



# Deploying Connected Vehicle Technology

*Merging  
Technology  
with  
Human  
Intellect*

**Additional Roadside and Onboard Equipment**

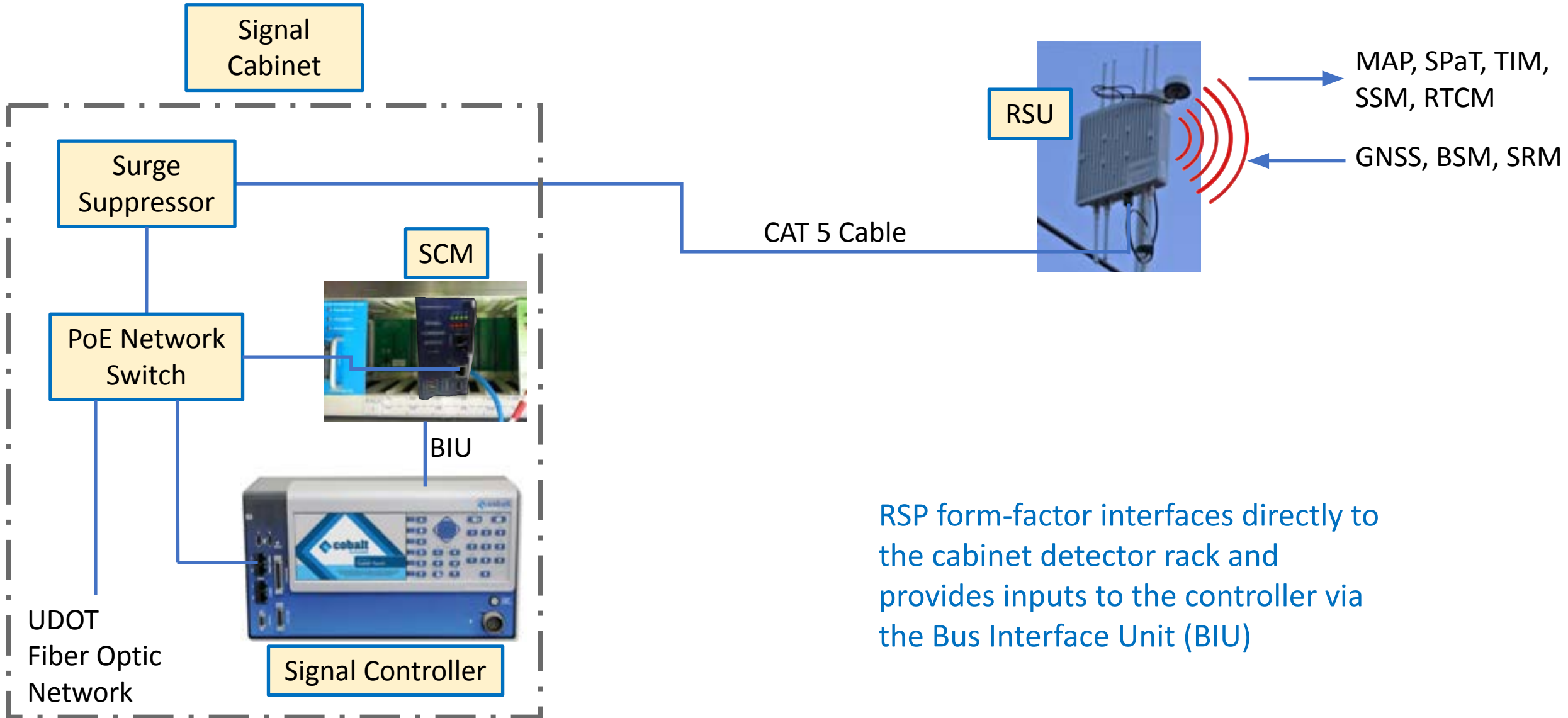


# Additional Hardware / Software

- 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 in a 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 UI MAIN ST & 100 E AF (6025)

Status	RSU	Admin
4	protected-Movement-Allowed	08/21 15:17:40
5	stop-And-Remain	08/21 15:17:56
6	stop-And-Remain	08/21 15:17:56
7	stop-And-Remain	08/21 15:19:35
8	protected-Movement-Allowed	08/21 15:17:51

