Connected Vehicle Pilot Deployment Program Phase 2

Comprehensive Maintenance and Operations Plan – Tampa (THEA)

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16. Abstract

This Comprehensive Operations and Maintenance Plan (CMOP) covers planning for the operations and maintenance of all in-vehicle, roadside, mobile device, center, and other equipment and supporting capabilities required in the deployed system. The CMOP also identifies the types and number of equipment required to be maintained and summarizes key operational methods and procedures that ensure safe and efficient operations in Phase 3. Finally, the CMOP provides an overview of the proposed operational methods and processes, a high-level maintenance approach, as well as a high-level plan for inventory and configuration management, including:

a. Routine maintenance requirements/schedules;
b. Inspection procedures;
c. Maintenance/replacement procedures (and responsible entities);
d. QA/QC processes;
e. Hardware/software configuration control processes;
f. Recall processes; and
g. Spare parts/warranty contingency plans.

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1	3-30-2018	THEA	First Draft
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4	5-5-2018	THEA	Made 508 Compliant

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Acronyms

Acronym	Definition
BOM	Bill of Materials
CCB	Change Control Board
CIP	Comprehensive Installation Plan
CM	Configuration Management
CU	Controller Unit
CV	Connected Vehicle
CUTR	Center for Urban Transportation Research
DSRC	Direct Short Range Communications
GPS	Global Positioning System
HART	Hillsborough Area Regional Transit
HMI	Human Machine Interface
LTE	Long Term Evolution
OBU	Onboard Unit
PC	Personal Computer
PEP	Product Evolution Process
QA	Quality Assurance
QC	Quality Control
QM	Quality Management
RMA	Returned Material Authorization
TECO	Tampa Electric Company
THEA	Tampa Hillsborough Expressway Authority
TMC	Traffic Management Center
V2I	Vehicle to Infrastructure
VM	Virtual Machine

List of References

The convention used to reference external documents appears as [RDn], where n is the left-most column of the table below.

Table 1: List of References

[RDn]	Reference	Source
1	Comprehensive Installation Plan	USDOT
2	DSRC Multichannel Test Tool Manual	3M
3	ESCoS Roadside Unit –WAVE User Manual	Siemens
4	ESCoS Roadside Unit Installation Manual	Siemens

[RDn]	Reference	Source
5	Concert Server Support Manual	Siemens
6	Vehicle Installation and Diagnostics Procedure	Brand Motion ID
7	Bus Installation and Diagnostics Procedure	Brand Motion
8	Streetcar Installation and Diagnostics Procedure	Brand Motion

1 Introduction

1.1 Purpose of the Plan

The Comprehensive Operations and Maintenance Plan (CMOP) covers planning for the operations and maintenance of all in-vehicle, roadside, mobile device, center, and other equipment and supporting capabilities required in the deployed system. The CMOP includes:

- Identification of the types and number of equipment required to be maintained
- Summary of key operational methods and procedures that ensure safe and efficient operations in Phase 3.
- A section for operations
- A section for maintenance that includes subsections for:
    - vehicles and in-vehicle equipment,
    - roadside equipment
    - mobile devices
    - management center equipment
    - other equipment and supporting capabilities.
- An overview of the proposed operational methods and processes
- A high-level maintenance approach
- A high-level plan for inventory and configuration management.
- A description of the required elements of a maintenance-focused demonstration to be included as part of the ORP.

“Participants” referenced in this document are defined as the owner/operators of the OBU-equipped vehicles participating in Phase 3 of the project.

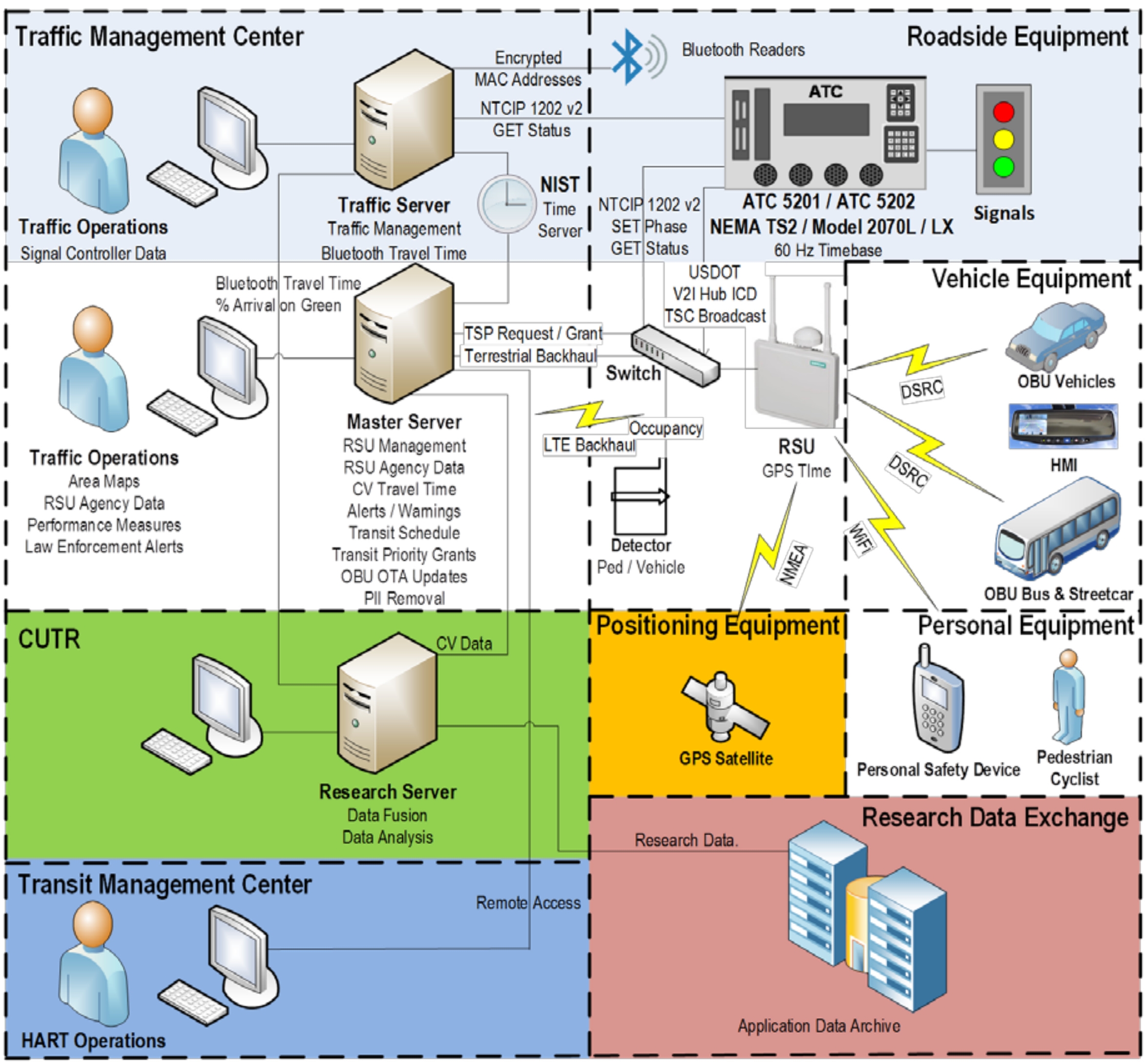
1.2 Scope of the Plan

The equipment of Figure 1 is operated and maintained during project Phase 3 is listed in Table 2. The operation and maintenance of the equipment and associated software described in the CMOP is identified in white. The operation and maintenance of other equipment used during project Phase 3 not the subject of the CMOP, but covered by existing operation and maintenance processes of the organizations is shown in Table 2, color coded to Figure 1. For example, City of Tampa Traffic Management System supplies a portion of the data for the Phase 3 study, but operated and maintained by per City of Tampa policy that is not described in this CMOP. Bluetooth travel time data and performance measures such as stops on green are used in daily traffic operations. The traffic operations team is trained separately by the suppliers of the travel time equipment and traffic management software to identify and report anomalies in that data under separate warranties and maintenance agreements outside the scope of this project.

Table 2: Equipment Operated and Maintained

Color	Equipment Description	Operation & Maintenance Policy
Light Blue	Existing traffic management	City of Tampa FL
Green	CUTR research	CUTR, University of South FL
Dark Blue	Transit management	HART Transit
Red	Research Data Exchange	USDOT
White	Connected Vehicle Pilot	CMOP

Figure 1: Equipment Operated and Maintained



1.3 Execution of the Plan

Overall control and execution of the system is conducted by the Change Control Board (CCB) as described in the Operational Readiness Plan (ORP). The CCB meetings and agenda are governed by the CCB bylaws including but not limited to:

- Configuration Management
- Engineering Change Orders
- Conformance to Safety Management Plan
- Conformance to Quality Management Plan
- Monitor overall system performance

2 Equipment Identification

This section lists the equipment types and numbers installed before and during project Phase 3.

