Integrated Vehicle-to-Infrastructure
Prototype (IVP)

Draft V2I Hub Sample Set-up Guide

Hardware & Software, Physical Connections, and Configuration for a Limited Deployment of V2I Hub at a Signalized Intersection to Send SPaT and MAP Messages

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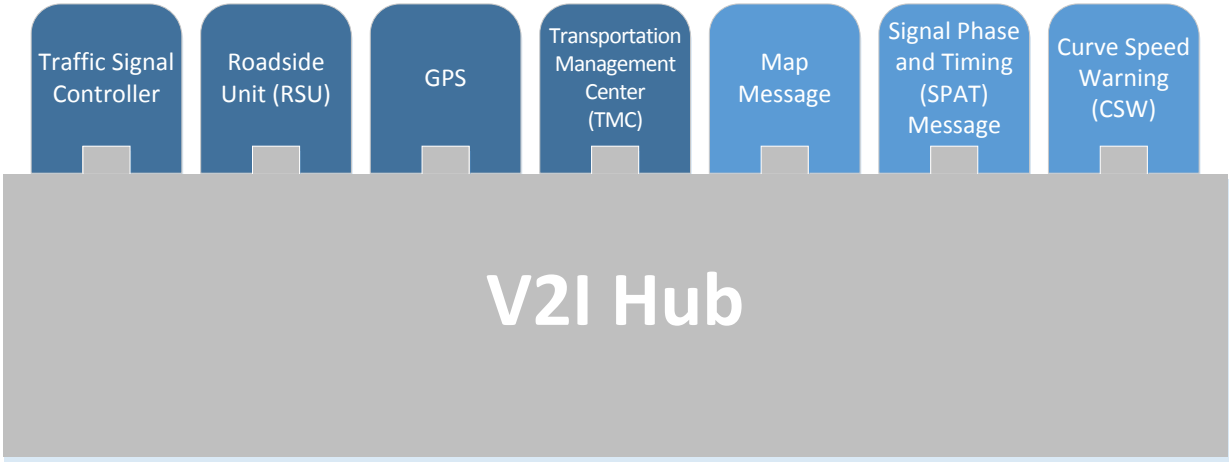

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Chapter 1. Introduction

1.1 V2I HUB

The Integrated Vehicle-to-Infrastructure Prototype (IVP), called V2I Hub, is part of USDOT's Vehicle-to-Infrastructure (V2I) Program and was developed to support jurisdictions in deploying V2I technology by reducing integration issues and enabling use of their existing transportation management hardware and systems. V2I Hub is a software platform that utilizes plugins to translate messages between different devices and run connected vehicle safety applications on roadside equipment.

The V2I Hub software was created and tested on Ubuntu 14.04 LTS, but can run on most Linux operating systems. The V2I Hub software uses a plugin architecture so that each installation can be configured to run a suite of different software applications and plugins. The V2I Hub software contains the communication routing for the plugins, the configuration for the plugins, and the processes to start, stop, and monitor the plugins. Each plugin in the V2I Hub software is created to do a function, such as communicate with a signal controller and produce Signal Phase and Timing (SPaT) messages.

1.2 DOCUMENT PURPOSE

The purpose of this document is to outline the hardware and software required to deploy a V2I Hub unit in an existing traffic signal controller cabinet, and the installation and configuration for sending SPaT messages, MAP infrastructure geometry messages, and Radio Technical Commission for Maritime Services (RTCM) position correction data. **It should be noted this guidance is for a sample deployment for a knowledgeable user and specific hardware as outlined below, and therefore does not provide information on all of the elements and scenarios where V2I Hub can support connected vehicle technology.**

This document covers the following areas:

- Required Hardware and Software
- Connecting V2I Hub Hardware
- Configuration

1.3 TARGET AUDIENCE

The target audience for this document is the IT personnel for the deploying agency. The end user will need familiarity with connected vehicle technology and experience using telnet, secure shell (ssh), secure copy (scp), and basic command line tasks in Linux.

1.4 DEPLOYMENT SCENARIO AND ASSUMPTIONS

The V2I Hub system is comprised of a compact, industrial computer running the V2I Hub software and is referred to as V2I Hub. This document assumes that the end user already has an industrial computer with the V2I Hub software installed and describes the physical connections needed for the V2I Hub software to function correctly. The V2I Hub software can be obtained from the United States Department of Transportation's (USDOT) Open Source Application Development Portal (OSADP). Additional support documents for V2I Hub are also available on the OSADP.

Although V2I Hub can operate with a variety of different Traffic Signal Controllers (TSC) and Roadside Unit (RSU) radios, the guidance provided in this document is specific to an Arada LocoMate Commando RSU and an Econolite TSC. This guidance is based on Society of Automotive Engineers International's (SAE) J2735-201509 message set for Dedicated Short Range Communications (DSRC).

A variety of plugins have been developed to connect with different transportation management equipment, provide functionality, and run Connected Vehicle Safety Apps. This document provides instructions to set up a V2I Hub system and configure the following four plugins:

- DSRC Message Manager Plugin
- MAP Plugin
- SPaT Plugin
- RTCM Plugin

Chapter 2. Required V2I Hub Hardware and Software

2.1 REQUIRED HARDWARE AND SOFTWARE

Listed below is the hardware required for this sample deployment and the equipment needed to support the installation and verification of functionality.

2.1.1 Hardware and Software

- **Industrial Computer –** For running the V2I Hub software with minimum specifications as listed below.
  - Intel Core i3 processor
  - 4GB of memory
  - 10 GB of HD space
  - Ubuntu 14.04 LTS
- **V2I Hub Software**
  - V2I Hub software and installation instructions are available on the Open Source Application Development Portal (OSADP).
  - XML input files for the MAP and SPaT plugins specific to the deployment intersection (instructions available on the OSADP).
- **Roadside Unit (RSU)** –Dedicated Short Range Communications (DSRC) radio.
  - Arada LocoMate Commando version 3.1.
  - Firmware WAVE_LOCOMATE-200_1.90.0.16_firmware to support the SAE J2735-201509 message set.
  - GPS attachment.
  - Power over Ethernet (PoE) adapter.
  - Mounting hardware (as needed).
- **Traffic Signal Controller (TSC)**
  - Econolite ASC/3.
  - Minimum requirements to support SAE J2735-201509 message set.
    - Firmware v2.58
    - Boot v1.14.03
  - The traffic signal controller will need to send the Traffic Signal Controller Broadcast Message via an Ethernet port as defined in Table 4 of the *Interface Control Document for the Signal Phase and Timing and Related Messages for V-I Applications* (Battelle, 2013). This table is included in Appendix for reference.
- **Standard Ethernet Cables** - Cat5e or Cat6 for connecting V2I Hub, the RSU's PoE adapter, and connecting the maintenance computer in the field during deployment.
- **Shielded, Outdoor-Rated Ethernet Cable** - To connect the externally mounted RSU to its PoE adapter in the traffic signal controller cabinet.
- **IPv4 or IPv6 Ethernet Switch**

  - All devices connected to this switch must have static IP addresses on the same class C network (i.e., netmask of 255.255.255.0).
  - An example configuration is:
    - V2I Hub: 192.168.25.20
    - TSC: 192.168.25.50
    - RSU: 192.168.25.10
    - Maintenance computer: 192.168.25.200

- **Power Outlet(s) -** 110 volt power outlets in the traffic signal controller cabinet for the V2I Hub (and the RSU PoE, TSC, and Ethernet Switch if they are not currently installed).
- **Internet Connection** in the cabinet to enable the RTCM Plugin to retrieve position correction information and provide remote access for configuration and monitoring.
  - For this connection V2I Hub obtains an IP address via DHCP from a Virtual Private Network (VPN) server. This can be provided via a Transportation Management Center with the appropriate network connections and port configurations.

2.1.2 Installation and Testing Equipment

- **Maintenance computer** with the following software:
  - Windows or Linux operating system.
  - PuTTY.exe or other telnet/ssh client software installed.
  - WinSCP.exe installed.
  - Web browser (i.e., Firefox, Internet Explorer, etc.).
- **On-board Unit (OBU) or Aftermarket Safety Device (ASD)** – To receive messages from the RSU using the same SAE J2735-2015 protocol to verify receipt of the traffic signal, map, and position correction information.

2.2 HARDWARE COMPONENTS

Photos of the different hardware components are provided in Figure 1 through Figure 5.

