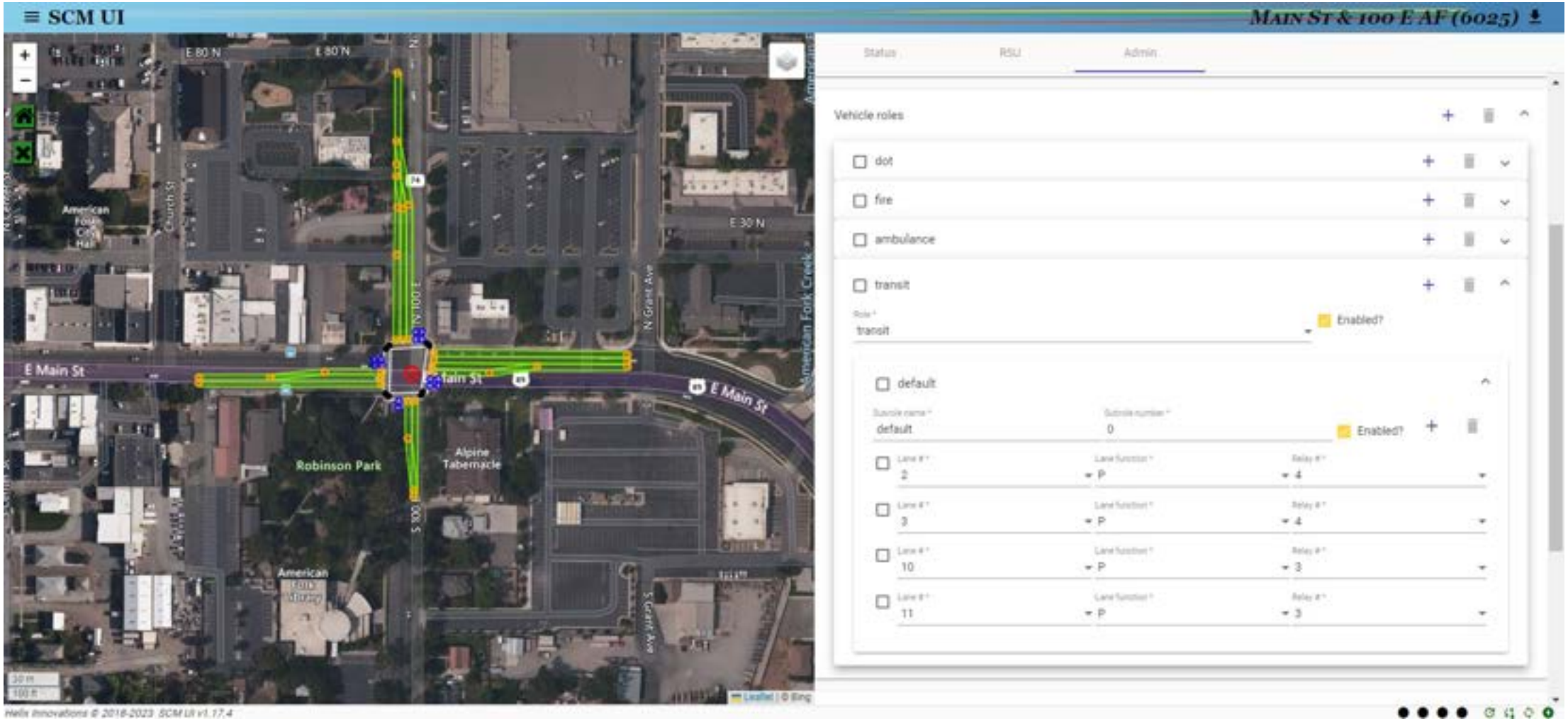
SCM Software Interface

SCM Software Interface

J2735 Messages