2.1 Traffic Management Center

Table 3 lists the CV equipment installed in the TMC.

Table 3: TMC Equipment Installations

Item	Equipment Type	Description	# Procured	# Installed
1	Master Server	Physical VMWare™ rack server host	1	1
		VM1: Concert™ application server	1	1
		VM2: Concert workstation	1	1
		VM3 NexConnect™ server	1	1
		VM4: MS™ SQL™ database server	1	1
2	Workstation	Personal computer	1	1
		MS Windows™ operating system	1	1

2.2 Vehicles

Table 4 lists the vehicle types and numbers of vehicles deployed by the owner/operators.

Table 4: Vehicle Types and Numbers

Item	Type	Owner/Operator	Number
1	Private light vehicles	Phase 3 private owner participants	1,600
2	Public Transit Bus	HART transit agency	10
3	Public Streetcar	TECO power company	8

Table 5 lists the equipment procured and installed within the vehicles of Table 4. Procured includes installations plus equipment for developers and test, plus spare stock. Vehicles have multiple antennas, depending upon type (private vehicle, bus, or streetcar).

Table 5: In-Vehicle Equipment Installations

Item	Type	Equipment	# Procured	# Installed
1	Private light vehicles	OBU	1,610	1,580
		Antenna assembly, DSRC and GPS	4,850	4,800
		12 VDC power cable assembly	1,610	1,580
		HMI, mirror	1,610	1,580
2	Streetcar / Bus	OBU	25	20
		Antenna assembly, DSRC and GPS	75	60
		12 VDC power cable assembly	25	20
		HMI, tablet with mounting hardware	25	20

2.3 Infrastructure

Table 6 lists the CV Infrastructure equipment procured and installed at locations identified in the Comprehensive Deployment Plan.

Table 6: Infrastructure Roadside Equipment Installations

Item	Equipment Type	Description	# Procured	# Installed
1	RSU Kit	RSU	65	44
		DSRC antenna	130	88
		LTE antenna	130	88
		GPS antenna	65	44
		WiFi / Bluetooth antenna	65	44
		Mounting bracket	65	44
2	RSU Power	PoE Injector	65	44
3	Pedestrian Detector	Lidar sensor	1	1
4	Vehicle Detector	Radar sensor	1	1
5	Wrong Way Detector	Radar sensor	1	1

2.4 Personal Information Devices

Table 7 lists the Personal Information Device (PD) equipment procured separately by the participants

Table 7: PID Installations

Item	Equipment Type	Description	# Procured	# Installed
1	Personal Information Device	Android™ smartphone	0	0
		Pedestrian application	500	500

2.5 Support Equipment

Table 8 lists the support equipment.

Table 8: Support Equipment

Item	Equipment Type	Description	# Procured	# Used
1	DSRC Multichannel test tool	3M™ DSRC-MCTT-5.9Ghz	1	1

3 Operations

The operational methods described here are limited to the subsystems coded as white in Table 2 and Figure 1.

3.1 Vehicle Systems High Level Operations

3.1.1 Light Vehicle Operations

Light vehicles are owned and operated by private individual participating in the Phase 3 study per the Informed Consent Agreement. Each participant is trained regarding the operation of the connected vehicle equipment, specifically the Human Machine Interface (HMI) and its alerts and warnings. Each participant understands and has signed a participant agreement. Participants are trained to identify correct HMI operation and how to report defective or malfunctioning HMI. Further, participants are trained to report incidences, such as crashes that require a service appointment or sale of vehicle. HMI mirror shows system status, error messages and heartbeat icon as a monitor to inform drivers. Please refer to Participant Training and Stakeholder Education Plan, March 14, 2018.

3.1.2 Transit Vehicle Operations

Transit vehicles are owned and operated by HART in the Phase 3 study. HART operators are trained regarding the operation of the connected vehicle equipment, specifically the Human Machine Interface (HMI) and its alerts and warnings. HART has signed a participant agreement. Operators are trained to identify correct HMI operation and how to report defective or malfunctioning HMI. Further, participants are trained to report incidences, such as crashes or sale of vehicle.

3.1.3 Streetcar Vehicle Operations

Streetcar vehicles are owned and operated byTECO in the Phase 3 study. TECO operators are trained regarding the operation of the connected vehicle equipment, specifically the Human Machine Interface (HMI) and its alerts and warnings. TECO has signed a participant agreement. Operators are trained to identify correct HMI operation and how to report defective or malfunctioning HMI. Further, participants are trained to report incidences, such as crashes or sale of vehicle.

3.2 Infrastructure Systems High Level Operations

Infrastructure is owned and operated as described in the project Concept of Operations. Traffic Management operators are trained regarding the operation of the connected vehicle equipment, specifically the RSU and its alerts and warnings.

3.3 Back Office Systems High Level Operations

Back office equipment is owned and operated as described in the project Concept of Operations. Traffic Management operators are trained regarding the operation of the connected vehicle equipment, specifically the Concert system and its graphical screens. In addition to Concert training, the operations staff has access to the Concert operations and maintenance manuals that are updated with each new software release.

3.4 Personal Information Device High Level Operations

Personal Information Devices (PID) are owned and operated by private individual participating in the Phase 3 study. The PID consists of an Android smart phone and connected vehicle applications. Each participant is trained regarding the operation of the connected vehicle applications. Each participant understands and has signed a participant agreement. Participants are trained to identify correct HMI operation and how to report defective or malfunctioning PID applications.

4 Maintenance

4.1 High Level Maintenance Plan

4.1.1 Vehicles

4.1.1.1 Light Vehicle Maintenance

The vehicle systems have no planned maintenance requirements during the Phase 3 of the project that require operator intervention. Maintenance of vehicle application software is done automatically without operator intervention. Software updates are performed Over the Air (OTA), whereby updated software is sent from RSUs to vehicles via DSRC as vehicles pass through the range of RSUs. A complete software update is seldom completed in one pass by an RSU, rather, each pass results in a portion of the software download. When the download is completed after several passes, the software is automatically installed by the vehicle. The RSU supports software updates for all three suppliers of vehicle On Board Units (OBU). See the Informed Consent Document and associated participant training for repair and replacement of vehicle hardware.

4.1.1.2 Transit Vehicle Maintenance

The transit vehicle systems have no planned maintenance requirements during the Phase 3 of the project that require operator intervention. Maintenance of transit vehicle application software is done automatically without operator intervention. Software updates are performed OTA, whereby updated software is sent from RSUs to vehicles via DSRC as vehicles are out of service within range of an RSU at the transit center.

4.1.1.3 Streetcar Vehicle Maintenance

The streetcar vehicle systems have no planned maintenance requirements during the Phase 3 of the project that require operator intervention. Maintenance of streetcar vehicle application software is done automatically without operator intervention. Software updates are performed OTA, whereby updated software is sent from RSUs to vehicles via DSRC as vehicles are out of service within range of an RSU at the streetcar maintenance center.

4.1.2 Infrastructure Systems Maintenance

The RSUs have no calibration or optics that requires periodic adjustment or cleaning. The RSUs have planned software maintenance during Phase 3 of the project that requires operator intervention. Major feature updates occur annually, with one maintenance update between feature updates if needed. Maintenance of RSU application software is done by traffic operations personnel using the Concert™ system area map that pictorially shows the location of each RSU and its operational status. For example, the operator can point to and select an RSU on the map. The status is pictorially displayed, such as loss of communications, RSU on line or off line, the current software installed in the RSU and other information. RSU software updates are communicated from Concert to RSUs via the terrestrial or cellular backhaul connection. RSU installation was preceded by site surveys with “as built” engineering drawings of the RSU installation. Each RSU includes a MAP file associated with a signal timing plan document for that intersection. Changes to lane markings result in changes to the "as built" drawings and changed to MAP files by Siemens. Changes to signal timing result in changes to the timing plan documents. The signal controllers adjust the SPaT data in accordance to the signal plan.

4.1.3 Back Office Maintenance

The back-office equipment is subject to the routine maintenance schedule and backup, similar to the existing central system that manages the wide area network of traffic signal controllers, including data backup, archiving, controlled environmental temperature and others. Major feature updates occur annually, with one maintenance update between feature updates if needed.