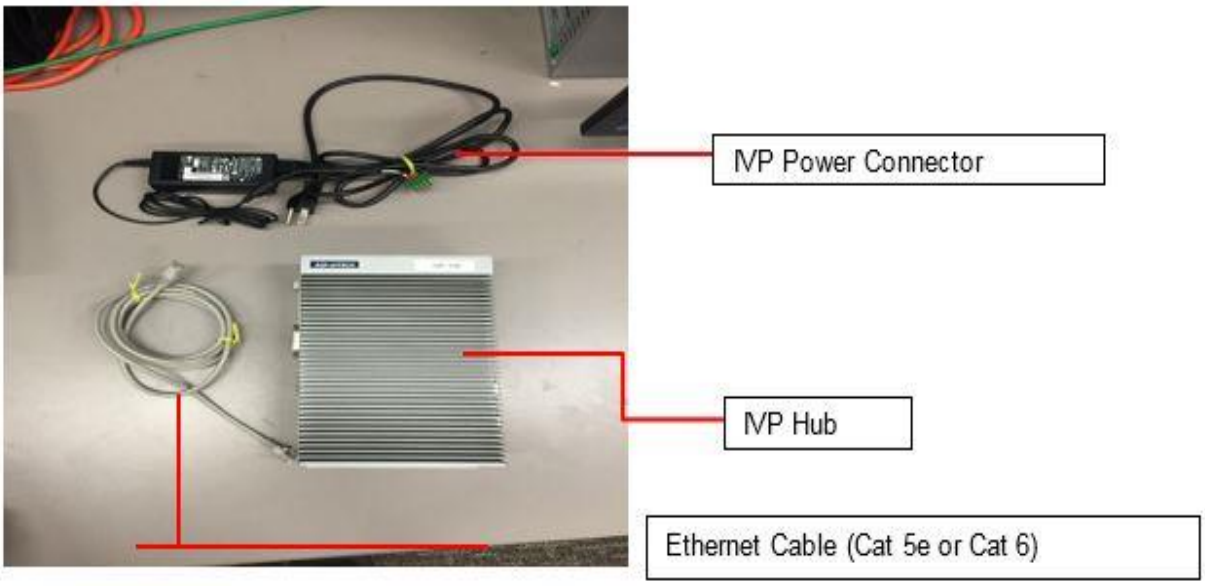


Figure 1. V2I Hub

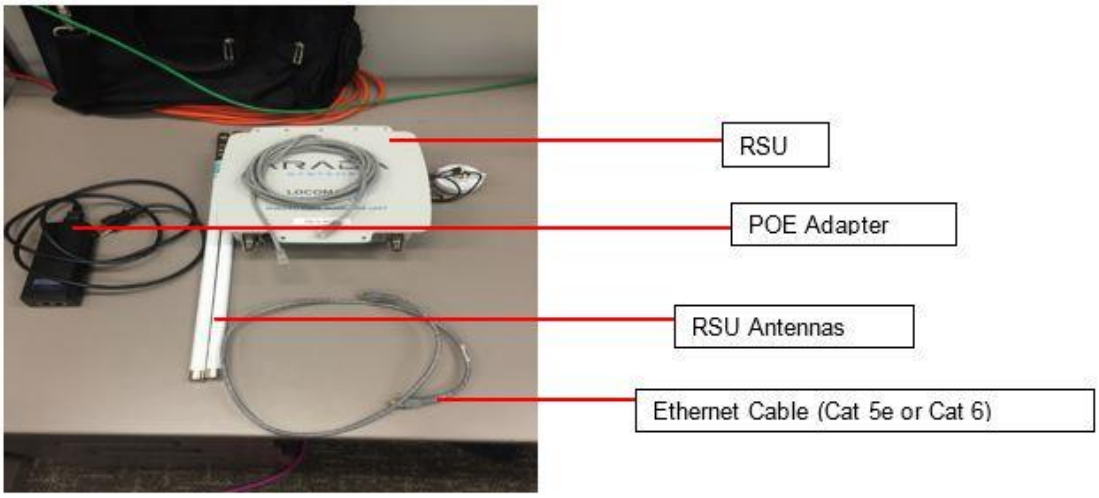


Figure 2. Roadside Unit (RSU) with Power Adaptor

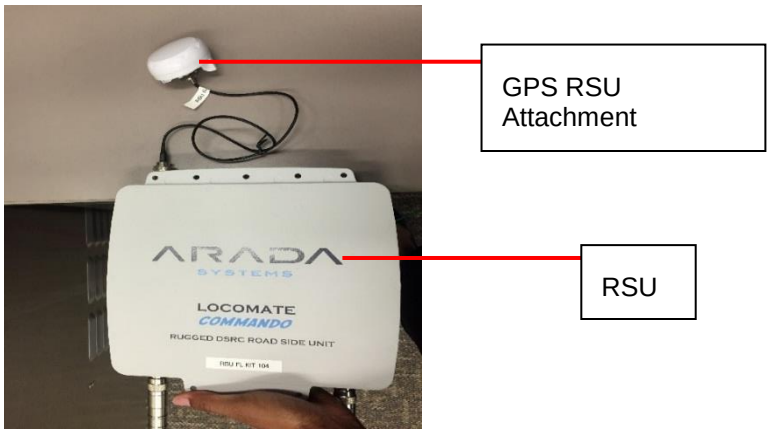


Figure 3. RSU with GPS Antenna

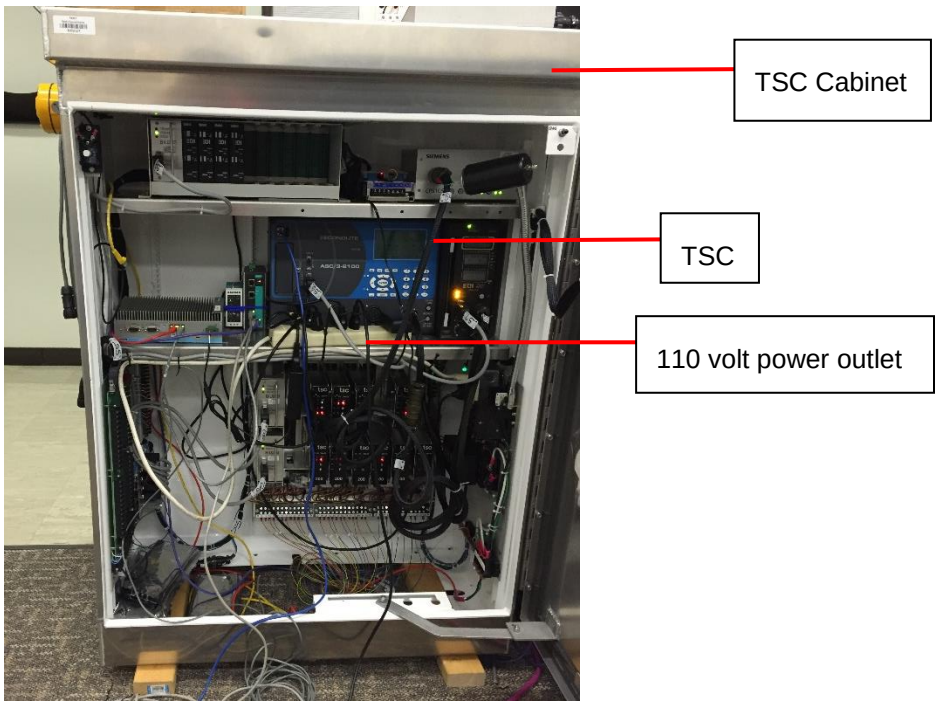


Figure 4.Traffic Signal Controller (TSC) Cabinet

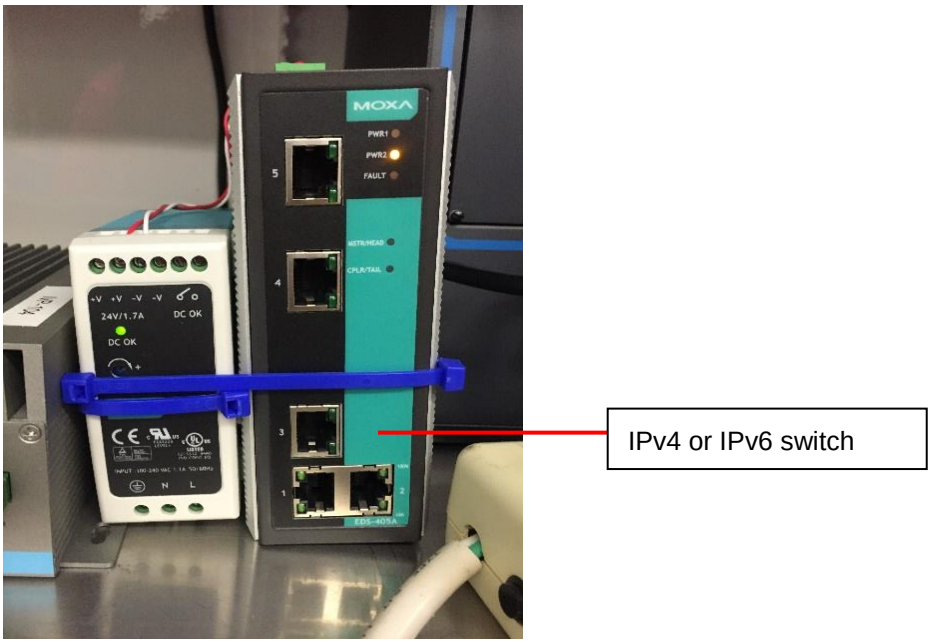


Figure 5. Network Switch in the Cabinet

Chapter 3. Connecting V2I Hub Hardware

The following is a sequential set of steps that describes how to connect the hardware components needed to deploy V2I Hub. Figure 6 shows a simplified depiction of the configuration of the different hardware components as described in this chapter.