RSU Status: 08/21/2023 15:17:31 - operate

RTCM broadcasts: 2 messages broadcasting

**BSM - 8510**  
08/21/2023 15:17:36.224  
25.5 mph - W  
7.0 m from map center

**SRM - 8510**  
08/21/2023 15:17:14.507  
Req 1 - request, LaneID 1  
Role transit (0)  
25.7 mph - W

**SSM - 8510**  
08/21/2023 15:17:35.499  
Req 1 - rejected  
LaneID 1

Helix Innovations © 2018-2023 SCM UI v1.17.4



# SCM Software Interface

The image shows the SCM UI interface. On the left is a map visualizer showing a street intersection with green and yellow lines representing traffic flow. On the right is a table of SPaT status data. Below the table are sections for RSU Status, RTCM broadcasts, and a list of messages (BSM, SRM, SSM).

Status	Role	Admin	Duration	Details
4	protected-Movement-Allowed	08/21 15:17:40	4 s	7:straight,7:right:right on red
5	stop-And-Remain	08/21 15:17:56	20 s	
6	stop-And-Remain	08/21 15:17:56	20 s	
7	stop-And-Remain	08/21 15:19:35	119 s	
8	protected-Movement-Allowed	08/21 15:17:51	15 s	15:straight,15:right:right on red

RSU Status: 08/21/2023 15:17:31 - operate

RTCM broadcasts: 2 messages broadcasting

BSM - 8510  
08/21/2023 15:17:36.224  
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25.7 mph - W

SSM - 8510  
08/21/2023 15:17:35.499  
Req 1 - rejected  
LaneID 1

SPaT Status

J2735 Messages

- SPaT
- MAP



# SCM Software Interface

The screenshot displays the SCM UI interface for the intersection of Main St & 100 E AF (6025). The interface is divided into a map view on the left and a data panel on the right. The map shows a satellite view of the intersection with green and yellow lines indicating vehicle trajectories. The data panel on the right contains several sections:

- Status Table:** A table with columns for Status, RSU, Admin, and other parameters. The table contains 8 rows of data.
- RSU Status:** A dropdown menu showing '08/21/2023 15:17:31 - operate'.
- RTCM broadcasts:** A dropdown menu showing '2 messages broadcasting'.
- Message Details:** A list of messages with details such as ID, timestamp, speed, and location.

Two orange ovals highlight specific elements: one around the message details list and another around the '2 messages broadcasting' dropdown.

Status	RSU	Admin		
4	protected-Movement-Allowed	08/21 15:17:40	4 s	7:straight,7:right:right on red
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RSU Status: 08/21/2023 15:17:31 - operate

RTCM broadcasts: 2 messages broadcasting

**J2735 Messages**

- RTCM
- BSM
- SRM
- SSM

Message Details:

- BSM - 8510**  
08/21/2023 15:17:36.224  
25.5 mph - W  
7.0 m from map center
- SRM - 8510**  
08/21/2023 15:17:14.507  
Req 1 - request, LaneID 1  
Role transit (0)  
25.7 mph - W
- SSM - 8510**  
08/21/2023 15:17:35.499  
Req 1 - rejected  
LaneID 1





# SCM Software Interface

The screenshot displays the SCM UI interface. On the left, a satellite map shows an intersection of E Main St and N Main St. A red square highlights the intersection, and green lines indicate the lane configuration. On the right, the configuration panel is titled "MAIN ST & 100 E AF (6025)". It has tabs for "Status", "RSU", and "Admin". Under "Vehicle roles", there are checkboxes for "dot", "fire", "ambulance", and "transit". The "transit" role is expanded, showing a "Role" dropdown set to "transit" and an "Enabled?" checkbox checked. Below this, a table lists lane configurations:

Role	Source name	Subrole number	Enabled?
<input type="checkbox"/>	default	0	<input checked="" type="checkbox"/>
<input type="checkbox"/>	Lane #1	2	<input type="checkbox"/>
	Lane function	= P	
	Relay #1	= 4	
<input type="checkbox"/>	Lane #1	3	<input type="checkbox"/>
	Lane function	= P	
	Relay #1	= 4	
<input type="checkbox"/>	Lane #1	10	<input type="checkbox"/>
	Lane function	= P	
	Relay #1	= 3	
<input type="checkbox"/>	Lane #1	11	<input type="checkbox"/>
	Lane function	= P	
	Relay #1	= 3	