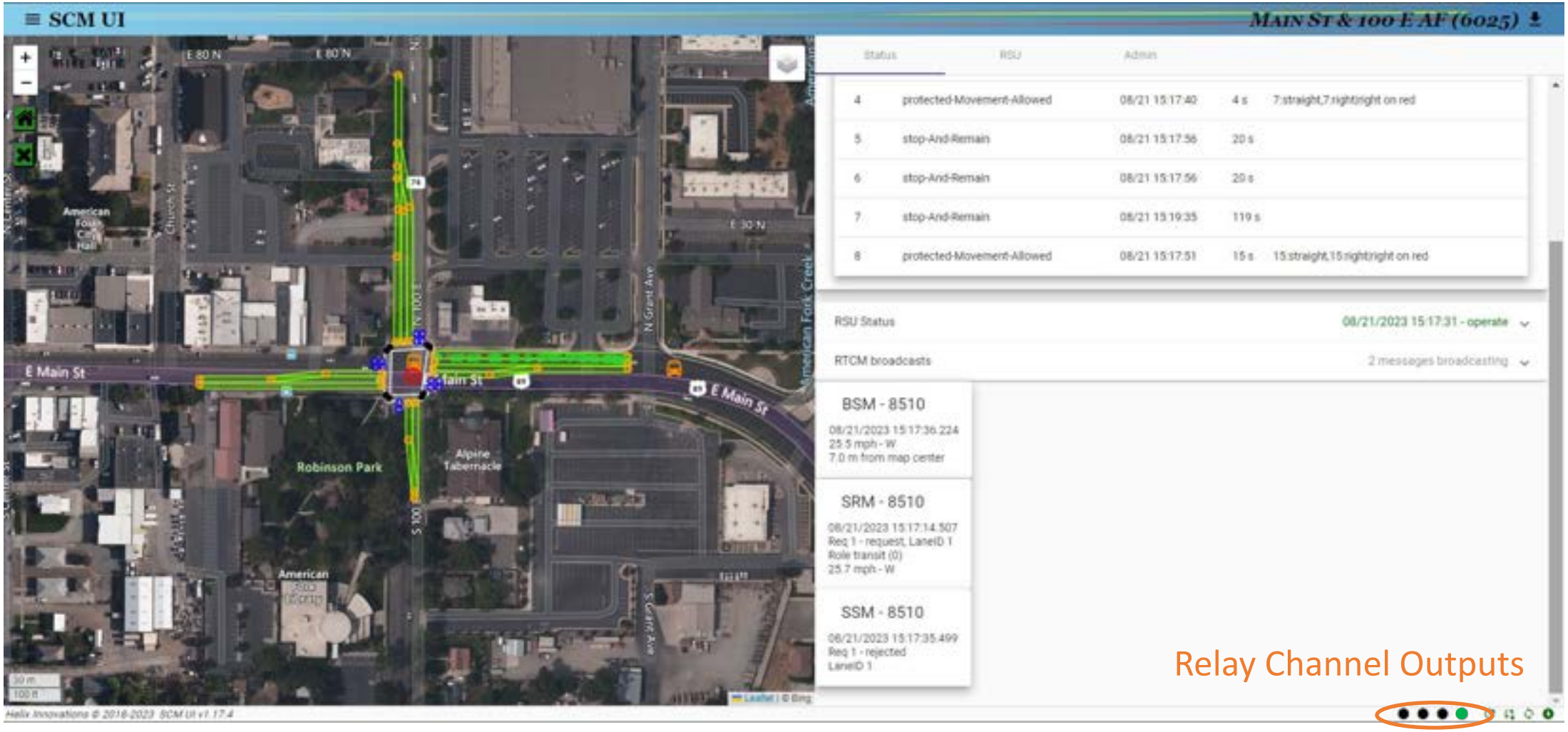
- RTCM
- BSM
- SRM
- SSM

SCM Software Interface

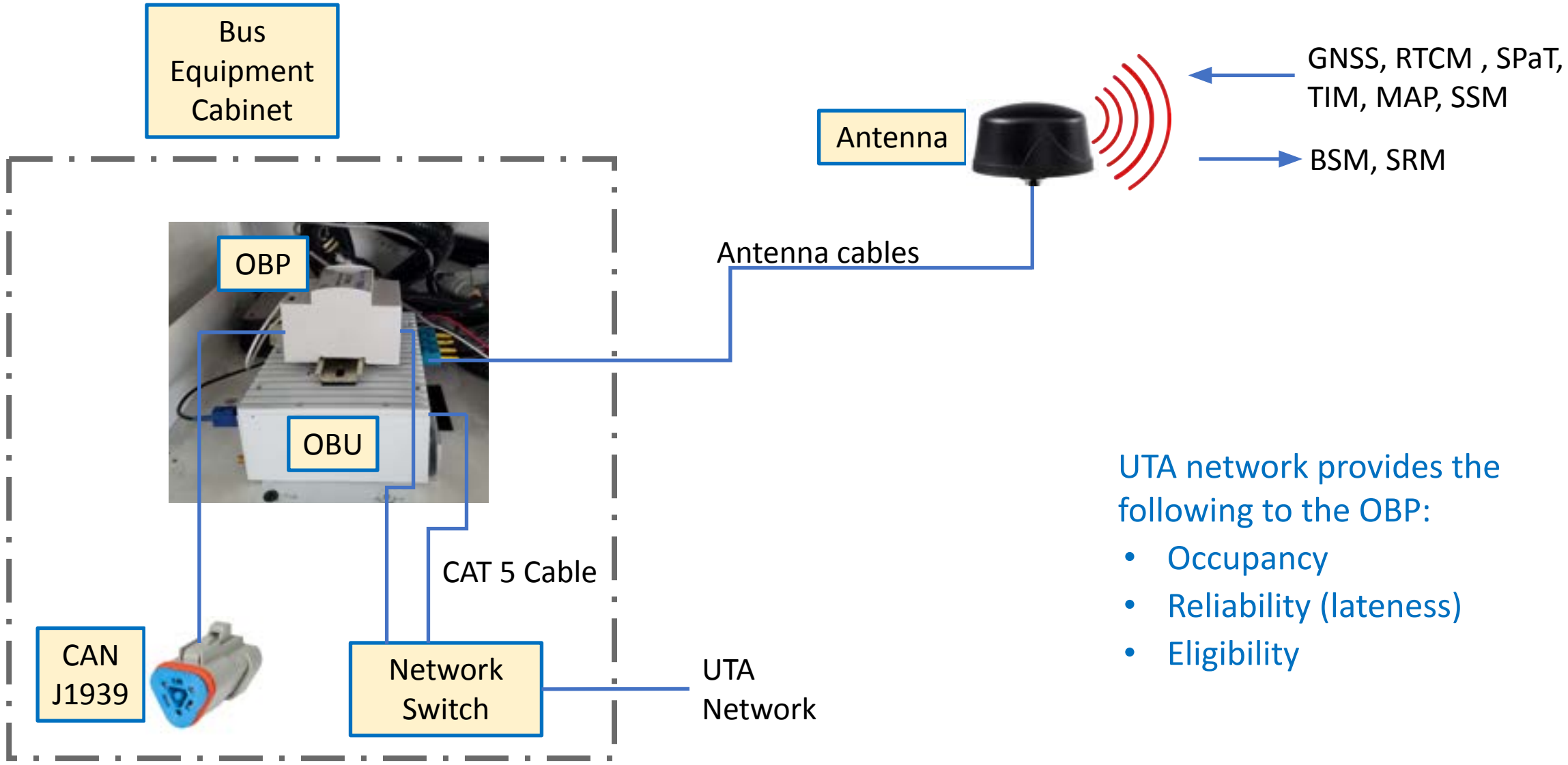


Vehicle Roles and Lane-Level Configuration

SCM Software Interface



Onboard - Bus



UTA network provides the following to the OBP:

- Occupancy
- Reliability (lateness)
- Eligibility

Onboard - Snowplow

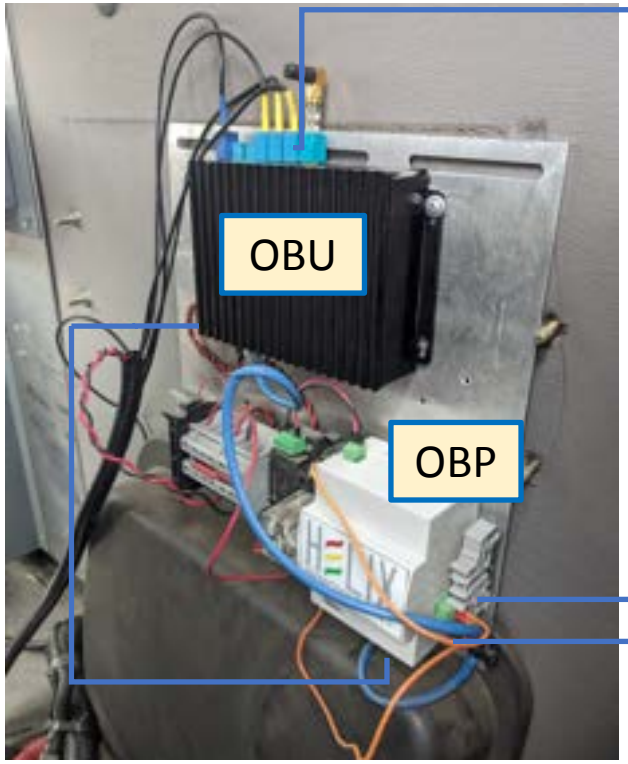
Antenna

GNSS, MAP, SSM

BSM, SRM

Plow Cab

Antenna cables



Signal Cable

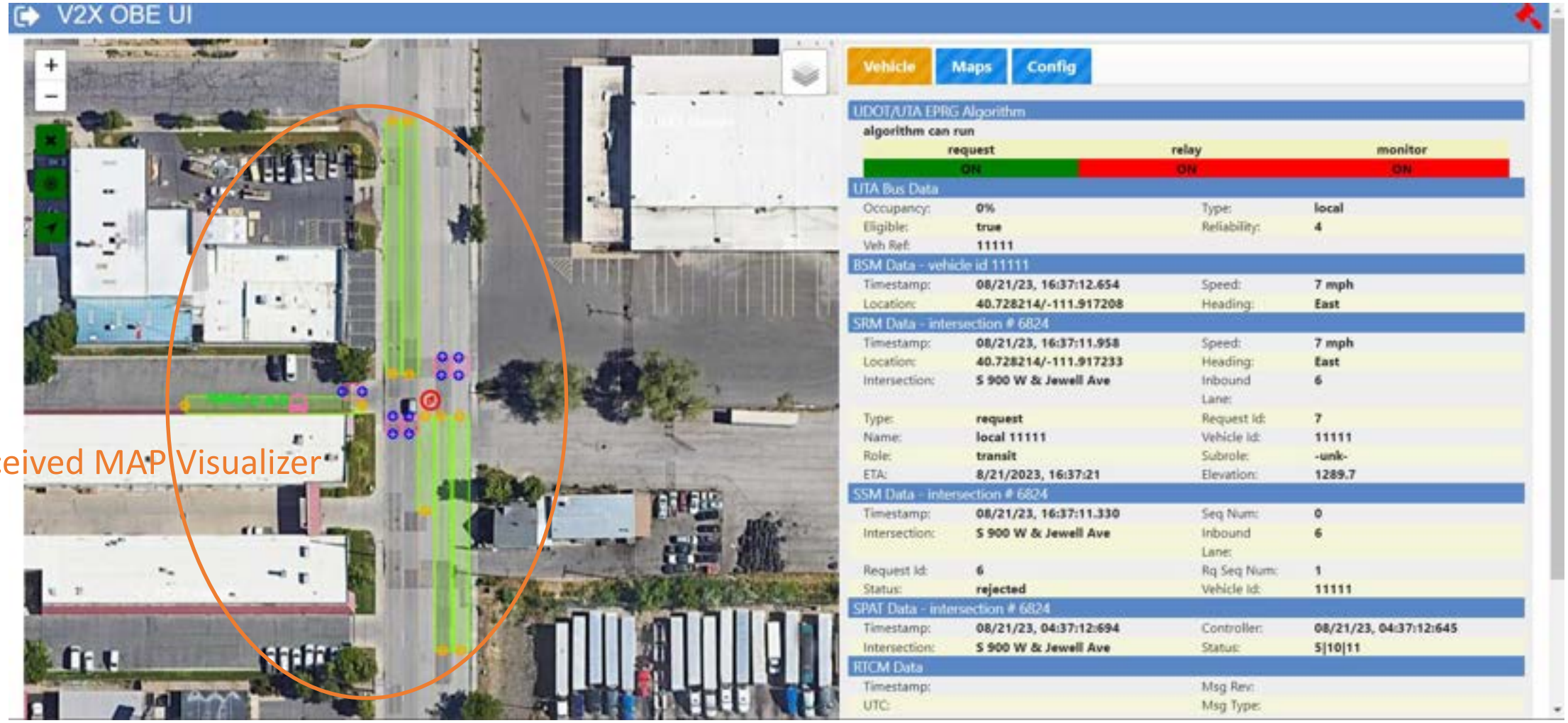
CAN
J1939

Plow salt/sander controller outputs logic voltage when sander/spreader is activated