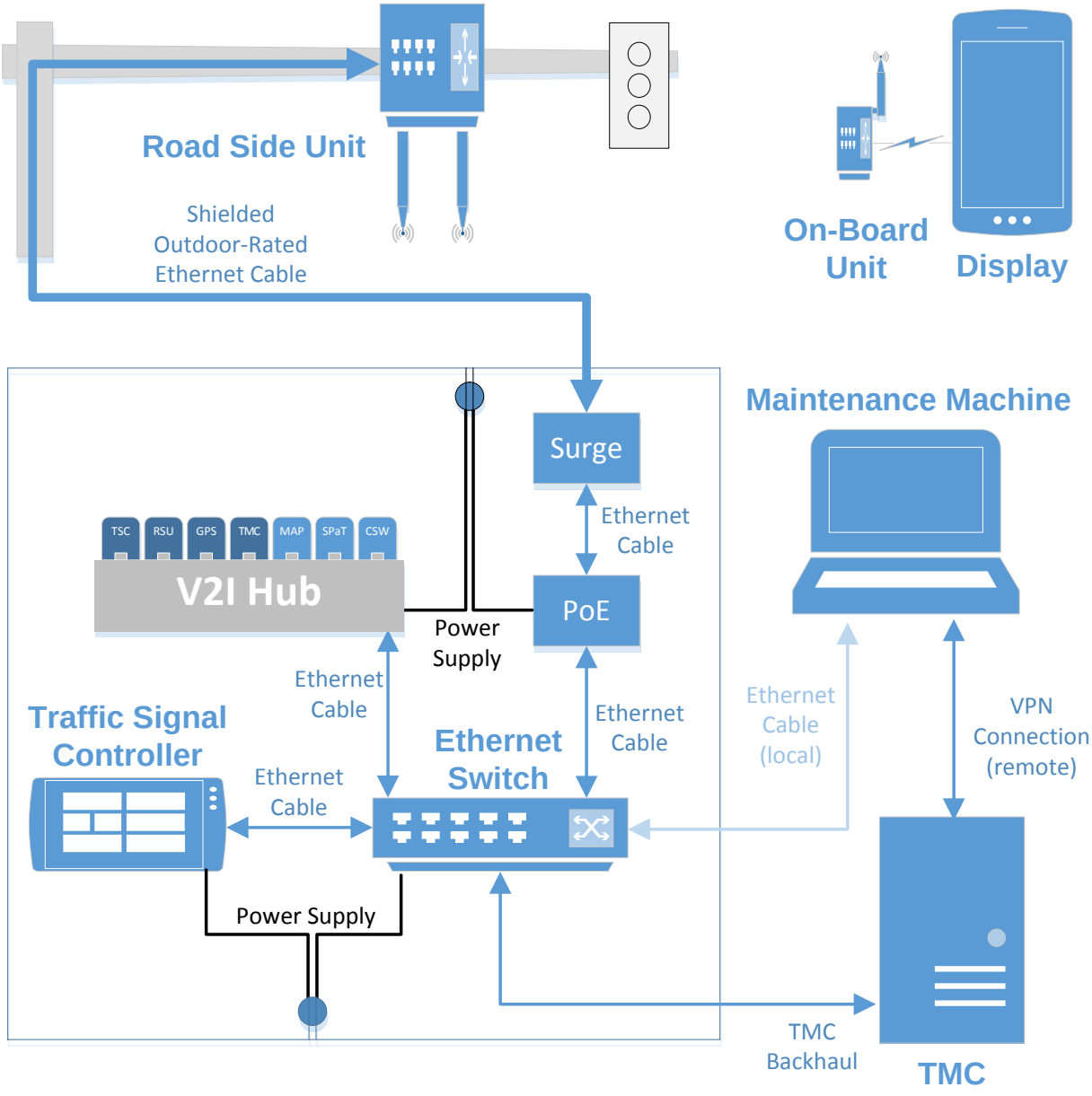


Figure 6. Basic V2I Hub Deployment Configuration

1. Connect one end of an Ethernet cable to the maintenance computer.

Figure 7. Ethernet Cable Connected to Computer

2. Connect the other end of the Ethernet cable to an open port on the IPv4/IPv6 switch.

Figure 8. Ethernet Cable Connected to IPv4/IPv6 Switch

3. Connect the **shielded, outdoor-rated Ethernet cable** to the WAN port on the RSU.

Figure 9. Ethernet Cable Connected to ARADA RSU

4. Connect the other end of the Ethernet cable to the Power and Data port on the Power over Ethernet adapter.

Figure 10. Ethernet Cable Connected to PoE's Injector

5. Connect an Ethernet cable to the Data port on the POE adapter.

Figure 11. Data Input Connected to PoE's Injector

6. Connect the other end to an open port on the IPv4/IPv6 switch.

Figure 12. Data Input Connected to IPv4/IPv6 Switch

7. Connect the POE adapter to the power supply using the power adapter that came with the POE adapter.

8. Plug the V2I Hub Power Connector into the V2I Hub and connect the V2I Hub Power Connector to an electrical outlet.

Figure 13. V2I Hub Network Interfaces

9. Connect an Ethernet cable to the LAN port on the V2I Hub

Figure 14. V2I Hub with LAN Connection

10. Connect the opposite end to any port on the IPv4/IPv6 switch.

Figure 15. V2I Hub Connected to IPv4/ IPv6 Switch

11. Connect another Ethernet cable to the WAN port of the V2I Hub.

Figure 16. V2I Hub Connected to WAN or Internet

12. Connect the opposite end of that Ethernet cable to an active internet/VPN server.

13. Push the power button on the V2I Hub.

Figure 17. Power Button for V2I Hub

Chapter 4. Configuration

This section of the document outlines the configuration steps listed below.

- Install the software applications used to log in, support and transfer files to the V2I hardware elements.
- Configure the Traffic Signal Controller outputs.
- Configure the V2I Hub port connection.
- Configure the Roadside Unit radio.
- Verify the V2I Hub plugin configurations.
    - The plugins are assumed to be configured when preloaded to the V2I Hub. However, if the V2I plugins need to be modified or updated, this section also describes the steps required to change common parameters.
- View or verify Plugin Message Activity.

4.1 INSTALLING THE SUPPORTING SOFTWARE APPLICATIONS

A temporary maintenance computer is recommended for configuration of the components in the traffic signal controller cabinet. This computer must have an IP address in the same subnet as the other devices and be attached to the local IPv4/Ipv6 switch as described in the V2I Hub System Prerequisites and V2I Hub Hardware Set-Up Photos. Alternatively, components can be configured remotely through a VPN connection if the V2I Hub is connected to the Internet and configured for VPN access. VPN setup is beyond the scope of this document.

The maintenance computer can run either the Windows or Linux operating system as described in the following sections.

For a **Windows maintenance computer**, the recommended applications are PuTTY and WinSCP.

- PuTTY is a telnet and SSH (Secure Shell) client for Windows. Telnet is used to connect to the RSU for configuration and SSH is used to connect to the V2I Hub. PuTTY is a free software package available at the PuTTY website. All that is required is putty.exe executable.
- WinSCP is a SCP (Secure Copy Protocol) client for Windows. It is used to transfer files to a Linux computer (e.g., V2I Hub, RSU). WinSCP is a free software package available at the WINSCP official website.
    - The WinSCP application may only be necessary to download if updates/modifications to the V2I Hub plugins are required.

For a **Linux maintenance computer**, no special applications are required when Linux is the operating system on the maintenance computer. The standard Bash Unix shell can be used for all telnet, SSH, and SCP operations. For example, the following are valid commands that can be executed in a Bash shell:

- telnet 192.168.25.10
- ssh 192.168.25.20
- scp map.xml ivp@192.168.25.20:~/

4.2 TRAFFIC SIGNAL CONTROLLER (TSC) CONFIGURATION

The following steps detail how to ensure that the traffic signal controller is configured to communicate with the V2I Hub.

