THEA Pilot Acquisition and Installation Experiences

Govind Vadakpat  Rafal Ignatowicz  Dave Miller

ITS Joint Program Office
TODAY’S AGENDA

Purpose of this Webinar
- Provide an overview of the approach for identifying the type and number of devices, equipment, and software-based capabilities that needed to be acquired
- Share experiences of engaging with vendors and getting the devices in hand and installed while adhering to a stringent installation schedule
- Identify technical and other barriers and how they are being overcome

Webinar Content
- Connected Vehicle Pilot Deployment Program Overview
- THEA Pilot Acquisition and Installation Experiences
- Stakeholder Q&A

Webinar Protocol
- Please mute your phone during the entire webinar
- You are welcome to ask questions via chatbox at the Q&A Section
- The webinar recording and the presentation material will be posted on the CV Pilots website
PROGRAM GOALS

- Participate in upcoming Webinars/Conference Presentations from the three Pilot Sites (see website for exact dates and times)

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<thead>
<tr>
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</table>

STAY CONNECTED

- Visit Program Website for Updates: [http://www.its.dot.gov/pilots](http://www.its.dot.gov/pilots)
- Contact: Kate Hartman, Program Manager, Kate.Hartman@dot.gov
THEA CV Pilot Deployment
Overview

Rafal Ignatowicz Brandmotion
Dave Miller, Siemens
Pilot Site Overview: Location

[Map showing various locations and key points in Tampa with different case scenarios indicated.]
## Pilot Site Overview: Vehicles

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th># Procured</th>
<th># Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle OBU</td>
<td>1,610</td>
<td>1,580</td>
</tr>
<tr>
<td>Streetcar/Bus OBU</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Antennas, 3 per vehicle</td>
<td>4,850</td>
<td>4,800</td>
</tr>
</tbody>
</table>

- **1,600** Privately Owned Vehicles
- **10** TECO Line Streetcars
- **10** HART buses
## Pilot Site Overview: Roadside

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th># Procured</th>
<th># Installed</th>
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</thead>
<tbody>
<tr>
<td>RSU Kits</td>
<td>65</td>
<td>44</td>
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<tr>
<td>Pedestrian Detector Kit</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vehicle Detector Kit</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wrong Way Detector Kit</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Pilot Site Overview: Master Server

Sitraffic Concert

- Virtual DMS
- CMS
- Detector Data Processing
- Incident Management
- Response Plans
- Intersection Management
- Central Data Storage

Middleware

- Standard Interface OCIT-C
- Standard Interface OCIT-C
- Standard Interface OCPI
- 3rd Party System A
- 3rd Party System B
- NextConnect
- Standard Interface NTCIP / TMDD
- 3rd Party System C
- RSU Log Data Archive
- TSP Request Interface
- RSU
- RSU

SOURCE: SIEMENS
Pilot Site Overview: Personal Device

500+ Private Smartphones
# Pilot Site Overview: Software Apps

<table>
<thead>
<tr>
<th>App</th>
<th>RSU SW Object</th>
<th>OBU SW Object</th>
<th>PID SW Object</th>
<th>MS Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWE</td>
<td>Siemens</td>
<td>OBU Vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PED-X</td>
<td>Siemens</td>
<td>OBU Vendors</td>
<td></td>
<td>Siemens</td>
</tr>
<tr>
<td>ERDW</td>
<td>Siemens</td>
<td>OBU Vendors</td>
<td></td>
<td></td>
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<tr>
<td>IMA</td>
<td>OBU Vendors</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>EEBL</td>
<td></td>
<td>OBU Vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCW</td>
<td></td>
<td>OBU Vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VTRFTV</td>
<td></td>
<td>OBU Vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTMW</td>
<td>Siemens</td>
<td>OBU Vendors</td>
<td>Siemens</td>
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</tr>
<tr>
<td>PCW</td>
<td></td>
<td>OBU Vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-SIG</td>
<td>OSADP</td>
<td>OBU Vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSP</td>
<td>OSADP</td>
<td>OBU Vendors</td>
<td>Siemens</td>
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<td>PED-SIG</td>
<td>OSADP</td>
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<td>PDETM</td>
<td>Siemens</td>
<td>OBU Vendors</td>
<td></td>
<td>Siemens</td>
</tr>
</tbody>
</table>
THEA CV Pilot Acquisition Experiences