Onboard Processor (OBP)

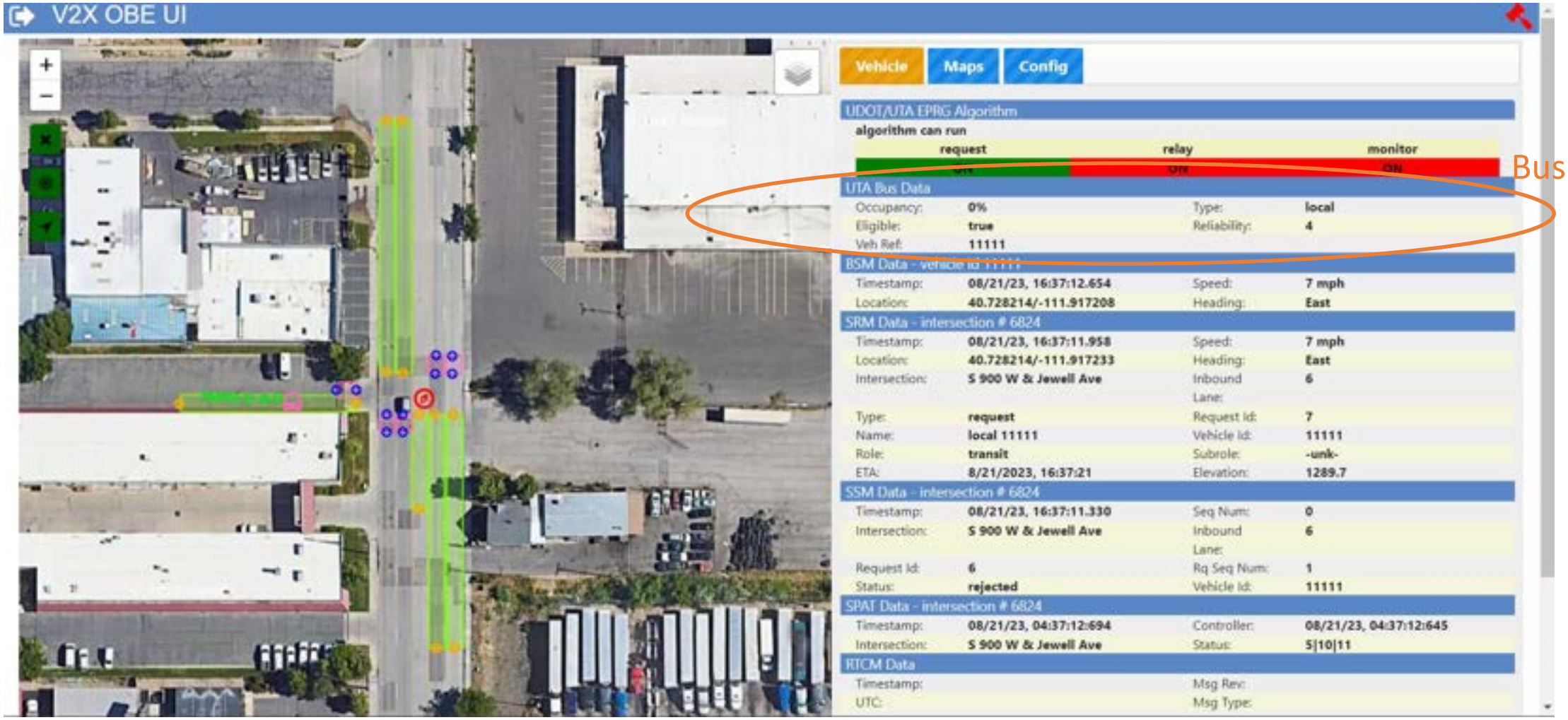
- Functions and Capabilities
  - Provides interface between native environment of commercial vehicle and OBU
  - Ability to visualize the operation of V2X messages in software including:
    - MAP
    - SPaT
    - RTCM
    - SRM
    - SSM
  - Off-the-shelf equipment to install an operational V2X application in vehicles (TSP / Preemption) using generic V2X equipment
  - Interface between various vehicle input types
  - Ability to directly interface with OBUs supporting Immediate Message Forwarding (IFM)
  - Ability to correct location (BSM) using received RTCM correction messages from the RSU
    - The OBP produces BSM in the architectures so the positioning can be corrected