Select the following sequence of menus using the traffic signal controller controls:

MAIN MENU → 1. CONFIGURATION → 5. COMMUNICATIONS → 1. ETHERNET

The following example shows the traffic signal controller with a local IP address of 192.168.25.50. In this case, the SERVER IP field refers to the IP of the V2I Hub. It is configured to send the Traffic Signal Controller Broadcast Message to the V2I Hub at 192.168.25.20. The UDP port used by the V2I Hub to receive communications from the traffic signal controller cannot be modified in this screen on the Econolite traffic signal controller, and is hard coded to 6053. If the IP Address of the traffic signal controller is not on the same network as the V2I Hub, please refer to your traffic signal controller's user guide to change the IP address.

Figure 18. Traffic Signal Controller Ethernet Configuration

Select the following sequence of menus using the traffic signal controller controls:

MAIN MENU → 1. CONFIGURATION → 5. COMMUNICATIONS → 5. NTCIP

The following example shows the traffic signal controller is configured for SNMP NTCIP communications using port 501.

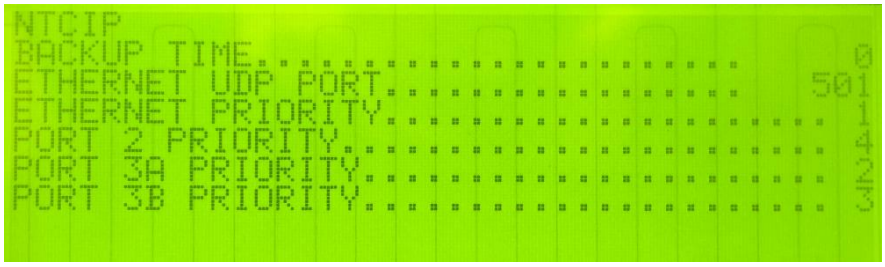


Figure 19. Traffic Signal Controller with NTCIP Configuration

4.3 V2I HUB CONFIGURATION

The V2I Hub comes configured with a static IP address of 192.168.25.20 for its LAN port. Follow the steps below to change the ip address of the V2I Hub for your network.

To log in to the V2I Hub:

- The maintenance machine and V2I Hub will need to be on the same network. Change the IP address of your maintenance machine to 192.168.25.* (i.e., 192.168.25.82).
- Open the PuTTY (putty.exe application).

- Enter the IP Address (Default: 192.168.25.20).
- Select SSH for connection type.
- Click Open, as shown in Figure 20.

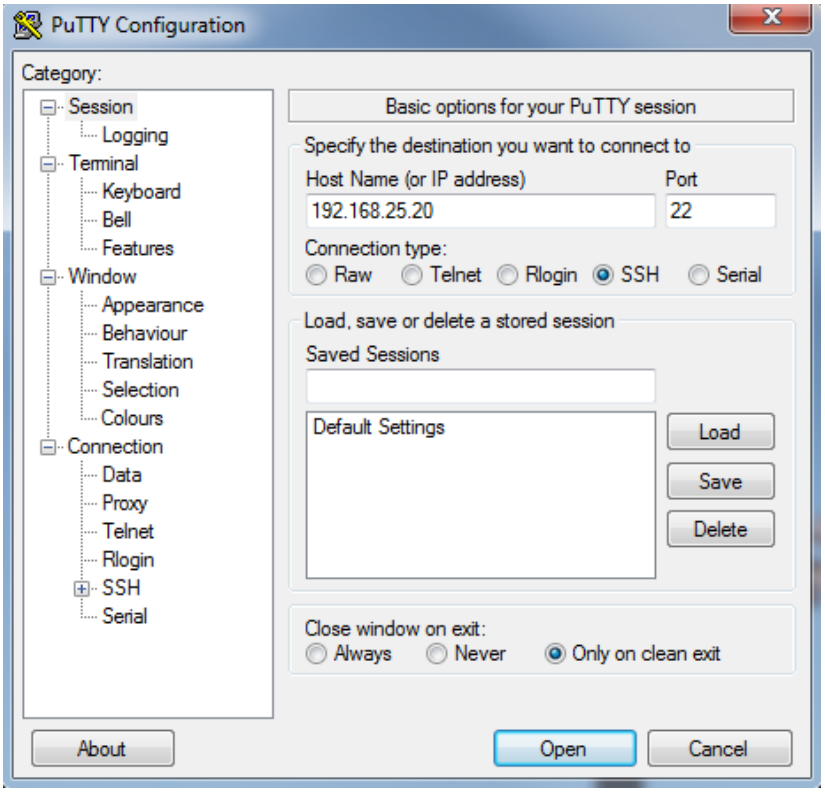


Figure 20. PuTTY Configuration for V2I Hub

- Log in to the V2I Hub using the username and password provided by the owner of the V2I Hub[1].
  - The cursor may not move and the password may not display while entering in the corresponding password.
- Once the command prompt appears, change directory to /etc/network (cd /etc/network)
- Open the interfaces file in nano (sudo nano interfaces) or a text editor of your choice as super user by prefixing the command with “sudo”.
- Modify the default IP address of 192.168.25.20 to that of your desired IP address.
  - Save the file (nano ctrl + X, enter Y for save file).
- Reboot the V2I Hub (sudo reboot). This will terminate the connection.

[1] The deploying agency is expected to own the V2I Hub and manage credentials used to access the V2I Hub. Ubuntu is used to create and assign usernames and passwords for the V2I Hub.

4.4 ROAD SIDE UNIT (RSU) LOG IN AND CONFIRMATION

This section describes how to log in and configure the Arada LocoMate Commando RSU to send J2735 SPaT, MAP, and RTCM messages via the radio when they are received from the V2I system. The instructions were created with an Arada LocoMate Commando RSU v3.1 running firmware WAVE_LOCOMATE-200_1.90.0.16_firmware. The instructions assume the PuTTY application is used as the telnet client.

To log in to the RSU:

- If not already the same, the maintenance machine and the RSU will need to be on the same subnet. Change the IP address of your maintenance machine to match the subnet of the RSU's existing IP address.
- Open the PuTTY putty.exe application.
- Enter the Host Name (or IP address) for the RSU.
- Select Telnet for connection type.
- Click Open, as shown in Figure 21.

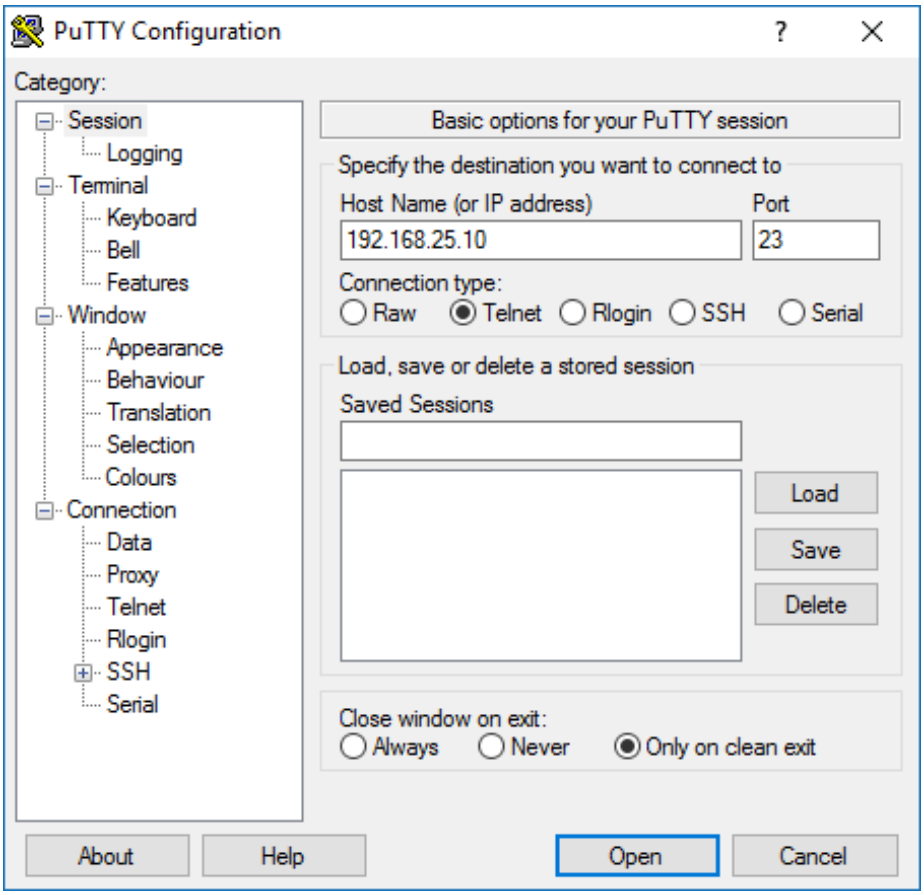


Figure 21. PuTTY Configuration for RSU

- The configuration is the same as shown in Figure 21 when using PuTTY as an SSH client, except the SSH Connection type should be specified instead of Telnet.
- Once the black login screen appears, log in to the RSU using the username and password provided by the owner of the RSU[2].
    - The cursor may not move and the password may not display while entering in the corresponding password.
- Type “cli” to enter the Arada command line interface and press enter.
    - The Arada command line interface is entered by typing cli. Multiple commands can be given while in the command line interface. cli should not be typed while already in the command line interface.
- Type “show configuration” to list the current configuration and press enter.
- After enter is pressed, at the end of the output, the list of configured applications is displayed as shown in Figure 22. This figure shows the final desired configuration, where the getwbsstxrxencdec application is configured twice to forward the appropriate messages.