Rafal Ignatowicz, Brandmotion

Dave Miller, Siemens
Vehicle System Acquisition Approach

Needs & Feasibility

Project Stakeholders

Concept of Operations

System Validation LTP

System Validation

QG5

System Verification LTP

System Verification

QG4

Unit/Device LTP

Units / Devices

QG3

High Level Design

Subsystem LTP

Sub Systems

QG2

Detailed Design

Units/Device LTP

QG1

Existing Software & Hardware (Available From)

From Other Projects

P3 Deliverable

Measure the Effect

Install & Test

40 Locations

Install & Test

In 1500 Cars

Integrate & Test

6 Use Cases

Integrate & Test

Apps into RSU

Integrate & Test

Apps into Phones

Integrate & Test

Apps into OBU

Integrate & Test

Vehicle HW Security & Test

Integrate & Test

V2X Apps (OSADP, CAMP)

Integrate & Test

V2I Apps (OSADP, CAMP)

Integrate & Test

Android Phone Security & Test

Integrate & Test

V2X Apps (OSADP)

Integrate & Test

V2V Apps (CAMP)

Integrate & Test

Mirror, Screen, OBU

(U.S. Department of Transportation)

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Phase 2C

Phase 3

Phase 2B

Phase 2A

Phase 1

Vehicle Systems Scope:

- User Interface (HMI) components
- On-Board Units components
- Wiring assemblies/components
- Antennas
- Mounting hardware
- Installation Services

Brandmotion safer cars today
Brandmotion’s role in the acquisition was to source and procure the following:

- Human Machine Interface (HMI) components for cars, buses and streetcars
  - Mirrors, Monitors, Speakers
  - Driver display graphics and auditory design
- On-Board Units (OBUs) components (multiple suppliers)
- Wiring assembles/components (Brandmotion and supplier sourced)
- GPS and DSRC Antennas (multiple suppliers)
- Mounting hardware
- Installation Services
Vehicle System Acquisition Approach

Vehicle System Components
- antenna, DSRC radio, computing platform, applications (software components) and HMI/vehicle interfaces

Car system Configuration
- Antenna
- OBU

Bus Configuration
- Antenna
- OBU

Streetcar Config. - front
- Antenna 1
- OBU

Streetcar Config. - rear
- Antenna 2
- OBU

HMI Display supplied by Brandmotion
- HMI - Mirror
- HMI - on Dash Display
- HMI - on Dash Display

Note: National Television Standards Committee (NTSC) is an analog video standard
HMI Design

- Screen Warnings combine US DOT road signage with symbols based on ISO 2575 design practices.
- We are following SAE J 2395 2002-02 to determine a Warning Message priority for the THEA Pilot. Our warnings are direct, highly relevant, and have an emergency time frame.
Brandmotion used a process flow during the acquisition portion of this project that included the following key steps of engineering design, supplier selection, sourcing and testing, and process improvement.

Key aspects of the Brandmotion Supplier Policy include customer focus, quality assurance, supplier privacy and compliance and supplier requirements to address governance, conflict of interest, anti-corruption, adherence to applicable government regulations and quality record retention.