Vehicle Roles and Lane-Level Configuration



# SCM Software Interface

SCM UI MAIN ST & 100 E AF (6025)

Status	RSU	Admin
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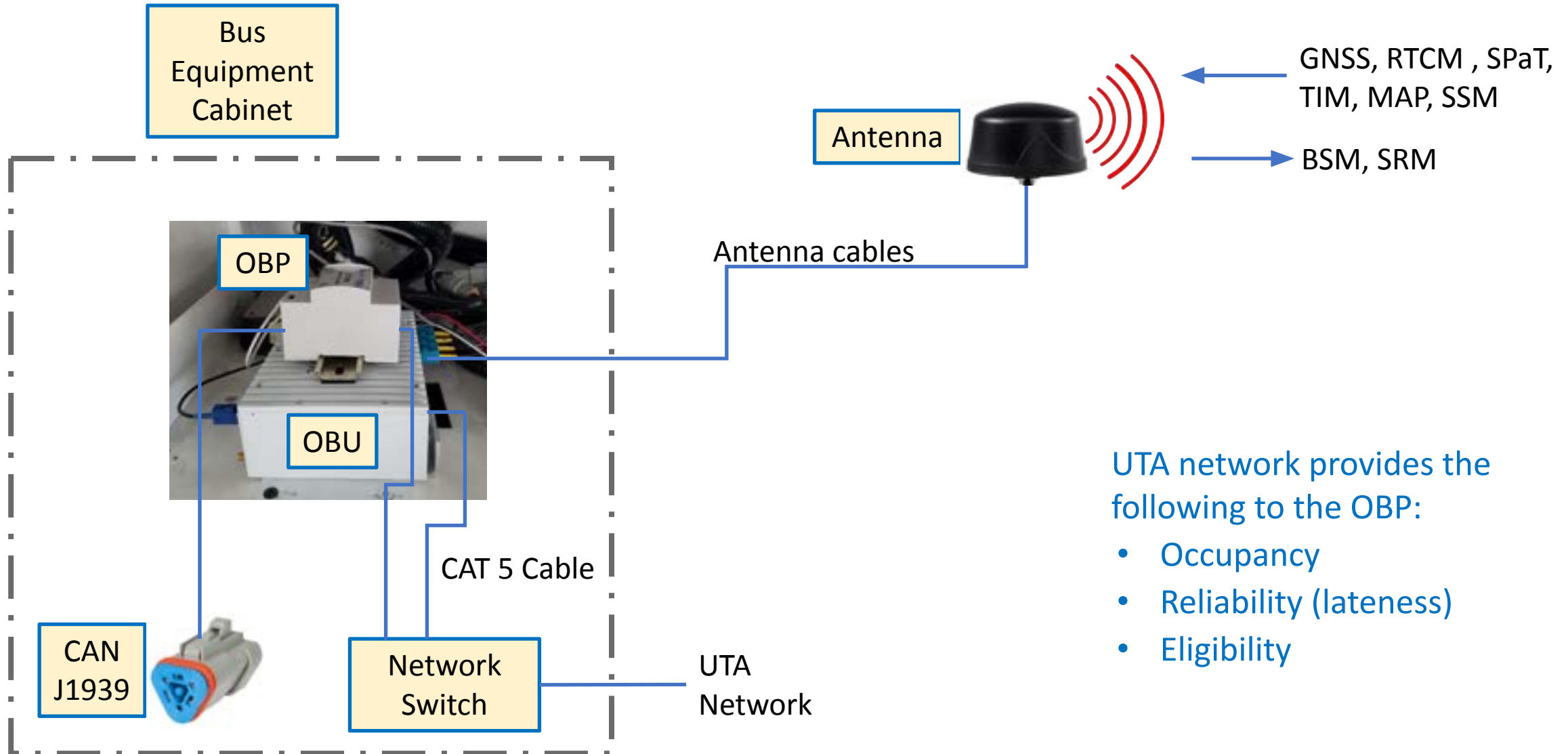
**SRM - 8510**  
08/21/2023 15:17:14.507  
Req 1 - request, LaneID 1  
Role transit (0)  
25.7 mph - W