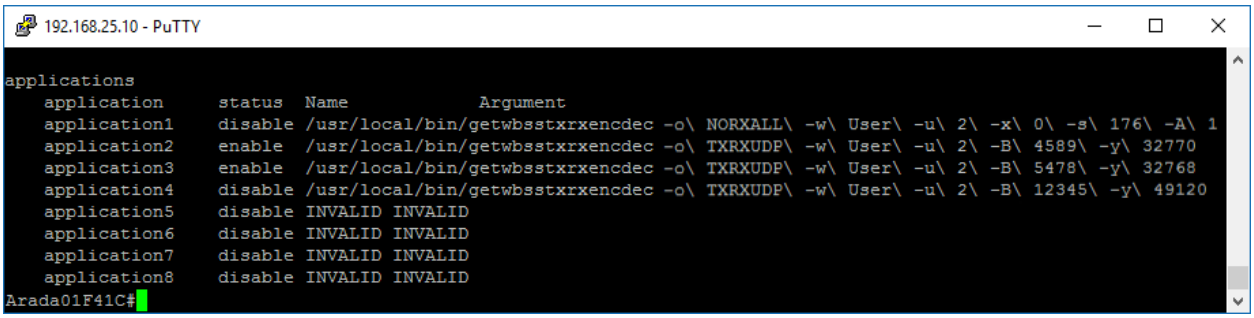


Figure 22. ARADA Command Line Interface Application Configuration

- All applications should be disabled except for application2 and application3.
- Examine the output and ensure that the command line for application2 and application3 appear exactly as displayed in Figure 22. Note that any application with a status of disable can be ignored.
    - If the output DOES NOT match Figure 22 for application2 and application3, see RSU Application Configuration in 0.
    - If the output DOES match Figure 22 for application2 and application3, then you can continue to the next steps of exiting.
- To close the command line interface, type “exit” and press enter.
- Type “exit” and press enter again to close the PuTTY application.

[2] As with the V2I Hub, the deploying agency is expected to own the RSU and manage credentials used to access the RSU.

4.5 V2I HUB PLUGINS AND COMMUNICATION WEB PORTAL

The V2I Hub is preconfigured to operate at an intersection sending J2735 SPaT and J2735 MAP messages. This includes the following four plugins:

- DSRC Message Manager
  - Listens for messages and forwards them to the DSRC Radio (i.e., the RSU)
    - The Arada RSU is currently the only supported radio.
- MAP r41
  - Reads intersection geometry from a configuration file and publishes a J2735 r41 MAP message
- SPaT r41
  - Reads PTLM data from a configuration file, receives live data from the signal controller, and publishes a J2735 r41 SPaT message
- RTCM
  - Connects and listens to a Networked Transport of RTCM via Internet Protocol (NTRIP) caster and publishes a J2735 RTCM message

4.5.1 V2I Hub Administration Portal

Plugin installation and configuration is performed in a web portal running on theV2I Hub computer. To access and log in to the portal:

- Ensure that the maintenance computer is configured and attached to the IPv4/IPv6 local switch.
  - Open a web browser on the maintenance computer (i.e., Firefox, Internet Explorer).
- Navigate to the following address: http://ipaddress/
  - ipaddress is the IP address of the V2I Hub Communication.
    - Here is an example IP address
- Log in with the default username and password provided in the Readme file included in the software download zip file on the OSADP. It is strongly recommended that the default username and password be changed with the first login to the Administration Portal, via the menu on the left.
- Under the System Admin Menu, click Installed Plugins to view the pre-loaded plugins on the V2I Hub.

Figure 23 shows the *Installed Plugins* page with the four preinstalled plugins. This page shows all installed plugins, common properties of each plugin, and controls to configure and update each plugin. The available controls are:

 The *gears* icon shows all plugin specific configuration parameters and allows them to be edited.

 The *upload* icon allows a new version of the plugin to be uploaded.

 The *pencil* icon edits the record of the plugin (i.e., Enabled/Disabled, Max Message Interval).

The *trashcan* icon deletes the plugin.

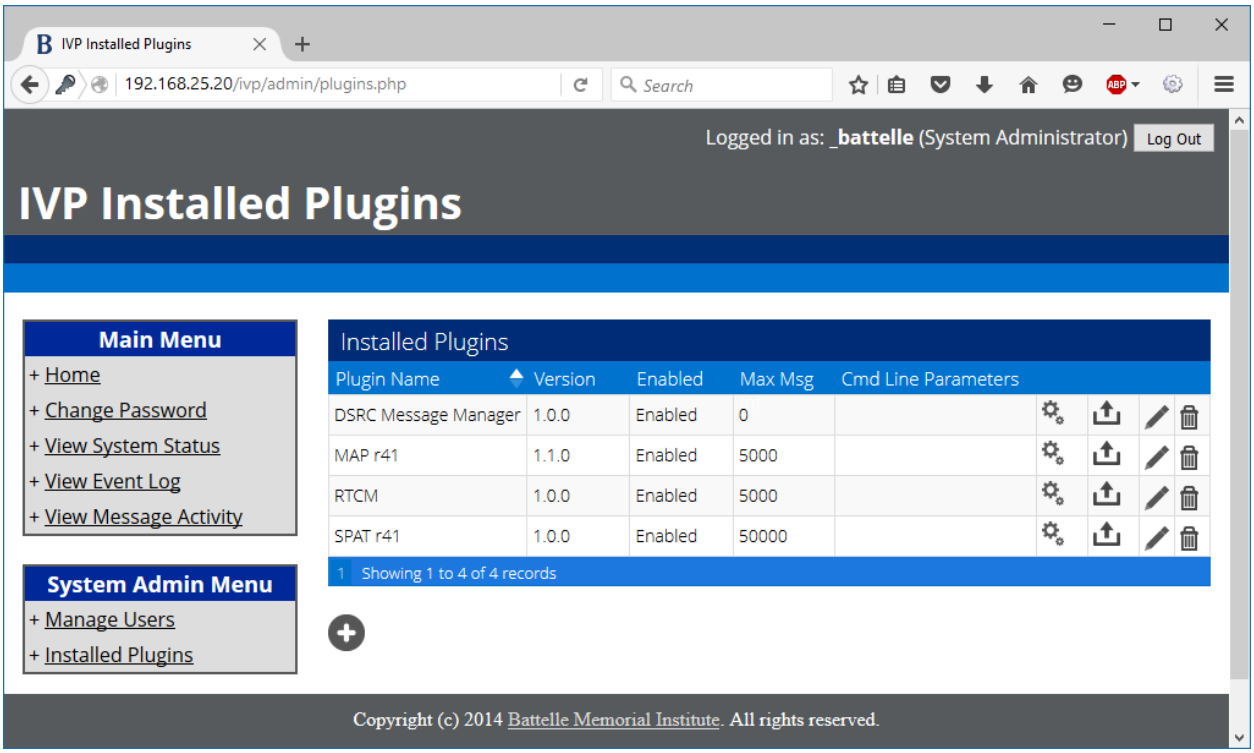


Figure 23. Web Portal Installed Plugins

4.5.2 DSRC Message Manager Plugin

To confirm the parameters for the DSRC Message Manager Plugin:

- Navigate to the Installed Plugins page of the web portal.
- Click the gears icon for DSRC Message Manager to display all configuration parameters of the plugin as shown in Figure 24.
- Use the pencil icon next to each configuration parameter to change a value
  - Most parameters are preconfigured with the correct values.
- Verify that the IP address under the DSRC_Radio_IP is correct. If not, edit the following parameters as needed.
  - DSRC_Radio_IP – Specify the correct IP address for the DSRC radio (i.e., the RSU).