4.1.4 Personal Information Device Maintenance

Maintenance of application software is accomplished by informing participants that application updates are available, similar to the app stores for Android devices. The participant then downloads and installs the update per the instructional training and the Informed Consent Document

4.2 Inventory Control

4.2.1 Vehicle Systems

HCC is responsible for inventory control of vehicle systems according to the Bill of Material (BOM) and all equipment is shipped to HCC according to the delivery schedule defined in [RD1]. HCC supervision provides conducts inventory assessment on Friday pm which is reported to Brandmotion, so that equipment can be ordered as described in [RD1].

4.2.2 Infrastructure Systems

Twenty spare RSUs were purchased during procurement of the RSU devices during project Phase 2. These spare RSUs are inventoried and stored at THEA headquarters to be used for system expansion, warranty repair rotating stock and test activities. No additional stock of RSUs is anticipated during project Phase 3. RSU warranty extends through the end of project Phase 3, meaning that RSUs returned during Phase 3 will be repaired or replaced without additional purchase orders. A Return Material Authorization (RMA) is issued to City of Tampa by the manufacturer to ensure that the material returned to the factory for repair or replacement is labeled and tracked by serial number as customer-owned equipment through the warranty process.

4.3 Configuration Management (CM)

4.3.1 Vehicle System CM

4.3.1.1 Light Vehicle CM

CM for OBUs conforms to the supplier's configuration management process, which requires:

- identification of software/hardware elements to be under CM
- a formalized change control process
- software component and system testing prior to release

- firmware/software releases are archived, along with information regarding development tools and test results using a commercially-available CM software product.
- software/hardware design elements and test results under CM archive are regularly backed up and maintained by the OBU supplier.

4.3.1.2 Transit Vehicle CM

CM for OBUs conforms to the supplier's configuration management process, which requires:

- identification of software/hardware elements to be under CM
- a formalized change control process
- software component and system testing prior to release
- firmware/software releases are archived, along with information regarding development tools and test results using a commercially-available CM software product.
- software/hardware design elements and test results under CM archive are regularly backed up and maintained by the OBU supplier.

4.3.1.3 Streetcar Vehicle CM

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- identification of software/hardware elements to be under CM
- a formalized change control process
- software component and system testing prior to release
- firmware/software releases are archived, along with information regarding development tools and test results using a commercially-available CM software product.
- software/hardware design elements and test results under CM archive are regularly backed up and maintained by the OBU supplier.

4.3.2 Infrastructure System CM

CM for RSUs conforms to the Siemens Product Lifecycle Management (PLM) process, which includes numbered milestones from product inception through product end-of-life ahead of successor product releases. The RSU has passed M300 as a fully-released and tested product under revision control. Revision control consists of software updates with regression testing. Software releases are archived, along with information regarding development tools and test results using a commercially-available CM software product. All branches of the CM archive are regularly backed up and maintained.

4.3.3 Back Office System CM

CM for Concert conforms to the Siemens Product Lifecycle Management (PLM) process, which includes numbered milestones from product inception through product end-of-life ahead of successor product releases. Concert has passed M300 as a fully-released and tested product under revision control. Revision control consists of software updates with regression testing. Software releases are archived, along with information regarding development tools and test results using a commercially-available CM software product. All branches of the CM archive are regularly backed up and maintained. Concert has major planned periodic releases including new customer-requested features, plus minor maintenance releases as needed.

4.3.4 Personal Information Device CM

CM for PID includes software releases that are archived, along with information regarding development tools and test results using a commercially-available CM software product. All branches of the CM archive are regularly backed up and maintained.

4.4 Equipment Maintenance

4.4.1 Vehicles

Global 5 is responsible for all communications with participants and employs a hot line to obtain participant feedback. CUTR will analyze participant feedback and provide responses to Global 5 for potential updates to information on website, frequently asked questions etc.

4.4.2 In-Vehicles

Brandmotion contracts with HCC to install and maintain the process for equipping vehicles, specifically:

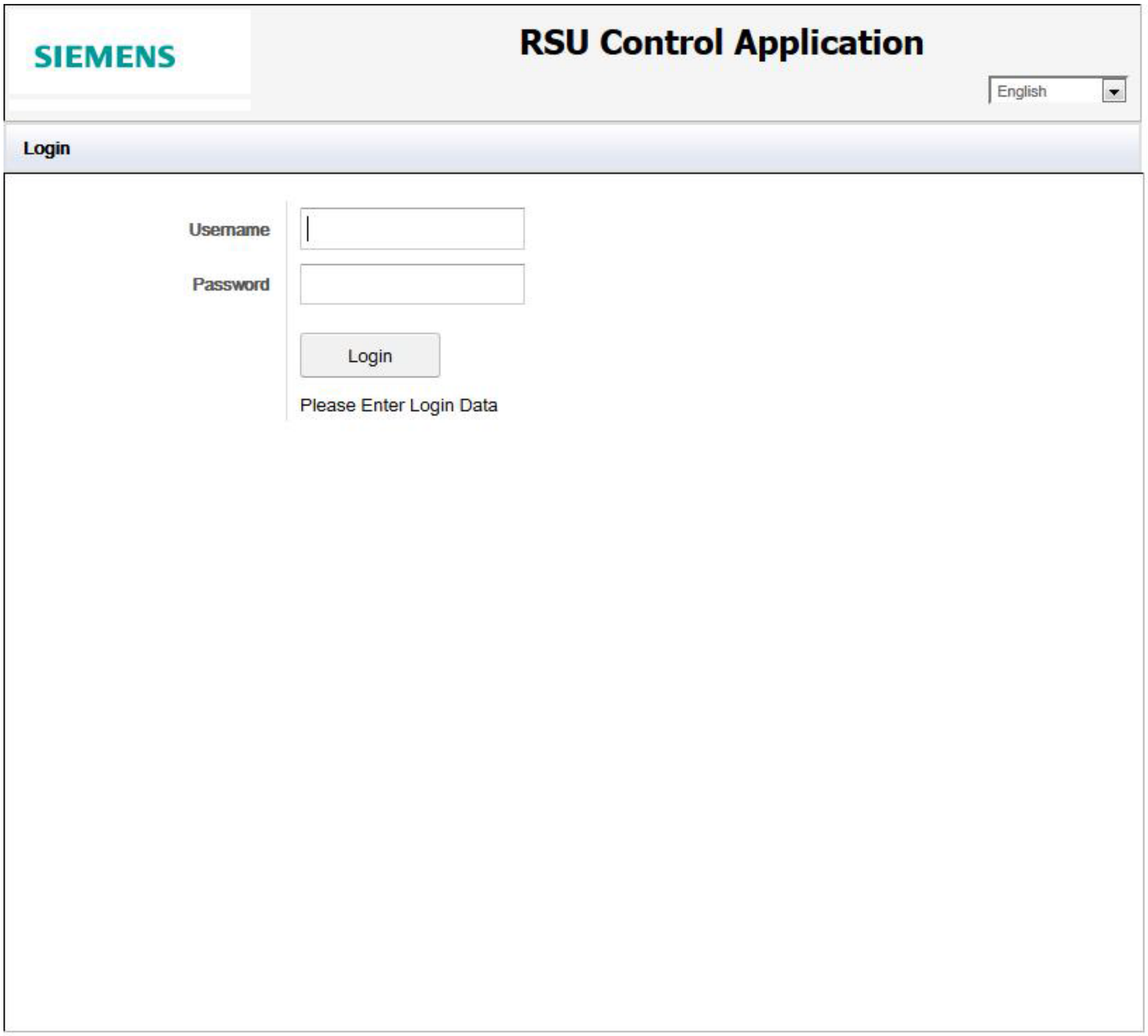
- Installation facilities
- Tools
- Equipment

Brandmotion jointly with HCC is responsible for ongoing training of new installers under HCC supervision. Brandmotion provides diagnostic procedures to determine if equipment requires replacement.