1. **Create Product Design Assumptions - completed in Phase 1 with Tampa CVP input**
   - Product concept and key functional requirements
2. **Initiate Request for Proposal as needed - completed early in Phase II with Tampa CVP input**

- Identify potential partners/suppliers and specific targets
  - Identified key long lead and strategic components (e.g. OBU)
  - Brandmotion’s strategy for success is early sourcing and partnerships

- Evaluate and source key suppliers
  - Directional specification
  - Warranty Requirements

- Refine design assumptions with supplier input
- Shortlist of interested and capable suppliers
3. **Required Request for Quotation to evaluate partners/suppliers - completed with Tampa CVP input and review**

- Commercial/Legal requirements
  - Business aspects/volumes
  - Selection criteria
    - **Musts**: performance (based on technical requirements), timing (based on milestones), affordability/availability, application support, technical capability/track record.
    - **Wants**: Application quality (demonstrated), technical skills, delivery, previous experience, commitment and support, value added proposals

- Program requirements (timing)
  - Customer input

- Technical Requirements/Specification
  - Core engineering with Marketing Support
4. **Supplier Selection - completed with Tampa CVP input**

- Program musts (requirements) shall be met
- Program wants forced ranged and weighted (Kepner-Tregoe)
- Antennas were methodically tested and statistical analysis was applied in order to make the final selection (Reference SAE Paper)
- Evaluation matrix with sourcing team assessment, client input
- Appropriate feedback to non-selected suppliers
5. Early Sourcing commitment for long lead components (OBU) - completed with Tampa CVP input.

- Sourcing letter or Memorandum of Understanding (MOU) to align agreement to program targets
6. **Finalize Specifications, and Statement of Work (SOW) with Program Timing** - completed with Tampa CVP input
   - Collaborative supplier involvement
     - Weekly meetings and discussions to finalize specifications for hardware and software
     - Monthly on site design reviews with all partners
   - Non-disclosure agreement
7. **Program Execution, Final component acquisition**

- **Contracts**
  - Terms and conditions – reflect client requirements
  - Service Level Agreement (SLA) to address technical support and other associated services
  - SOW to define supplier, client and Brandmotion roles and timing for development/verification

- **Development program**
  - Program managers selected
  - Design reviews monthly with biweekly telecons
  - Shared document process
  - Verification testing

- **Product/service delivery**
  - Issue Purchase Orders
  - Complete acquisition matrix (part of the CIP)
  - Validation
  - Technical support
8. **Post Program, Phase III - Scheduled to begin September 1st, 2018**

- Continuous Improvement
  - Target improvement
  - Lessons learned
  - Supplier assessment/feedback
- Ongoing technical support
  - Resolve technical issues
  - Staffed Hotline
  - Warranty
Major vehicle system suppliers are as follows:

- **OBU Suppliers:**
  - Savari
  - SiriusXM
  - Commsignia

- **Antenna Supplier:**
  - Harada
  - SiriusXM (provides their own antennas for their OBUs)

- **Common OBU Specification,** across all suppliers was released July 2017 and to meet the program requirements

- **Brandmotion acquired and assembled all vehicle system related components as a kit,** that is all necessary components assembled/packaged together, for the installers at Hillsborough Community College (HCC) who is Brandmotion’s installation partner
Technical and other barriers

- Being at the forefront of innovation
  - Unspecified requirements
  - Changing standards
## Ancillary Equipment Acquisition

### Source: Siemens

<table>
<thead>
<tr>
<th>Pedestrian Detector</th>
<th>Vehicle Detector</th>
<th>Wrong Way Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidar: Metrotech</td>
<td>Radar: Wavetronix</td>
<td>Microwave: MsSedco</td>
</tr>
<tr>
<td>Lidar: Quanergy</td>
<td>Radar: Siemens</td>
<td>Radar: Wavetronix</td>
</tr>
<tr>
<td>Radar: Wavetronix</td>
<td>Video: Iteris</td>
<td>Radar: Siemens</td>
</tr>
<tr>
<td>Radar: Siemens</td>
<td>Video: Econolite</td>
<td>Video: Iteris</td>
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<tr>
<td>Video: Iteris</td>
<td>Video: Flir</td>
<td>Video: Econolite</td>
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<tr>
<td>Video: Econolite</td>
<td>Video: Gridsmart</td>
<td>Video: Flir</td>
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<td>Video: Gridsmart</td>
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## Master Server Acquisition