Plugin Name	Version	Enabled	Max Msg Int	Cmd Line Parameters
DSRC Message Manager	1.0.0	Enabled	0	

Configuration Parameters

Key	Value	Default Value	Description
DSRC_Radio_IP	192.168.25.10	192.168.25.10	The IPv4 or IPv6 address of the destination DSRC radio (i.e. the RSU).
Messages_UDP_Port_1	{ "Messages": [{ "TmxType": "SPAT-P", "SendType": "SPAT", "PSID": "0x8002" }, { "TmxType": "MAP-P", "SendType": "MAP", "PSID": "0x8002" }] }	{ "Messages": [{ "TmxType": "SPAT-P", "SendType": "SPAT", "PSID": "0x8002" }, { "TmxType": "MAP-P", "SendType": "MAP", "PSID": "0x8002" }] }	JSON data defining the message types and PSIDs for messages forwarded to the DSRC radio on UDP Port 1.
Messages_UDP_Port_2	{ "Messages": [] }	{ "Messages": [] }	JSON data defining the message types and PSIDs for messages forwarded to the DSRC radio on UDP Port 2.
Messages_UDP_Port_3	{ "Messages": [] }	{ "Messages": [] }	JSON data defining the message types and PSIDs for messages forwarded to the DSRC radio on UDP Port 3.
Messages_UDP_Port_4	{ "Messages": [] }	{ "Messages": [] }	JSON data defining the message types and PSIDs for messages forwarded to the DSRC radio on UDP Port 4.
Signature	False	False	True or False value indicating whether to sign the messages.
UDP_Port_1	4589	4589	The destination UDP port number on the DSRC radio for all messages specified by Messages_UDP_Port_1.
UDP_Port_2	0	0	The destination UDP port number on the DSRC radio for all messages specified by Messages_UDP_Port_2.
UDP_Port_3	0	0	The destination UDP port number on the DSRC radio for all messages specified by Messages_UDP_Port_3.
UDP_Port_4	0	0	The destination UDP port number on the DSRC radio for all messages specified by Messages_UDP_Port_4.

1 Showing 1 to 10 of 10 records

Figure 24. DSRC Message Manager Configuration Parameters.

4.5.3 MAP r41 Plugin

The MAP r41 plugin requires one or more MAP XML files to be uploaded to the V2I Hub. Instructions on creating a MAP XML file are provided in the V2I Hub Documentation on the OSADP. To confirm the parameters for the MAP r41 Plugin:

- Navigate to the *Installed Plugins* page of the web portal.
- Click the *gears* icon for MAP r41 to display all configuration parameters of the plugin as shown in Figure 25.
- Use the *pencil* icon next to each configuration parameter to change a value
  - Most parameters are preconfigured with the correct values.
- Verify the value in **MAP_ Files** is correct**.** If not, edit the following parameters as needed.
  - MAP_ Files – This parameter specifies the correct MAP XML file to load for the environment (e.g., intersection) for each action set specified by the traffic signal controller. Many intersections will only

have one MAP file specified, as in the example shown in Figure 25. Each MAP file specified by the FilePath JSON key must be present in the plugin folder as described earlier.

- Use WinSCP or ssh/scp to transfer the XML files containing geometry for the intersection to the V2I Hub. The XML file must be placed in the folder for the MAP r41 plugin: /var/www/plugins/MAPr41.

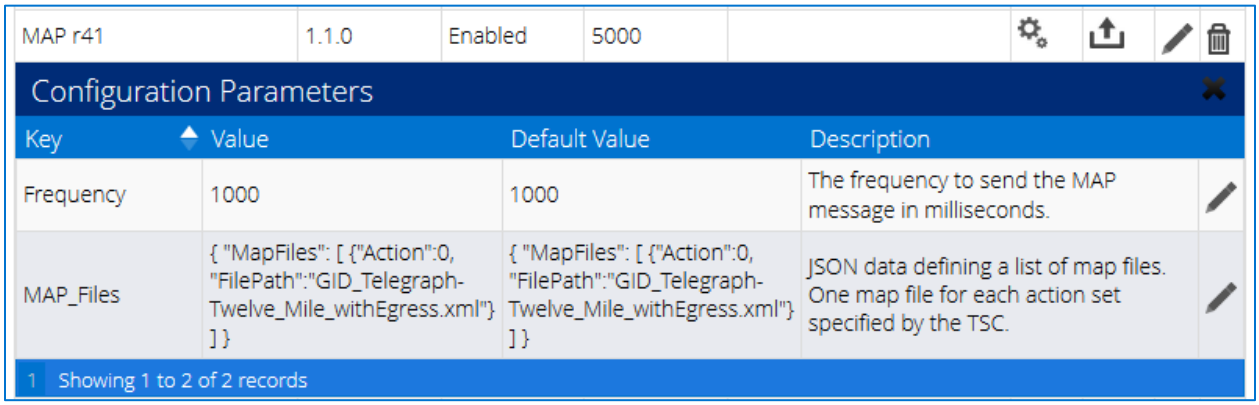
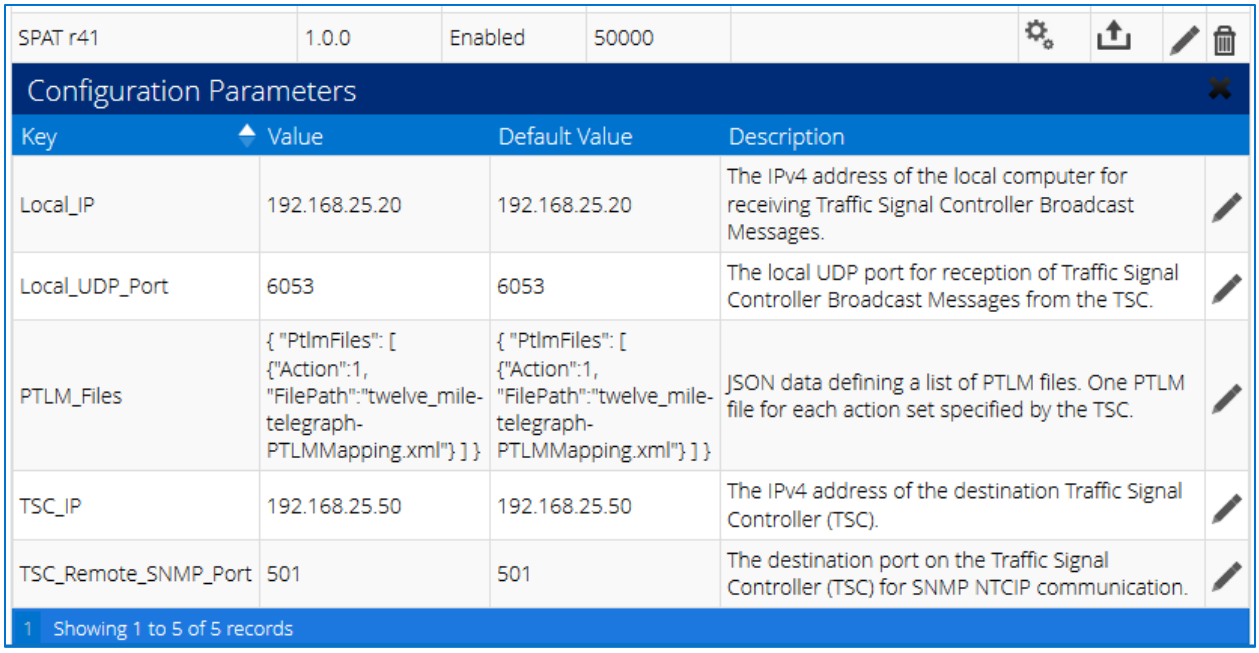


Figure 25. MAP r41 Plugin Configuration Parameters

4.5.4 SPaT r41 Plugin

The SPaT r41 plugin requires one or more PTLM XML files to be uploaded to the V2I Hub. Instructions on creating a PTLM XML file are provided in the V2I Hub Documentation on the OSADP. To confirm the parameters in the SPaT r41 Plugin:

- Navigate to the Installed Plugins page of the web portal.
- Click the gears icon for SPaT r41 to display all configuration parameters of the plugin as shown in Figure 26.
  - Use the pencil icon next to each configuration parameter to change a value.
  - Most parameters are preconfigured with the correct values.
- Verify the values in Local_IP, PTLM_Files and TSC_IP are correct. If not, edit the following parameters as needed.
  - Local_IP – Specify the correct IP address of the local V2I Hub computer (i.e., 192.168.25.20 is the default).
  - PTLM_Files – This parameter specifies the correct PTLM XML file to load for the environment (e.g., intersection) for each action set specified by the traffic signal controller. Many intersections will only have one PTLM file specified, as in the example shown in Figure 26. (Each MAP file specified by the FilePath JSON key must be present in the plugin folder as described earlier).
    - Use WinSCP or ssh/scp to transfer the XML files containing PTLM data for the intersection to the V2I Hub. The XML file must be placed in the folder for the SPaT r41 plugin: /var/www/plugins/SPaTr41.
  - TSC_IP – Confirm the IP address of the traffic signal controller providing the signal phase and timing data is correct.