4.4.3 Infrastructure

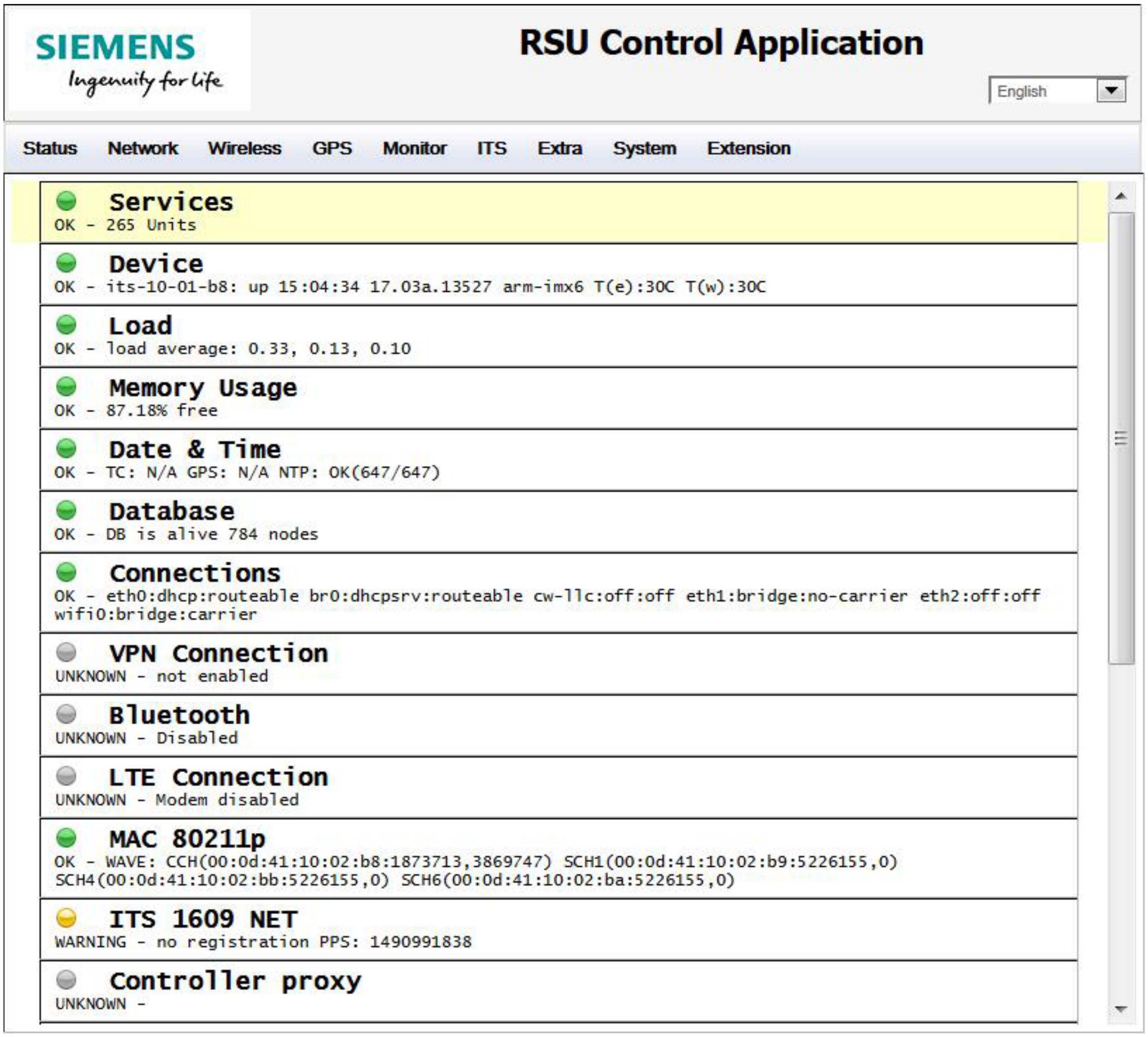
The RSU Service Console use is described in [RD3]. The Service Console consists of a web service hosted by the RSU that is accessed by a personal computer (PC). No special software is required to be installed on the PC. The Service Console is accessed by a standard web browser via login as shown in Figure 2.

Figure 2: RSU Login



After login, the maintenance personnel are able to quickly obtain status of the RSU via the Status Screen shown in Figure 3. From there, each RSU service has its own screen to set configuration and obtain status, including, DSRC, Bluetooth, WiFi, cellular, Ethernet, network configuration security settings and others. Refer to [RD3} for detailed information on the operation of each service screen.

Figure 3: RSU Status Screen



4.4.4 Personal Information Devices

PIDs are owned by the participants in the form of Android smart phones. The manufacturer of each phone supplies periodic software updates, specific to that manufacturer's device. Participant PIDs are screened for manufacturer, model and operating system version.

4.4.5 Traffic Management Center

4.4.5.1 Server Maintenance

4.4.5.1.1 Virtual Infrastructure Client

All servers are hosted in VMware vSphere ESXi Hypervisor environment. VMWare ESXi Client (also known as vSphere Client) is the primary method for managing the servers. The vSphere client can be access via web browser (for example: Internet Explorer) and navigating to the following URL and credentials:

URL to access vSphere Client: https://10.199.108.10
UserName/Password:****/*********

The vSphere client screen gives an overview of the performance which is a good initial picture of the status of the system; 0% or 100% CPU usage is a quick indication of a problem with a server.

Figure 4: vSphere client, Overall Performance Overview

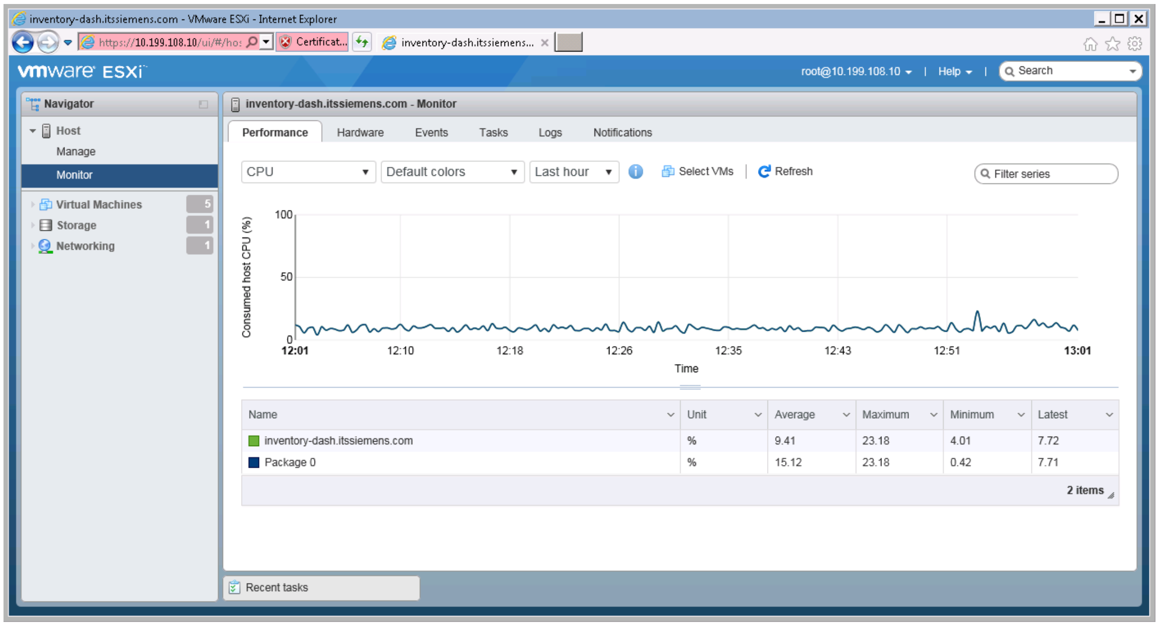
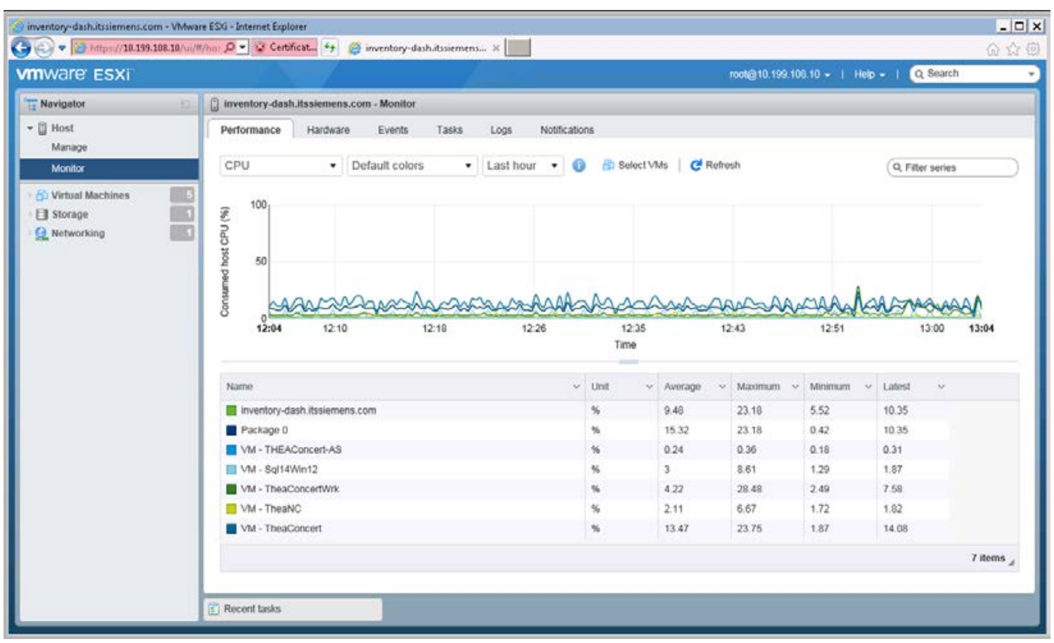
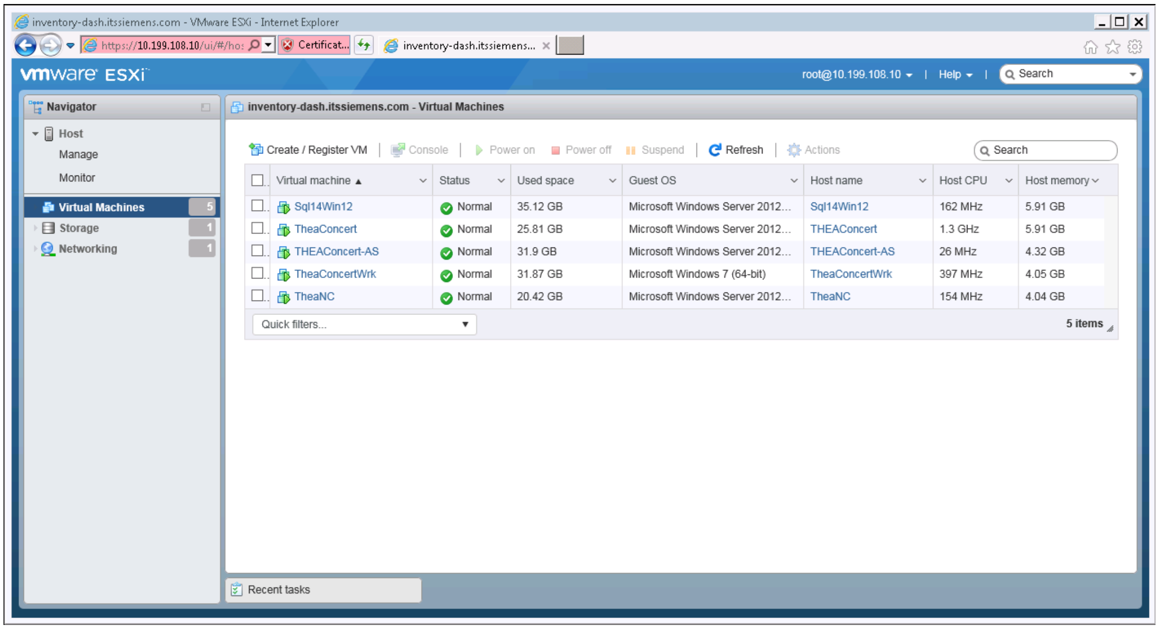