OBP Software Interface



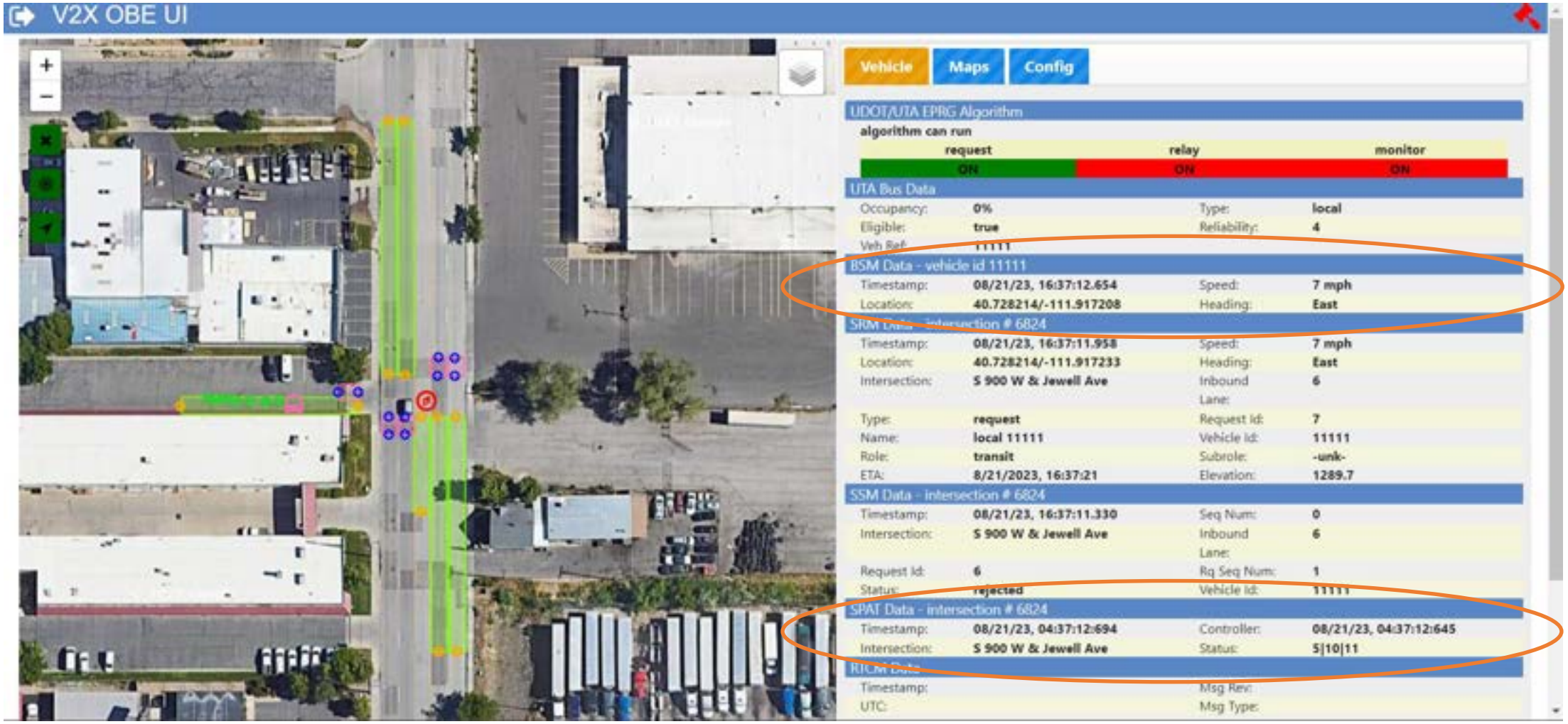
Received MAP Visualizer

OBP Software Interface

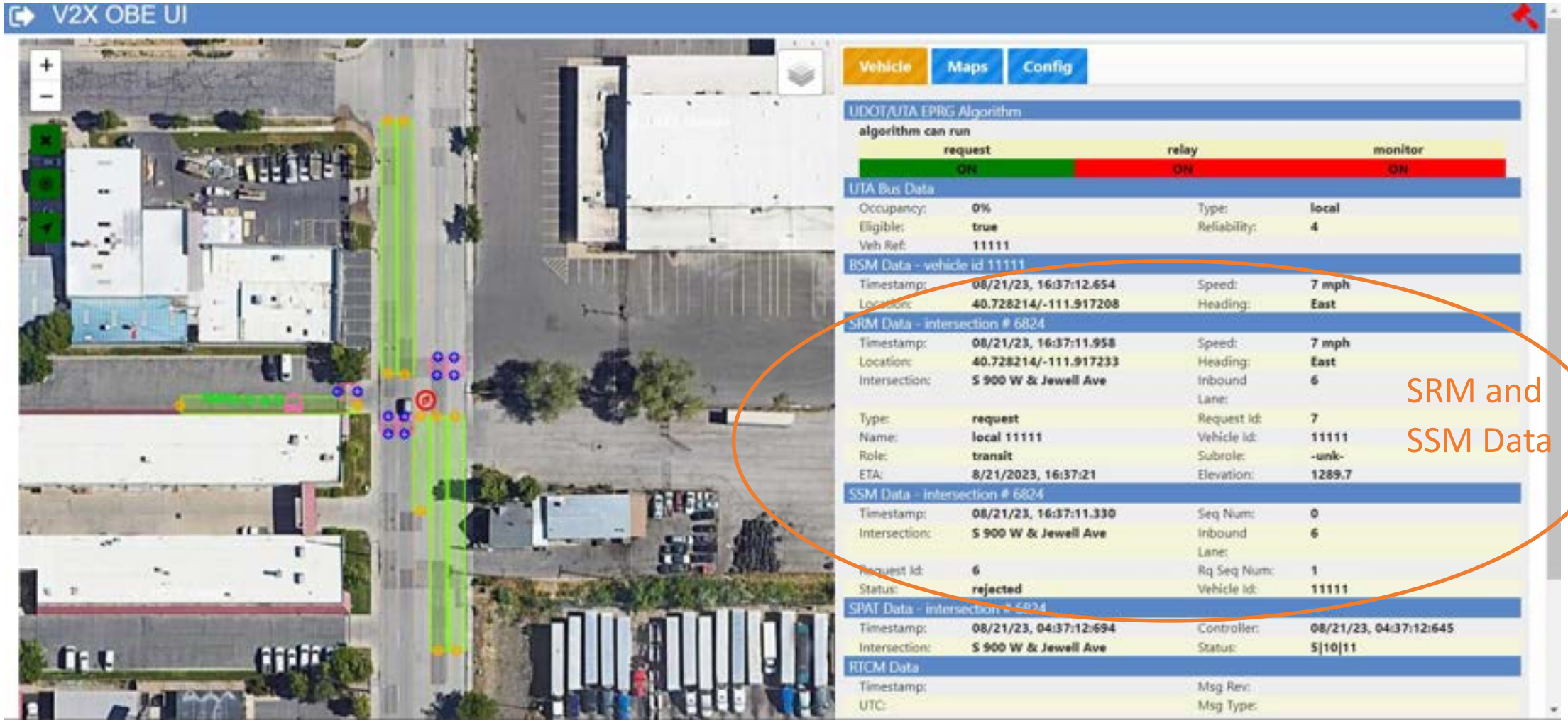


Bus Info

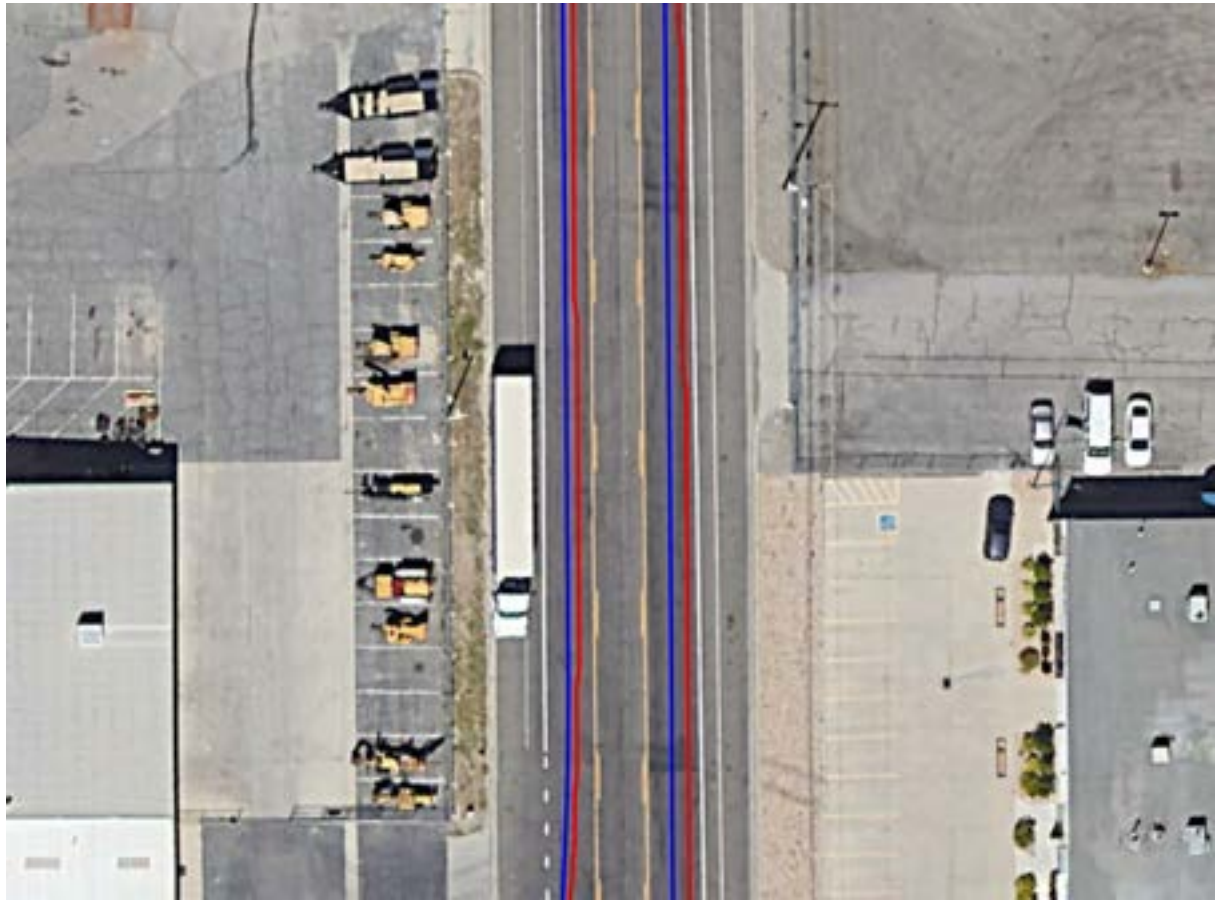
OBP Software Interface



OBP Software Interface



RTCM Correction - DGNSS



Red Line – Native OBU GNSS

Blue Line – Differential GNSS (DGNSS)

TSP Summary of Operation

- RSE continuously broadcast MAP
- OBE continuously broadcast BSM
- Bus network provides reliability and lateness threshold to OBP
- When Bus enters MAP geographic area and if bus is later than lateness threshold then OBE broadcasts SRM
- RSE receives SRM and checks SRM vehicle role against lane mapping profile
- RSE sends SSM (Requested, Processing or Rejected)
- RSP activates detector card relay when vehicle role and lane mapping match
- Signal controller logic flags activate and TSP is granted according to programming
- When bus crosses stop bar or leaves MAP boundaries for any reason an SRM "cancel" request is sent by OBE and TSP process stops

Preemption Summary of Operation

- RSE continuously broadcast MAP
- OBE continuously broadcast BSM
- When emergency vehicle or snow plow enters MAP geographic area and conditions are met then OBE broadcasts SRM
- RSE receives SRM and checks SRM vehicle role against lane mapping profile.
- RSE sends SSM (Requested, Processing or Rejected)
- RSP activates detector card relay when vehicle role and lane mapping match
- Signal controller logic flags activate and preemption is granted according to programming
- When plow crosses stop bar or leaves MAP boundaries for any reason an SRM “cancel” request is sent by OBE and preemption process stops.

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