SPAT r41	1.0.0	Enabled	50000					

Configuration Parameters

Key	Value	Default Value	Description	
Local_IP	192.168.25.20	192.168.25.20	The IPv4 address of the local computer for receiving Traffic Signal Controller Broadcast Messages.	
Local_UDP_Port	6053	6053	The local UDP port for reception of Traffic Signal Controller Broadcast Messages from the TSC.	
PTLM_Files	{ "PtlmFiles": [{"Action":1, "FilePath":"twelve_mile-telegraph-PTLMMapping.xml"}] }	{ "PtlmFiles": [{"Action":1, "FilePath":"twelve_mile-telegraph-PTLMMapping.xml"}] }	JSON data defining a list of PTLM files. One PTLM file for each action set specified by the TSC.	
TSC_IP	192.168.25.50	192.168.25.50	The IPv4 address of the destination Traffic Signal Controller (TSC).	
TSC_Remote_SNMP_Port	501	501	The destination port on the Traffic Signal Controller (TSC) for SNMP NTCIP communication.	

1 Showing 1 to 5 of 5 records

Figure 26. SPaT r41 Plugin Configuration Parameters

4.5.5 RTCM Plugin

To confirm the parameters in the RTCM plugin:

- Navigate to the Installed Plugins page of the web portal.
- Click the gears icon for RTCM to display all configuration parameters of the plugin as shown in Figure 27.
- Use the pencil icon next to each configuration parameter to change a value.
  - Most parameters are preconfigured with the correct values.
- Verify the values are correct. If not, edit the following parameters as needed.
  - Endpoint IP – Specify the correct IP address of the NTRIP caster endpoint.
  - Endpoint Port – Specify the correct NTRIP caster endpoint port.
  - Mountpoint – Specify the NTRIP caster mountpoint.
  - Username – The username for the account to access the NTRIP information.
  - Password – The password for the account to access the NTRIP information.

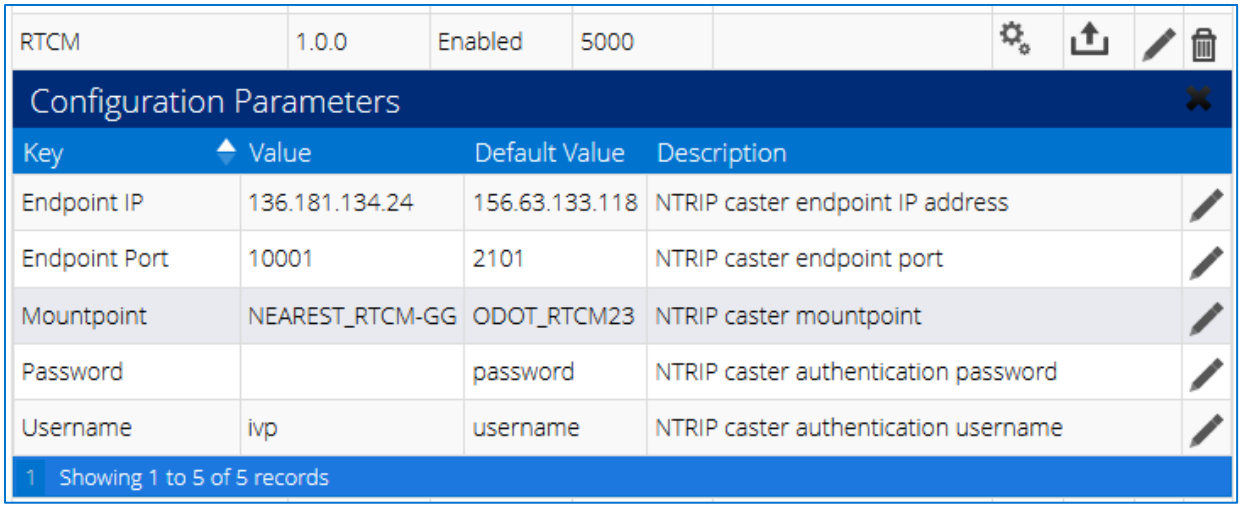


Figure 27. RTCM Plugin Configuration Parameters

4.5.6 Verify Message Activity

To confirm that all of the plugins are responding appropriately:

- Navigate to the Installed Plugins page of the web portal.
- Under Main Menu, click View Message Activity.
- The counts for each message from the SPaT and MAP plugins should increment every two seconds.

Appendix A. Abbreviations and Descriptions

Table A-1. Abbreviations and Descriptions

Abbreviation	Name	Description
DSRC	Dedicated Short Range Communications	DSRC is a two-way short- to- medium-range wireless communications protocol that supports vehicle-to-vehicle, vehicle-to-roadside, and roadside-to-vehicle communication.
DHCP	Dynamic Host Configuration Protocol	The Dynamic Host Configuration Protocol (DHCP) is a standardized network protocol used on Internet Protocol (IP) networks for dynamically distributing network configuration parameters, such as IP addresses for interfaces and services.
IPv4	Internet Protocol version 4	Internet Protocol version 4 (IPv4) is the fourth version of the Internet Protocol (IP).
IPv6	Internet Protocol version 6	Internet Protocol version 6 (IPv6) is the most recent version of the Internet Protocol (IP), the communications protocol that provides an identification and location system for computers on networks and routes traffic across the Internet.
IVP	Integrated Vehicle-to-infrastructure Prototype	A USDOT project to develop an Integrated Vehicle-to-Infrastructure (V2I) Prototype System that brings results from mapping, positioning, communications research, and SPaT and related message set development into a single operating environment that supports V2I communications-based connected vehicle applications.
J2735	Society of Automotive Engineers (SAE) Standard J2735	The SAE standard J2735 DSRC Message Set.
MAP	Map Data	Describes the static physical geometry of one or more intersections; i.e., lane geometries and the allowable vehicle movements for each lane, and introduces the idea of "intersection data frame" which describes barriers, pedestrian walkways, shared roadways and rail lines that may affect vehicle movements.
NIC	Network Interface Controller	A network interface controller (also known as a network interface card, network adapter, LAN adapter or physical network interface, and by similar terms) is a computer hardware component that connects a computer to a computer network.
NTCIP	National Transportation Communications for Intelligent Transportation Systems Protocol	A family of standard protocols for allowing traffic management systems to talk to intelligent transportations systems field devices such as: dynamic message signs, CCTV cameras, vehicle detection sensors, traffic signals, Road weather information stations (RWIS), along with many other types for roadway devices.
NTRIP	Networked Transport of RTCM via Internet Protocol	A protocol for streaming differential GPS data over the Internet in accordance with specifications published by the RTCM.
PoE	Power over Ethernet	describes any of several standardized or ad-hoc systems which pass electrical power along with data on Ethernet cabling.
PuTTY	PuTTY	A free and open-source terminal emulator, serial console and network file transfer application that supports several network

Abbreviation	Name	Description
		protocols, including SCP, SSH, Telnet, rlogin, and raw socket connection.
RSU	Road-Side Unit	DSRC communication unit that is located aside a road that provides connectivity support to passing vehicles.
RTCM	Radio Technical Commission for Maritime Services	Is an international standards organization that provides specifications for global positioning system (GPS) position correction.
RTCM Plugin	Position Correction Plugin	The Position Correction Plugin supplies V2I Hub with real time differential GPS correction data in RTCM format. This is done by communicating with a Networked Transport of RTCM via Internet Protocol (NTRIP) client to receive the differential GPS data over the internet.
SNMP	Simple Network Management Protocol	Is an Internet-standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behavior.
SPaT	Signal Phase and Timing data	Is the real-time provision of traffic signal phase and timing information to vehicles approaching signalized intersections. Describes the signal state of the intersection and how long this state will persist for each approach and lane that is active. The SPaT message sends the current state of each phase, with all-red intervals not transmitted. Movements are given to specific lanes and approaches by use of the lane numbers present in the message.
Telnet/ssh	Telnet/Secure Shell	Telnet is a network protocol that allows a user to communicate with a remote device. It is a virtual terminal protocol used mostly by network administrators to remotely access and manage devices. SSH uses encryption, which means that all data transmitted over a network is secure.
TSC	Traffic Signal Controller	A set of electrically operated signal lights used to direct or control traffic at intersections.
VPN	Virtual Private Network	a method employing encryption to provide secure access to a remote computer over the Internet.
WinSCP	Windows Secure Copy	An open source Secure file transfer protocol client for Windows. It allows secure file transfers between the client's local computer and the remote server.