Figure 5: vSphere client, Performance Overview per Server



vSphere client screen also gives an overview of the current state of each virtual machines for easy identification of whether VMs are running or not. Various use cases such as powering on and off, access VM console, managing snapshots, editing settings, etc. can be done via vSphere client.

Figure 6: vSphere client, inventory of virtual machines



4.4.5.1.2 Login information

The CONCERT server runs Concert as a service component. User can log on to these servers using Remote Desktop with local account to perform maintenance activities on the server. Please ensure not to run any memory or CPU-intensive applications that might interfere with the operation of the CONCERT Server application. Do not leave any programs running that might use up additional memory over time (such as Wireshark).

4.4.5.1.3 Detailed Server Information

4.4.5.1.3.1 TheaConcert

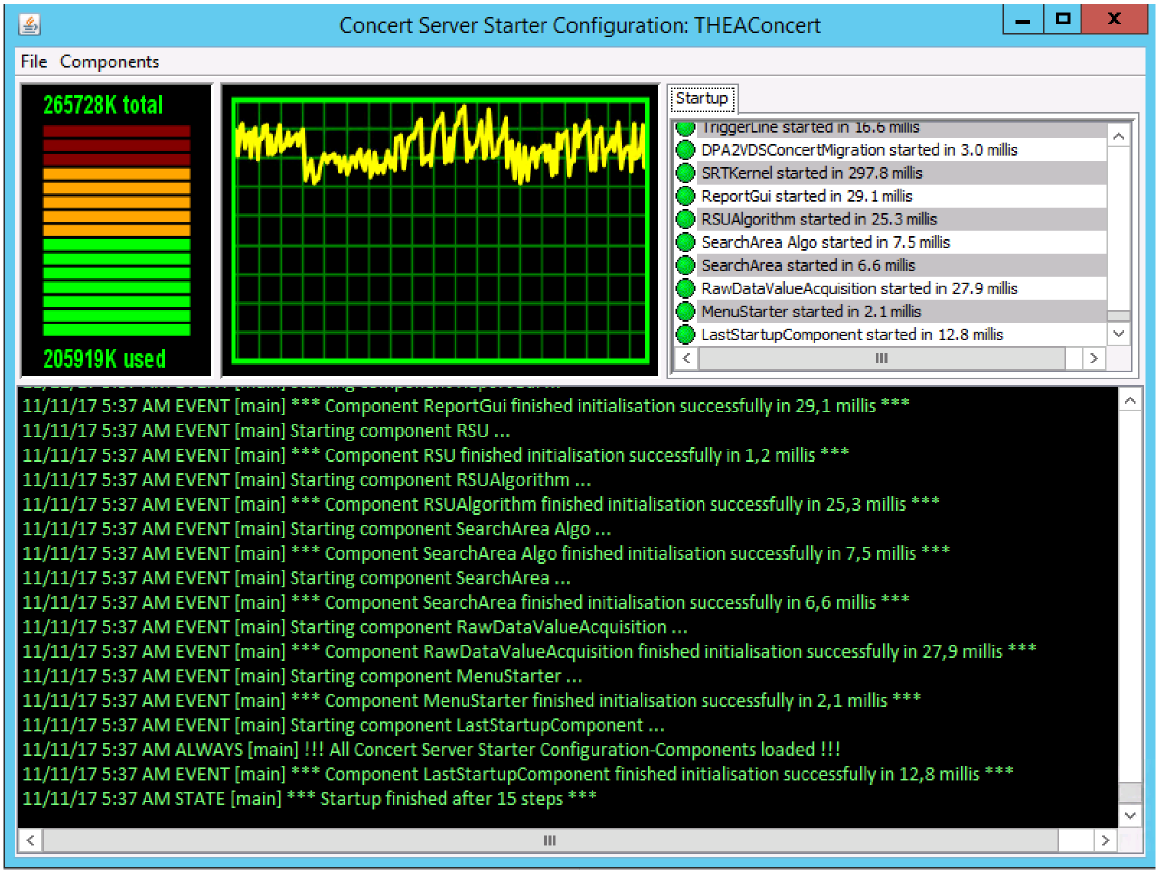
Table 9: Concert Server Detailed Information

Server Name	TheaConcert
IP address	10.199.108.11
User/Pass	****/****
OS	Windows Server 2012 R2 Standard
Primary Function	Main CONCERT application server
Services	• SitrafficConcert service (CONCERT app server) • SitrafficServiceController service (controls/monitors Concert service)
Drive Usage	C: (50GB) OS Boot drive E: (50GB) CONCERT application and archive drive

Server Name	TheaConcert
RAM:	6 GB, typical usage 4 GB
CPUs:	4
CPU usage	Typically, 5-10%, may spike to 100% every minute or so.
Key tasks in task manager	SitrafficConcert (main Concert service) SitrafficServiceController
Boot Configuration	Concert application runs as a service
Health checks	• Check CPU and memory not saturated • Check disks C, E not full • Check “ServiceGui” application. See note on Concert memory usage. • Check Windows Event Logs – Application and System
Restart Process	Restart process is complete when “Central Application Server” window shows “Server Started” in the Startup list. Note that the Concert service may restart itself periodically if it detects problems. The restart usually takes less than three minutes.
Log File Locations	E:\Sitraffic\log\Concert E:\Sitraffic\log

Note on CONCERT memory usage:
CONCERT is a Java application. Java applications typically pre-allocate a large amount of memory from the OS, and then the JVM allocates memory internally within that space. JVM memory usage typically grows over time, and then is periodically reduced when the Java “garbage collection” process runs. The CONCERT monitor window shows a graph of JVM usage over time. In normal operation, it should display a “saw tooth” pattern as seen in the screenshot below. This indicates that the server processes within the JVM are running correctly. If the memory graph ever “flat lines”, it may mean that key tasks within the JVM are not running, or, if the line is at the very top of the graph, it may mean that the JVM has run out of memory.