**SSM - 8510**  
08/21/2023 15:17:35.499  
Req 1 - rejected  
LaneID 1

Relay Channel Outputs



# Onboard - Bus

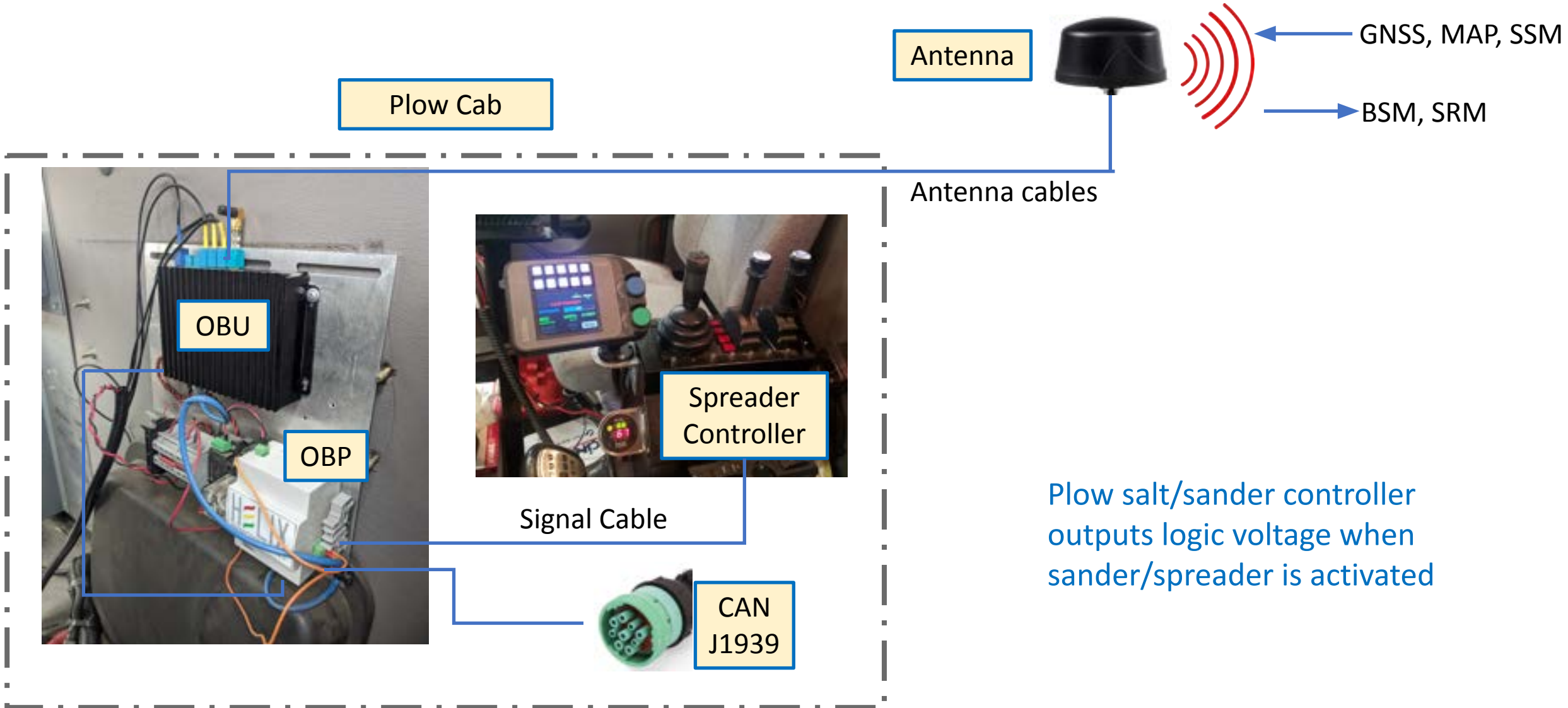


UTA network provides the following to the OBP:

- Occupancy
- Reliability (lateness)
- Eligibility



# Onboard - Snowplow





# 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

V2X OBE UI

Received MAP Visualizer

Vehicle Maps Config

UDOT/UTA EPRG Algorithm  
algorithm can run

request	relay	monitor
ON	ON	ON

LTA Bus Data

Occupancy:	0%	Type:	local
Eligible:	true	Reliability:	4
Veh Ref:	11111		

BSM Data - vehicle id 11111

Timestamp:	08/21/23, 16:37:12.654	Speed:	7 mph
Location:	40.728214/-111.917208	Heading:	East