<table>
<thead>
<tr>
<th>Hardware / Virtual Machine</th>
<th>Vehicle Detector</th>
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<tbody>
<tr>
<td>Physical Rack Server Host</td>
<td>(12) CPU Cores x 1.9 GHz</td>
</tr>
<tr>
<td>VM #1: Concert App Server</td>
<td>MS Windows™ Server x64</td>
</tr>
<tr>
<td>VM #2 Concert Workstation</td>
<td>MS Windows™ 7 x64</td>
</tr>
<tr>
<td>VM #3 NexConnect Server</td>
<td>MS Windows™ Server x64</td>
</tr>
<tr>
<td>VM #4 MS SQL Database Server</td>
<td>MS Windows™ Server x64</td>
</tr>
<tr>
<td>Workstation</td>
<td>Core i5-6400, MS Windows 7 x64</td>
</tr>
</tbody>
</table>

Source: Siemens
THEA CV Pilot Installation Experiences

Rafal Ignatowicz, Brandmotion

Dave Miller, Siemens
Vehicle System Installation Approach

- The installation of competed systems consists of three vehicle system types
  - 1600 participant/private passenger vehicles
  - 10 buses
  - 10 streetcars
- Hillsborough Community College is under contract to Brandmotion to provide installation services
  - Safe and accessible facilities
  - Brandmotion supplied certified installers
  - Installer candidates and student helpers
- Students at HCC are given an opportunity to expand their automotive knowledge while installing on participant vehicles as part of their studies/training to become certified mechanics
- Buses and streetcar installations are done with collaboration with HART, the local transit authority using Brandmotion’s installers
### Vehicle System Installation Approach

High-level inventory of vehicle equipment procured and installed

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Total to be Configured &amp; Installed</th>
<th>Currently Configured &amp; Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle OBUs</td>
<td>1600</td>
<td>500</td>
</tr>
<tr>
<td>Streetcar OBUs</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Bus OBUs</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>
Brandmotion created a dashboard as high level project management tool

**Tampa CV Project Scorecard**

**As of July 27, 2018**

**Average Rate per day since start**
- Completion Date at Current Rate
- Daily Rate Needed to Meet 8/31 Deadline
- Completion Percentage
- Ratio of current rate to Goal Rate
- Est. Completion at Deadline

**Installation Time Data**
- Average Install Time:
  - Average Install Time for Each OBU Supplier
  - Install Time Breakdown
  - Install Time Moving Average

**Scheduling and Daily Data**
- Scheduled Appointments Results Breakdown
- Daily Rates
  - Daily Rate by Week
  - Daily Totals
Vehicle System Installation Approach

- Brandmotion communicated OBU technical information to the suppliers through a document, VEHICLE SYSTEMS - OBU COMPONENT SPECIFICATION, OBU_COMPSPEC_BM_THEA v2.2 which incorporated the requirements from the System Architecture Document (SAD) and the System Design Document (SDD).
- Brandmotion procures the Onboard Units under contract and Service Level Agreement from Commsignia, SiriusXM and Savari.
- The antennas are purchased from Harada.
- Wiring, video adapters and display components are designed and procured separately by Brandmotion.
Each vehicle will have

- Two DSRC antennas
- GNSS antenna
- An OBU hidden and installed in the trunk of the car
- A mirror with a speaker up front for the interface with the driver
Vehicle System Installation Approach

- Antenna Configuration
  - Multiple antenna configurations are exercised during installation depending on vehicle type. Below is an example of one. Also, depending on the OBU and vehicle type, the OBU could be mounted in different locations.
Vehicle System Installation Approach

- Each bus will have
  - Two DSRC antennas
  - GNSS antenna
  - An OBU hidden and installed inside a cabinet
  - Display with a speaker up front for the interface with the driver
The streetcar physical architecture requires two separate vehicle systems, as the streetcar reverses direction and the operator moves to the other end of the streetcar. Each streetcar will have:

- Four DSRC antennas
- Two GNSS antenna
- Two OBUs hidden and installed inside a cabinets
- Two displays with a speakers on each end of the streetcar for the interface with the driver
The OBUs will come pre-configured from the vendor for the vehicle type they will be installed on. The hardware from the OBU vendors will then be joined with wiring harnesses that match the vehicle type. Final software configuration will be done by the installer with the instructions provided by each OBU supplier.
Vehicle System Installation Approach

Prior to Installation

- Potential participants sign up online and fill out a survey that provides Brandmotion with details about their vehicle.
- This information is then used to determine if the vehicle can participate in the pilot.
- Some disqualifying features include removable roofs, all glass roofs, safety systems implemented in the rear-view mirror, etc.
- Once the vehicle is approved, the participant is able to come in for an installation.
Vehicle System Installation Approach

Participant Appointments

- Two-hour appointment block is required for:
  - *Inspection of the vehicle*
  - *Installation of antennas, on-board units, and rear-view mirrors to the participant’s approved vehicle*
  - *Training session for the participant on the usage and intended reactions regarding the equipment and safety messages they will receive*
  - *Receipt and signature by the participant of an informed consent document regarding their participation in this human use study*

For the bus and streetcar installations, HART will provide training to their drivers separately and the informed consent form will be from HART, not individual bus/streetcar drivers like it is for participant vehicles
Installation Process

- The technician(s) will remove the existing rear-view mirror, placing the stock part in a container to be returned to the participant.
- The custom kit, provided by Brandmotion, will then be installed, including the OBU in the trunk or under dash of the vehicle, antenna(s) on the roof of the vehicle, wiring along the frame of the vehicle, and the rear-view mirror with video display along the windshield or ceiling of the vehicle.
- Following installation, the technician(s) will test the connection between the OBU and a stationary RSU located in the bay, or outside for clear sky reception. The technician will make certain data is received by the RSU, and that safety messages are received by the OBU, and transmitted to the screen in the newly installed rear-view mirror.

Once installation has begun, the participant will be trained in the use cases, warning system, and intended reactions. A series of videos will be shown to the participant, along with visuals for each individual safety message that will be displayed. The participant will also be informed of the control and treatment groupings, but will not be informed as to which set they will placed in during the test phase of the pilot.
Warranty

- Sparing strategy keeps a stock of all parts for timely service. Brandmotion has warranty agreements in place with the OBU suppliers that include Service Level Agreements (SLA), which provide technical support over the life of the pilot. The warrant agreement requires replacement parts for all defects. The contingency plan is for the OBU suppliers to provide onsite technical support if and when needed. The SLA has performance measurement requirements to ensure timely response to problems.
Technical and other barriers

- Working with the public
  - Participants showing to appointments
- Changing standards
- Certifications
- Multiple OBU suppliers
  - Managed collaboration among competitors
  - Application development
  - Component delays
- Training of HCC students
- Installation complexities
  - CAN Decoder
## Infrastructure Installation Approach

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installer</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSUs</td>
<td>Siemens Service, Southeast Operations</td>
</tr>
<tr>
<td>Pedestrian Detector</td>
<td>Siemens Service, Southeast Operations</td>
</tr>
<tr>
<td>Vehicle Detector</td>
<td>Siemens Service, Southeast Operations</td>
</tr>
<tr>
<td>Wrong Way Detector</td>
<td>Siemens Service, Southeast Operations</td>
</tr>
<tr>
<td>Master Server</td>
<td>Siemens ITS, Austin TX</td>
</tr>
<tr>
<td>Cyber Security</td>
<td>Siemens Corp. Technologies, Princeton NJ</td>
</tr>
<tr>
<td>PID Apps</td>
<td>Private PID user</td>
</tr>
</tbody>
</table>