Figure 7: CONCERT Monitor Window



4.4.5.1.3.2 SMPPALG2-NC

Table 10: TheaNC Server Detailed Information

Server Name	**TheaNC**
IP address	10.199.108.12
User/Pass	****/****
OS	Windows Server 2012 R2 Standard
Primary Function	NextConnect Server. Handles interface between RSUs, and data archive/storage device.
Services	Apache Tomcat NextConnect
Drive Usage	C: (50 GB) OS Boot drive, NextConnect service drive E: (50 GB) application drive
RAM:	4 GB, typical usage 1.7 GB
CPUs	4
CPU usage	Typically, 1-5%, short bursts to 35% every 20 seconds
Key tasks in task manager	Tomcat6.exe (NextConnect service)
Boot Configuration	All applications run as services and start automatically
Health checks	• Check CPU and memory not saturated • Check disk C and E not full • Check Windows Event Logs – Application and System • Open http:\\TheaNC:8080\NextC2C\version in a web browser. This will display NextConnect's version and status page. The page shows the running adapters. If none of these are not running, restart NextConnect: o RSU • Open http://TheaNC:8080/NextC2C/explorer.html in a web browser. This will display NextConnect's internal model explorer page. The page shows adapters and devices status. seven running adapters.
Restart Process	Services can be restarted individually, or entire server restarted.
Log File Locations	C:\SiemensITS\NextConnect\apache_tomcat\logs C:\view_stores

4.4.5.1.3.3 MS SQL Server

Table 11: MS SQL Server Detailed Information

Server Name	**Sql14Win12**
IP address	10.199.108.13
User/Pass	*********
OS	Windows Server 2012 R2 Standard
Primary Function	Microsoft SQL Server. Hosts databases used by NextConnect.
Services	SQL Server, SQL Server Agent, SQL Server Reporting Services
Databases	NextConnectCV, NextConnectSqlDbLog
Drive Usage	C: (50 GB) OS Boot drive
RAM:	6 GB, typical usage 1.7 GB
CPUs	4
CPU usage	Typically, 1-5%, short bursts to 35% every 20 seconds
Boot Configuration	MS SQL Components run as services and start automatically
Health checks	• Check CPU and memory not saturated • Check disk C not full • Check Windows Event Logs – Application and System
Restart Process	Services can be restarted individually, or entire server restarted.

4.4.5.1.4 Startup/Shutdown procedures

4.4.5.1.4.1 System Startup

If the entire system is started cold from a power up, all services should start automatically.

4.4.5.1.4.2 System Shutdown

1. On the Concert server, shut down the SitrafficServiceController service first, then shut down the SitrafficConcert service. (If the SitrafficServiceController service is running, it will restart the SitrafficConcert service automatically if it stops)
2. Shut down virtual machines using shutdown command

4.4.5.1.4.3 CONCERT Restart

To restart CONCERT without rebooting the servers, simply restart the SitrafficConcert service.

4.4.5.1.4.4 CONCERT Shutdown

On the Concert server, shut down the SitrafficServiceController service first, then shut down the SitrafficConcert services. (if the SitrafficServiceController service is running, it will restart the SitrafficConcert service automatically if it stops)

4.4.5.1.4.5 NextConnect Restart

To restart NextConnect without rebooting the servers, simply restart the Apache Tomcat NextConnect service from Service Control Manager GUI.

4.4.5.1.4.6 NextConnect Shutdown

To shutdown NextConnect without rebooting the servers, simply stop the Apache Tomcat NextConnect service from Service Control Manager GUI.

4.4.5.1.4.7 System validation

To verify that CONCERT is running correctly after a restart:

1. CONCERT “System Status” screen (under System Administration) reports no errors.
2. Most RSUs show online in the RSU list.
3. Map displays RSU icons with Green, Yellow, or Red color. (Not gray).

4.4.5.1.5 Logs and Archiving (Disk utilization)

4.4.5.1.5.1 Application log files

The primary log file on the CONCERT servers is the “ConcertServer.log” file in E:\Sitraffic\log\Concert. The primary log file on the NextConnect server is the “tomcat.log” file, located in the “\\SiemensITS\NextConnect\apache_tomcat\logs” directory under the directory where NextConnect is installed. There are also individual log files for each NextConnect adapter in this directory, which may be useful for focusing on a problem with a specific adapter. All the information logged in the adapter log files is also included in the tomcat.log file. By default, all of the files are set to roll over to a new file at a specific size, and the number of rollover files limited, usually to 10.

Some of the log files are very large, so it is hard to look at them with Notepad or WordPad. The “Kiwi Log Viewer” application makes it easier to view log files. This viewer also provides a “live” scrolling view of the file as it is updated, which can be used to just watch an application run.

4.4.5.1.5.2 Data Archiving

Refer to Data Management Plan, February 2017, Section 2.5 for data archived

4.4.5.1.6 Time Synchronization

The clocks on all of the THEA components and sub-systems must be closely synchronized for the distributed applications to work correctly. Since the VMware environment tends to make clocks drift erratically, and the Windows built-in domain time synchronization doesn’t run often enough to keep the clocks close together, the Tardis NTP time sync application is used, based on operational testing before the end of project Phase 2. Tardis can be installed on each server. The Tardis application runs as a service and is configured through an icon in the control panel.

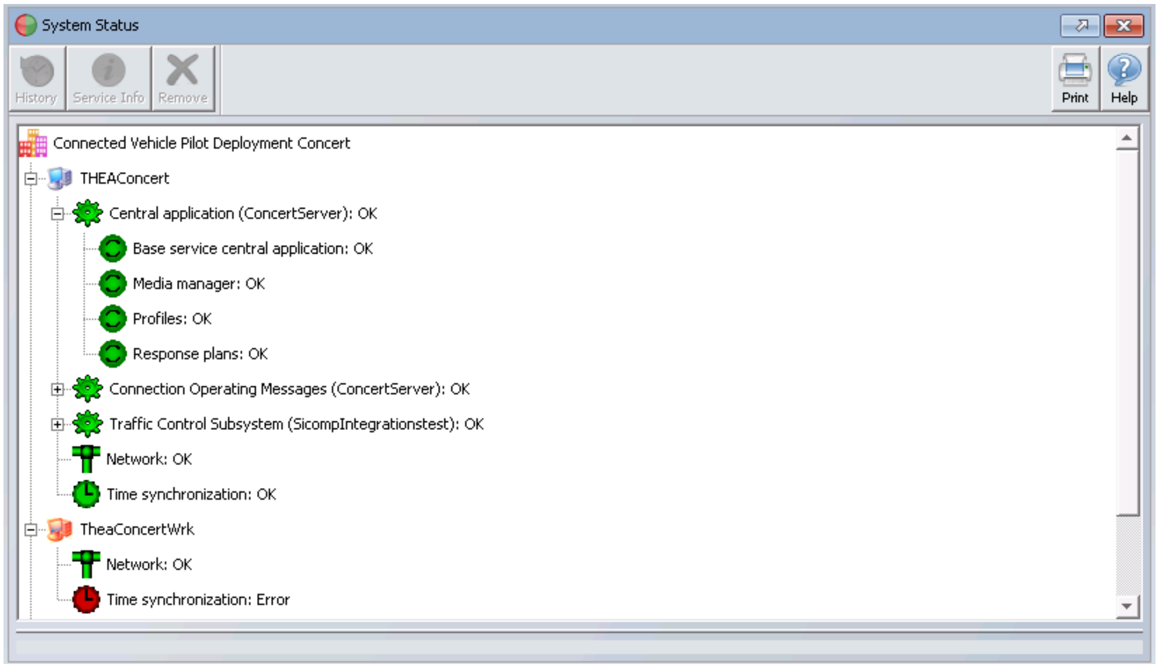
Note: Ensure that the “Time synchronization between the virtual machine and the ESXi server” option in VMware tools on each server is NOT checked. This can cause large jumps in the clock if the VM is migrated from one host to another and the host clocks are not synchronized.