SRM Data - intersection # 6824

Timestamp:	08/21/23, 16:37:11.958	Speed:	7 mph
Location:	40.728214/-111.917233	Heading:	East
Intersection:	S 900 W & Jewell Ave	Inbound:	6
Type:	request	Lane:	
Name:	local 11111	Request Id:	7
Role:	transit	Vehicle Id:	11111
ETA:	8/21/2023, 16:37:21	Subrole:	-unk-
		Elevation:	1289.7

SSM Data - intersection # 6824

Timestamp:	08/21/23, 16:37:11.330	Seq Num:	0
Intersection:	S 900 W & Jewell Ave	Inbound:	6
Request Id:	6	Lane:	
Status:	rejected	Rq Seq Num:	1
		Vehicle Id:	11111

SPAT Data - intersection # 6824

Timestamp:	08/21/23, 04:37:12.694	Controller:	08/21/23, 04:37:12:645
Intersection:	S 900 W & Jewell Ave	Status:	5 10 11

RTCM Data

Timestamp:		Msg Rev:	
UTC:		Msg Type:	



# OBP Software Interface

V2X OBE UI

**Vehicle** **Maps** **Config**

**UDOT/UTA EPRG Algorithm**  
algorithm can run

request	relay	monitor
on	on	on

**UTA Bus Data**

Occupancy:	0%	Type:	local
Eligible:	true	Reliability:	4
Veh Ref:	11111		

**BSM Data - vehicle id 11111**

Timestamp:	08/21/23, 16:37:12.654	Speed:	7 mph
Location:	40.728214/-111.917208	Heading:	East

**SRM Data - intersection # 6824**

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ETA:	8/21/2023, 16:37:21	Subrole:	-unk-
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**RTCM Data**

Timestamp:		Msg Rev:	
UTC:		Msg Type:	

Bus Info



# OBP Software Interface

V2X OBE UI

**Vehicle** **Maps** **Config**

**UDOT/UTA EPRG Algorithm**  
algorithm can run

request	relay	monitor
ON	ON	ON

**UTA Bus Data**

Occupancy:	0%	Type:	local
Eligible:	true	Reliability:	4
Web Ref:	11111		

**BSM Data - vehicle id 11111**

Timestamp:	08/21/23, 16:37:12.654	Speed:	7 mph
Location:	40.728214/-111.917208	Heading:	East

**SRM Data - intersection # 6824**

Timestamp:	08/21/23, 16:37:11.958	Speed:	7 mph
Location:	40.728214/-111.917233	Heading:	East
Intersection:	S 900 W & Jewell Ave	Inbound:	6
		Lane:	
Type:	request	Request Id:	7
Name:	local 11111	Vehicle Id:	11111
Role:	transit	Subrole:	-unk-
ETA:	8/21/2023, 16:37:21	Elevation:	1289.7

**SSM Data - intersection # 6824**

Timestamp:	08/21/23, 16:37:11.330	Seq Num:	0
Intersection:	S 900 W & Jewell Ave	Inbound:	6
		Lane:	
Request Id:	6	Rq Seq Num:	1
Status:	rejected	Vehicle Id:	11111

**SPaT Data - intersection # 6824**

Timestamp:	08/21/23, 04:37:12:694	Controller:	08/21/23, 04:37:12:645
Intersection:	S 900 W & Jewell Ave	Status:	5 10 11

**RTCM Data**

Timestamp:		Msg Rev:	
UTC:		Msg Type:	

BSM

SPaT





# OBP Software Interface

V2X OBE UI

**Vehicle** **Maps** **Config**

**UDOT/UTA EPRG Algorithm**  
algorithm can run

request	relay	monitor
ON	ON	ON

**LTA Bus Data**

Occupancy:	0%	Type:	local
Eligible:	true	Reliability:	4
Veh Ref:	11111		

**BSM Data - vehicle id 11111**

Timestamp:	08/21/23, 16:37:12.654	Speed:	7 mph
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**SPAT Data - intersection # 6824**

Timestamp:	08/21/23, 04:37:12:694	Controller:	08/21/23, 04:37:12:645
Intersection:	S 900 W & Jewell Ave	Status:	5 10 11

**RTCM Data**

Timestamp:		Msg Rev:	
UTC:		Msg Type:	

SRM and SSM Data



# 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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