Appendix B. Traffic Signal Controller Broadcast Message

Table B-1. Traffic Signal Controller Broadcast Message

Bytes	Description	
0	0xcd	
1	number of phase/overlap blocks below (16)	
2-14	0x01 (phase number) spatVehMinTimeToChange.1 spatVehMaxTimeToChange.1 spatPedMinTimeToChange.1 spatPedMaxTimeToChange.1 spatOvlpMinTimeToChange.1 spatOvlpMaxTimeToChange.1	(1 byte) (2 bytes) (2 bytes) (2 bytes) (2 bytes) (2 bytes) (2 bytes)
15-196	< repeat above for each phase and overlap >	
194-209	0x10 (phase#) spatVehMinTimeToChange.16 spatVehMaxTimeToChange.16 spatPedMinTimeToChange.16 spatPedMaxTimeToChange.16 spatOvlpMinTimeToChange.16 spatOvlpMaxTimeToChange.16	(1 byte) (2 bytes) (2 bytes) (2 bytes) (2 bytes) (2 bytes) (2 bytes)
210-215	phaseStatusGroupReds phaseStatusGroupYellows phaseStatusGroupGreens	(2 bytes bit-mapped for phases 1-16) (2 bytes bit-mapped for phases 1-16) (2 bytes bit-mapped for phases 1-16)
216-221	phaseStatusGroupDontWalks phaseStatusGroupPedClears phaseStatusGroupWalks	(2 bytes bit-mapped for phases 1-16) (2 bytes bit-mapped for phases 1-16) (2 bytes bit-mapped for phases 1-16)
222-227	overlapStatusGroupReds overlapStatusGroupYellows overlapStatusGroupGreens	(2 bytes bit-mapped for overlaps 1-16) (2 bytes bit-mapped for overlaps 1-16) (2 bytes bit-mapped for overlaps 1-16)
228-229	flashingOutputPhaseStatus	(2 bytes bit-mapped for phases 1-16)
230-231	flashingOutputOverlapStatus	(2 bytes bit-mapped for overlaps 1-16)
232	spatIntersectionStatus	(1 byte)
233	spatDiscontinuousChangeFlag	(1 byte, upper 5 bits are message version)
234	spatMessageSeqCounter	(1 byte, lower byte of controller up-time)
235-239	spatTimestamp	(5 bytes, hours-minute-second-millisecond)
240-241	spatPedestrianCall	(2 bytes, bit-mapped for phases 1-16)
242-243	spatPedestrianDetect	(2 bytes, bit-mapped for phases 1-16)

Appendix C. RSU Application Configuration

The following steps assume a new RSU is being configured and that only the applications configured here need to be running. Adjust application slots and enable/disable states as required for advance setups.

This section describes how to log in and configure the Arada LocoMate Commando RSU to send J2735 SPaT, MAP, and RTCM messages out the radio when they are received from the V2I Hub system. The instructions were created with an Arada LocoMate Commando RSU v3.1 running firmware WAVE_LOCOMATE-200_1.90.0.16_firmware.The instructions assume that the PuTTY application is used as the telnet client.

To log in to the RSU:

- If not already the same, the maintenance machine and the RSU will need to be on the same subnet. Change the IP address of your maintenance machine to match the subnet of the RSU's existing IP address.
- Open the PuTTY putty.exe application.
- Enter the Host Name (IP Address).
- Select Telnet for connection type.
- Click Open, as shown in Figure C-28.

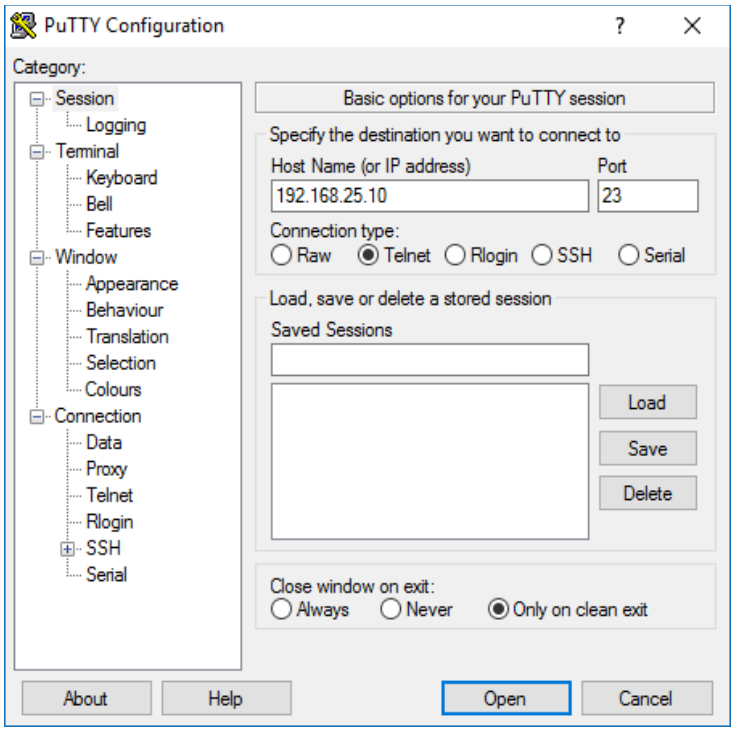


Figure C-28. PuTTY Configuration

- The configuration is the same as shown in Figure C-28 when using PuTTY as an SSH client, except the SSH Connection type should be specified instead of Telnet.
- Once the black login screen appears, log in to the RSU using the username and password provided by the owner of the RSU.

  - The cursor may not move and the password may not display while entering in the corresponding password.

- Type “cli” and press Enter to enter the Arada command line interface.

  - The Arada command line interface is entered by typing cli. Multiple commands can be given while in the command line interface. cli should not be typed while already in the command line interface

- Type “show configuration” and press Enter to list the current RSU configuration.
- After enter is pressed, at the end of the output, the list of configured applications is displayed as shown in Figure C-29. This figure shows the final desired configuration, where the getwbsstxrxencdec application is configured twice to forward the appropriate messages.

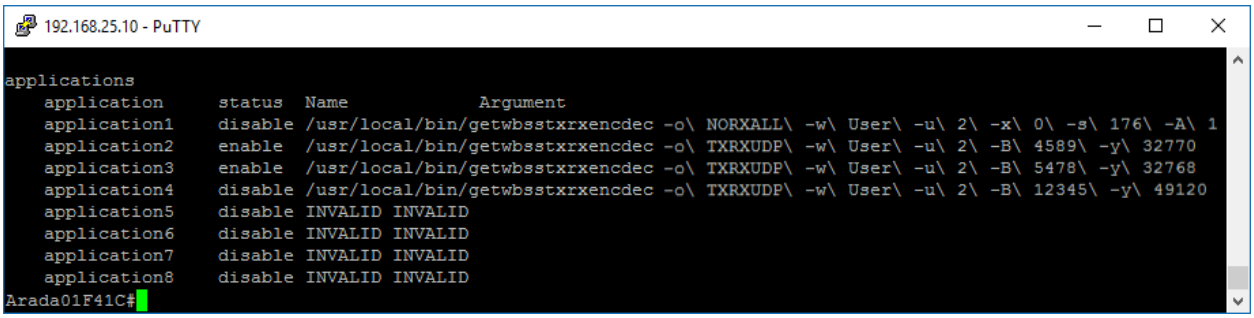


Figure C-29. ARADA Command Line Interface Application Configuration

- All applications should be disabled except for application2 and application3.
- Examine the output and ensure that the command line for application2 and application3 appear exactly as displayed in Figure C-29. Note that any application with a status of disable can be ignored. If the output does not match Figure C-29, follow the next steps.

  - Disable all applications except application2 and application 3 as required by entering:

    >> cli
    Arada# config application app1Status disable
    Arada# config application app4Status disable
    Arada# config application app5Status disable
    Arada# config application app6Status disable
    Arada# config application app7Status disable
    Arada# config application app8Status disable
    Arada# exit

  - Set up the RSU to send the SPaT and MAP J2735 r41 message with PSID 0x8002 by entering:

    >> cli
    Arada# config application app2Name /usr/local/bin/getwbsstxrxencdec
    Arada# config application app2arg -o TXRXUDP -w User -u 2 -B 4589 -y 32770
    Arada# config application app2Status enable
    Arada# exit

- Set up the RSU to send the RTCM messages with PSID 0x8000 by entering:

  >> cli
  Arada# config application app3Name /usr/local/bin/getwbsstxrxencdec
  Arada# config application app3arg – o TXRXUDP -w User -u 2 -B 5478 -y 32768
  Arada# config application app3Status enable
  Arada# config exit

- To close the command line interface, type “exit” and press Enter.
- Type “exit” and press Enter again to close the PuTTY application.