4.4.5.2 Concert Application Maintenance

4.4.5.2.1 System Status

Figure 8 System Status Screen in Concert shows information shows the status of the internal services running on each CONCERT server. If problems are reported here, check the indicated server for performance problems.

Figure 8: System Status Screen



4.4.5.2.2 Log Files

Most log files are automatically rolled over and deleted when they reach a certain size. However, the log file locations (see section above on each server) should still be monitored periodically. A log file that suddenly starts growing faster than it should may indicate a problem in the system. Data is pushed to the CUTR server automatically and also on-demand as required. Data bottleneck and overload is handled as described in Section 4.2.2 of the project Data Management Plan dated February 2017.

4.4.5.2.3 NextConnect

NextConnect is a general-purpose interface server that can be configured to do a number of different things; and in THEA it communicates to RSUs to obtain log information. This installation of NextConnect includes adapter for RSU.

4.4.5.2.4 Monitoring Tools

It is often useful to use a log file viewer to monitor application log files, rather than just opening the file in Notepad. The log file viewer, such as Kiwi Log Viewer, allows scrolling view of the scroll past as the application writes to it.

4.4.5.2.5 Troubleshooting

4.4.5.2.5.1 Concert Client Issues

When the “Communication Error” indication shows up with “Communication Error, Displayed Values May Be Obsolete”, it indicates a problem with the connection between Concert client (TheaConcertWrk) and Concert server (TheaConcert).

If this error occurs:

- On one workstation: Check the workstation’s network connection, or reboot the workstation
- On all workstations: Check connectivity or network loading

4.4.5.2.5.2 Client License Issues

There is a limit to the number of users that can log on to the system at the same time. This limit is currently set to 10 users. If this limit is exceeded, the system will continue to operate correctly, but error bars will be displayed in the GUI similar to the communication error shown above.

4.4.5.3 Support Equipment

4.5 Operational Readiness Demonstration Equipment

The required elements of a maintenance-focused demonstration is included as part of the ORP, Operational Demonstration dated April 24, 2018, Section 1.2.1 “Vehicle-Specific Demonstration Procedures

4.6 Routine Maintenance Requirements/Schedules

4.6.1 Vehicles

No routine maintenance

4.6.2 In-Vehicles

No routine maintenance

4.6.3 Infrastructure

No routine maintenance other than monitoring from the Concert central area map.

4.6.4 Personal Information Devices

No routine maintenance. PIDs are owned by the participant.

4.6.5 Traffic Management Center

Routine data backups and archiving

4.6.6 Support Equipment

No routine maintenance. COTS equipment has no adjustments that require routine calibration.

4.7 Inspection Procedure

4.7.1 Vehicles

Global 5 and HCC installers are jointly responsible for conducting an inspection of all vehicles as described in [RD1].

4.7.2 In-Vehicles

As described in [RD1] HCC is responsible for pre and post installation inspections/quality checks and the final test before the vehicle is returned to the participant (customer). HART and Brandmotion installers as described in [RD1] are responsible for streetcar and bus installation inspections.

4.7.3 Infrastructure

The installation and inspection procedures are included in [RD4] as shown in Figure 9.

Figure 9: RSU Installation and Inspection Topics

Contents

These topics include information for site survey, installation, commissioning and diagnostics. Along with [RD3], the maintenance staff uses the RSU service console to check operational status, load MAP files, and become familiar with the indicator lamp operation as a quick visual inspection as to the operation of an installed RSU as shown in Figure 10.

Figure 10: RSU Indicator Lamp Operation

LED	State	Description
Power LED	Off	No power
	Solid Green	Device is powered on
Status LED	Off	No power
	Blinking Green	Device start-up
	Solid Green	Device operational
	Amber	Firmware upgrade in progress
	Red	Fault, i.e. at least one service is in error state (see 3.2.2 Status)

4.7.4 Personal Information Devices

PIDs have no inspection procedure beyond the Android installation process. Once the application is installed, the application is tested by placing PED CALLS from the device when within range of an RSU connected to a signal controller.

4.7.5 Traffic Management Center

Concert operational inspection is included in [RD5], with excerpts shown in 4.4.5.1.

4.7.6 Support Equipment

Test equipment operation and inspection is included in [RD2].

4.8 Maintenance/Replacement Procedures

4.8.1 Vehicles

Participants using the Tampa CV hotline identify any vehicle level issues for Global 5 and Brandmotion to diagnose and determine if a repair needs to be schedule. Global 5 is responsible for determining any vehicle repair issues and HART repair issues relative to streetcars and buses.

4.8.2 In-Vehicles

Brandmotion and HCC will repair any participant vehicle systems as required. Brandmotion/HCC has replacement parts in storage. The suppliers (e.g. OBU) have Service Level Agreements (SLA) with Brandmotion that require on-going technical support to be accessible (e.g. technical hot lines) and if necessary on-site support. Warranty agreements are in place requiring replacement parts to be made available.

4.8.3 Infrastructure

Siemens will repair RSUs as required. THEA has replacement parts in storage. Warranty agreements are in place through project Phase 3. THEA or City of Tampa Traffic Operations first requests an RMA to return RSUs for repair. Once the RMA is in place, the RSU is returned with that RMA number included in the shipment. Siemens logs that RMA as customer-owned equipment received. After repair or replacement, the RSU is returned under that RMA number and the RMA is closed, but retained for historical records.

4.8.4 Personal Information Devices

PIDs are owned by the private participants. Maintenance, warranty and replacement are outside the scope of the project.

4.8.5 Traffic Management Center

Siemens will service equipment as required. Siemens has service agreements in place for servers and software. THEA or City of Tampa Traffic Operations first requests service via an on-line Help Desk ticket, with a priority level for response. Once the Help Desk ticket is in place, Siemens contacts the requestor for further information and to schedule a service call. Once the service is complete, the Help Desk ticket is archived for historical records.

4.8.6 Support Equipment

The manufacturer of the commercial test equipment provides the warranty repair policy.

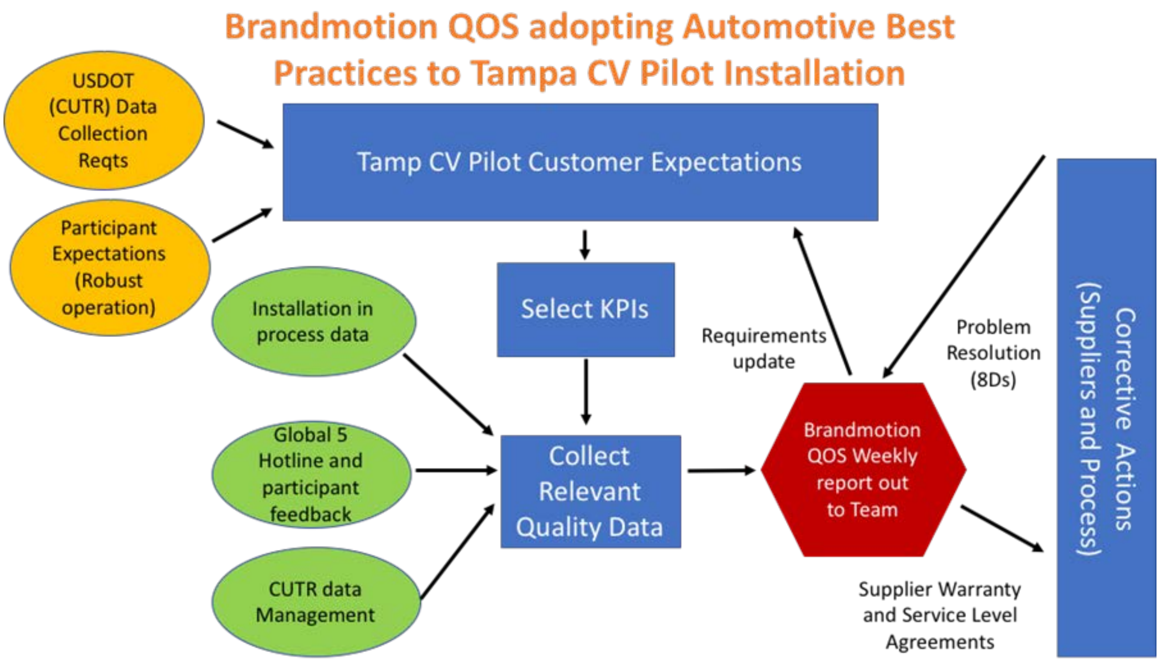
4.9 QA/QC Processes

4.9.1 Vehicles QA/QC

Brandmotion LLC, leveraging our experience as an automotive supplier of Connected Vehicle systems/services with launch a Quality Operating System (QOS). QOS was launched by the Ford Motor Company in the 1980s to create a disciplined approach to quality, standardize process/tools and be systematic in its application. QOS is a best business practice continuous improvement used by management to increase customer satisfaction (quality) and improve efficiency. The QOS methodology Is applied to this project as follows:

- Ensure customer (participant and THEA) expectations are met: functionality (data availability), quality, timely repairs, responsive suppliers, etc.
- Identify and maintain key process elements that satisfy customer's expectations. **Key performance indicator** (**KPI**) to measure and evaluate the efficiency and effectiveness of the installation process
- Evaluate supplier performance and drive continuous improvement, required to address all failures and component quality issues.
- Apply structured problem solving, the Eight Discipline (8D) approach by forming a QOS team when measured   performance indicates a problem.
- Increased customer satisfaction levels as an outcome through improved effectiveness and efficiency of the installation process.