Source: Siemens
### RSU Control Application

#### Services
- **OK** - 265 Units

#### Device
- **OK**
  - its-10-01-b8: up 15:04:34 17.03a.13527 arm-imx6 T(e):30C T(w):30C

#### Load
- **OK**
  - Load average: 0.33, 0.13, 0.10

#### Memory Usage
- **OK**
  - 87.18% Free

#### Date & Time
- **OK**
  - TC: N/A GPS: N/A NTP: OK(647/647)

#### Database
- **OK**
  - DB is alive 784 nodes

#### Connections
- **OK**
  - eth0:dhcpp:routeable br0:dhcppsv:routeable cw-llc:off eth1:bridge:no-carrier eth2:off:off wifi0:bridge:carrier

#### VPN Connection
- **UNKNOWN** - not enabled

#### Bluetooth
- **UNKNOWN** - Disabled

#### LTE Connection
- **UNKNOWN** - Modem disabled

#### MAC 802.11p
- **OK**
  - WAVE: CCH(00:0d:41:10:02:b8:1873713,3869747) SCH1(00:0d:41:10:02:b9:5226155,0) SCH4(00:0d:41:10:02:bb:5226155,0) SCH6(00:0d:41:10:02:ba:5226155,0)

#### ITS 1609 NET
- **WARNING** - no registration PPS: 1490991838

#### Controller proxy
- **UNKNOWN**
## Infrastructure Installation Timeline

<table>
<thead>
<tr>
<th>Process</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSU Site Survey</td>
<td>July 2017</td>
</tr>
<tr>
<td>RSU MAP Files, Install Apps</td>
<td>July 2017 to October 2017</td>
</tr>
<tr>
<td>RSU Installation</td>
<td>August 2017 to November 2017</td>
</tr>
<tr>
<td>Vehicle Detector Site Survey</td>
<td>July 2017</td>
</tr>
<tr>
<td>Vehicle Detector Installation</td>
<td>March 2017</td>
</tr>
<tr>
<td>Wrong-Way Site Survey</td>
<td>July 2017</td>
</tr>
<tr>
<td>Wrong-Way Installation</td>
<td>August 2017</td>
</tr>
<tr>
<td>Pedestrian Detector Site Survey</td>
<td>July 2017</td>
</tr>
<tr>
<td>Pedestrian Detector Installation</td>
<td>August 2018</td>
</tr>
<tr>
<td>Master Server Network Design</td>
<td>June 2017</td>
</tr>
<tr>
<td>Master Server Installation</td>
<td>September 2017 to October 2017</td>
</tr>
<tr>
<td>Master Server Security Scan</td>
<td>July 2018</td>
</tr>
</tbody>
</table>

Source: Siemens
<table>
<thead>
<tr>
<th>Technical Barrier</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind loading</td>
<td>Extended antennas for line-of-sight</td>
</tr>
<tr>
<td>HamWAN Interference</td>
<td>Identified source, cooperating to resolve</td>
</tr>
<tr>
<td>OBU software updates</td>
<td>Over the Air updates RSU → OBU</td>
</tr>
<tr>
<td>Infrastructure power</td>
<td>Permitting</td>
</tr>
<tr>
<td>Fiber connections</td>
<td>RSU cellular backhaul</td>
</tr>
<tr>
<td>SCMS delivery</td>
<td>Private SCMS</td>
</tr>
</tbody>
</table>

Source: Siemens
Workflow: Early Investigation

Investigation:
- Reduced uncertainty
- Few mature apps
- No OBU specifications

Source: Siemens
Site Surveys, OBU specifications, others
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STAKEHOLDER Q&A

- Please keep your phone muted
- Please use chatbox to ask questions
- Questions will be answered in the order in which they were received
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Visit the Pilot Site Websites for more Information:

- NYCDOT Pilot: https://www.cvp.nyc/
- Tampa (THEA): https://www.tampacvpilot.com/
- Wyoming DOT: https://wydotcvp.wyoroad.info/

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