Figure 11: Vehicle Quality Operating System



4.9.2 In-Vehicles QA/QC

The QOS as described above encompasses all in-vehicle components. The component/supplier problem solving process, 8D is described below:

Eight Disciplines (8Ds) Problem Solving is a method developed at the Ford Motor Company, and sued by other auto industry companies to resolve problems. Focused on product and process improvement, its purpose is to identify, correct, and eliminate recurring problems. It establishes a permanent corrective action based on statistical analysis of the problem and on the origin of the problem by determining, verifying the root cause of problems, and permanent corrective actions as part of a continuous improvement process.

- D0: **Plan**: Plan for solving the problem and determine the prerequisites.
- D1: **Use a Team**: Establish a team of people with product/process knowledge.
- D2: **Describe the Problem**: Specify the problem by identifying in quantifiable terms the who, what, where, when, why, how, and how many (5W2H) for the problem.
- D3: **Develop Interim Containment Plan**: Define and implement containment actions to isolate the problem from any customer.
- D4: **Determine and Verify Root Causes and Escape Points**: Identify all applicable causes that could explain why the problem has occurred. Also identify why the problem was not noticed at the time it occurred. All causes shall be verified.
- D5: **Verify Permanent Corrections (PCs) for Problem will resolve problem for the customer**: Using pre-production programs, quantitatively confirm that the selected correction will resolve the problem. (Verify that the correction will actually solve the problem.)

- D6: **Define and Implement Corrective Actions**: Define and Implement the best corrective actions.
- D7: **Prevent Recurrence / System Problems**: Modify the management systems, operation systems, practices, and procedures to prevent recurrence of this and similar problems.
- D8: **Congratulate main contributors to your CAR team**: Recognize the collective efforts of the team. The team needs to be formally thanked by the organization.

4.9.3 Infrastructure QA/QC

Quality Assurance and Quality Control relating to the RSU is governed by the Siemens Product Evolution Process (PEP). PEP includes quality management at mandatory milestones during the complete RSU product lifecycle, including:

- Concept
- Definition
- Implementation
  - Electronic hardware
  - Software development
  - Mechanical design
  - Agile
- Verification: Quality Assurance of design and first article testing
- Commercialization / product launch:
- Operations: Quality Control of ongoing RSU production
- Phase out

Quality Gates (QG) are set at each stage of the product life that require full review and archiving of design, test results, customer feedback and others.

4.9.4 Personal Information Devices QA/QC

QA and QC of PID are governed by the manufacturers of the smart phones used in Phase 3.

4.9.5 Traffic Management Center QA/QC

QA and QC of Concert and the support equipment are governed by the same PEP of 4.9.3.

4.9.6 System Level Performance

Overall system-level performance is monitored and reported weekly to the AOR during the transition from Phase 2 to Phase 3. Performance includes RSU performance, OBU performance, and data reliability as a minimum. Please refer to “Tampa CV Pilot Performance” document.

4.10 Hardware/Software Configuration Control Processes

4.10.1 Vehicles

Configuration control for private light vehicles, owner participants is maintained by Global 5. HART has responsibility for equipped public transit buses and TECO power company for equipped streetcars

Table 12: Owner Configuration Control by Vehicle Type

Vehicles	Owner
Private Light Vehicles	Phase 3 Private Owner Participants
Public Transit Bus	HART transit agency
Public Streetcar	TECO power company

4.10.2 In-Vehicles

Configuration control for all in-vehicle systems is maintained by Brandmotion. A baseline of all elements of the RSU is established, including:

- OBUs
- 12 VDC cabling, wiring
- antenna assemblies
- HMI, mirrors

Any change to any element represents a new baseline that requires regression testing, software archive, engineering drawing updates if electronic or mechanical design is changed. Each new release is accompanied by Release Notes that explain the differences from the prior baseline.

4.10.3 Infrastructure

Configuration control of the RSU is governed by the Siemens PEP described in 4.9.3. A baseline of all elements of the RSU is established, including:

- Electronic hardware
- Mechanical components
- WAVE software stack
- V2I application software

Any change to any element represents a new baseline that requires regression testing, software archive, engineering drawing updates if electronic or mechanical design is changed. Each new release is accompanied by Release Notes that explain the differences from the prior baseline.

4.10.4 Personal Information Devices

PID software configured with PID of multiple manufacturers represents a baseline. Changes to software requires regression testing and software archives. Each new release is accompanied by Release Notes that explain the differences from the prior software release.

4.10.5 Traffic Management Center

Configuration control of Concert is governed by the Siemens PEP described in 4.9.3. A baseline of all elements of the Concert is established, including:

- Hardware physical servers
- Server operating system software
- Virtual Machine (VM) software
- Applications, such as logging driver alerts and database access to research staff.

Any change to any element represents a new baseline that requires regression testing and software archive. Each new release is accompanied by Release Notes that explain the differences from the prior baseline.

4.10.6 Support Equipment

Configuration control of standard test equipment is governed by the manufacturer of the equipment

4.11 Recall Processes

4.11.1 Vehicles

Over-the-air updates are the approach for providing provisioning providing new firmware to update applications or to fix software issues. Global 5 as authorized by the Change Control Board is responsible for recalls and notification that participant should schedule appoints for repair, uninstall and reinstall of components.

4.11.2 In-Vehicles

Included in 4.11.1.

4.11.3 Infrastructure

RSU recall is governed by the RMA and Help Desk process described in 4.8.3. Tickets entered in the Help Desk are constantly monitored by Siemens technical staff. Common issues are communicated to the owner/operators of the RSU installed base. Mitigation of software issues includes remote updates without need for recall. In rare cases, customers with hardware issues requiring return are issued RMAs on a rolling schedule tailored to each customer.

4.11.4 Personal Information Devices

PIDs are owned by the private participants and subject to the recall policies of each PID manufacturer.

4.11.5 Traffic Management Center

Concert recall is governed by the RMA and Help Desk process described in 4.8.3. Tickets entered in the Help Desk are constantly monitored by Siemens technical staff. Common issues are communicated to the owner/operators of the Concert installed base. Mitigation of software issues includes remote updates without need for recall. Customers with hardware server issues are serviced via Siemens support agreements with suppliers of the server equipment. Siemens procurement enforces the service agreements for equipment repair and replacement.

4.11.6 Support Equipment

Recall process of standard test equipment are governed by the policies of the equipment manufacturer.

4.12 Spare Parts/Warranty Contingency Plans

4.12.1 Vehicles

Brandmotion is responsible for inventory control for installation and repair, directs HCC to take inventory and to stock spare stock of OBUs, rear-view mirrors, wiring, antennas, etc. as is funded in project Phase 2. Warranty and return policy is previously described above.

4.12.2 In-Vehicles

Brandmotion is responsible for inventory control for installation and repair, directs HCC to take inventory and to stock spare stock of OBUs, rear-view mirrors, wiring, antennas, etc. as is funded in project Phase 2. Warranty and return policy is previously described above.

4.12.3 Infrastructure

Spare stock of RSUs funded in project Phase 2 is inventoried at THEA headquarters. Warranty and return policy is previously described above.

4.12.4 Personal Information Devices

PIDs are owned by participants and subject to the warranty policies of each PID manufacturer.

4.12.5 Traffic Management Center

No spare stock of server equipment is maintained. Rather, Siemens has in place service agreements with equipment suppliers. Issues are categorized by severity, with associated responses, such as same-day, 48-hour, etc.

4.12.6 Support Equipment

Table 13: Commercial Support Equipment

#	Equipment	Supplier	Description
1	DSRC-MCTT-5.9Ghz	3M	DSRC Multichannel Test Tool

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" 866-367-7487
www.its.dot.gov

FHWA-JPO-17-465

U.S. Department of Transportation