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Final Report

C030588 CVII Phase 1

This report summarizes the results of the CVII Phase 1 Project.

Responsible	Tom Richter
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1 General Information

This document contains the final report for the NYS CVII Project - Phase 1.

1.1 Document Contacts

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1.2 Revision History

Issue	Date	Author	Changes
1.0	12 Dec 2011	Mike Siebert	Initial

1.3 Reference Documents

[1] Contract #C030588 – PIN: CC95.07.121
Commercial Vehicle Infrastructure Integration
New York State – Department of Transportation

[2] 6980-02821-01-02 C030588 CVII Program Plan
Volvo Technology – Tom Richter
Issue 3.1 – 06 Nov 2009

[3] 6980-02941-01-25 CVII System Architecture
Volvo Technology – Mike Siebert
Rev 1.0 – 05 Dec 2011

[4] 6980-02941-01-07 CVII Task 2 Acceptance Test Report
Volvo Technology – Mike Siebert
Issue 1.1 – 02 Feb 2010

[5] 6980-02941-01-09 CVII Tasks 3 and 4 Acceptance Test Report
Volvo Technology – Mike Siebert
Issue 1.0 – 03 Nov 2010

[6] 6980-02941-01-15 CVII Task 5 Acceptance Test Report
Volvo Technology – Purser Sturgeon
Issue 1.0 – 18 Nov 2011

[7] 6980-02941-01-17 CVII Task 6 Acceptance Test Report
Volvo Technology – Mike Siebert
Issue 1.0 – 16 Dec 2011

[8] 6980-02941-01-24 CVII OBE Wiring Diagram
Volvo Technology – Mike Siebert
Rev 1.0 – 05 Dec 2011

[9] 6980-02941-01-26 CVII OBE Installation Kit
Volvo Technology – Chuck Villa
Rev 1.0 – 21 Nov 2011

1.4 Abbreviations

BAH	Booz Allen Hamilton, Inc.
CVII	Commercial Vehicle to Infrastructure Integration
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
GBS	Government Back-office System
IIS	Intelligent Imaging Systems
N/A	Not Applicable
NYS	New York State
NYSDOT	New York State Department of Transportation
OBE	On Board Equipment
RF	Radio Frequency
RSE	RoadSide Equipment
SwRI	Southwest Research Institute
VII	Vehicle Infrastructure Integration
VTEC	Volvo Technology
WRI	Wireless Roadside Inspection

2 NYS CVII Project (Phase 1)

The overall scope of the NYS CVII Project can be found in References [1] and [2].

2.1 Background

CVII (Commercial Vehicle Infrastructure Integration) is a term coined by the New York State DOT (NYSDOT) to refer to the development, adaptation and application of the technology being developed for the US DOT's Connected Vehicle Initiative using 5.9 GHz Dedicated Short Range Communications (DSRC) to commercial vehicles (trucks). CVII is a technology program that enables a variety of safety, mobility and security applications.

CVII is anticipated to provide the following advantages, encompassing all of the Connected Vehicle functions and applications, but with specific application to commercial vehicles:

- Safety advantages
- Transportation system efficiency advantages
- Driver convenience advantages
- Regulatory advantages
- Traffic operations advantages

2.2 Results

The NYSDOT CVII Project has successfully completed the development and demonstration of VII technology adapted to a commercial vehicle platform which is sufficient to enable decisions regarding the future deployment and commercialization of the CVII technologies.

The specific results are as follows:

- Adapted the existing VII on-board equipment (OBE) to a commercial vehicle
- Adapted and demonstrated existing cross-cutting VII applications
- Developed and demonstrated applications specific to commercial vehicles:
    - Developed and tested a solution for verifying and authenticating driver identification
    - Researched, developed, and demonstrated a wireless roadside inspection application

  - Integrated the wireless roadside inspection service into the NYS back office network for screening application

- Assembled and installed OBE kits for four NYS maintenance vehicles, based on hardware, software and designs that have been developed and tested for commercial vehicles, and provided plans to support installation for additional maintenance vehicles in the future
- Performed acceptance tests for all of the CVII functionality developed in this project using the Volvo commercial vehicle in Greensboro, NC
- Engaged in a program of outreach and communications that will continue to identify relevant stakeholders, communicate key aspects and results of the project to relevant stakeholders, both in terms of technical results and benefit to potential users of CVII
- Documented the results of the analysis and demonstration including vehicle design plans, test and demonstration plans, and analysis of results.

2.3 Report

This report provides information on end-to-end system architecture, acceptance test results and analysis, and developed system hardware. Technology discussions covering missing components (e.g. encryption, RF interference, etc.), open issues (e.g. J2735 candidate additions approval, etc.), and future roadmap which have been identified during the project but were outside the scope of this project will be deferred to the Phase 2 Final Report.

3 System Architecture

The end-to-end system architecture can be found in Reference [3]. This drawing identifies the components, interfaces, and protocols for each of the four back office/maintenance vehicle configurations used during the project. The protocols are identified in the gray box near each interface which identifies the interface control document and supported message groups. Additional information on this drawing can be found in the following subparagraphs.

It should be noted that the OBE architecture has remained consistent throughout the project with additional applications being added for each development task.

3.1 Existing Connected Vehicle Applications

The system architecture for the existing Connected Vehicle applications (Probe Vehicle Data and Traveler Information) can be found on page 1 of the drawing (*Task 2*). Existing SwRI and BAH back office applications from the VII Proof-of-Concept were used to facilitate providing probe vehicle data to the NYS back office systems.

3.2 Simulated Commercial Vehicle Applications

The system architecture for the simulated commercial vehicle applications (Driver Credentials Validation and Wireless Roadside Inspection) can be found on page 2 of the drawing (*Task 3/4*). A simple Government Back-office Simulator was used to verify the operation of the applications.

3.3 Emergency Vehicle Alerts

The system architecture for the emergency vehicle alerts (Snow Plow Warning) can be found on page 3 of the drawing (*Task 5*). A Jeep, utilizing a slightly modified test truck OBE, was used to simulate the maintenance vehicle with a simple toggle switch controlling the snow plow warning.

3.4 NYS Back Office Integration

The system architecture for the NYS back office integration (Driver Credential Validation and Wireless Roadside Inspection) can be found on page 4 of the drawing (*Task 6*). The system was interfaced to the NYS back office system (IIS Smart Roadside™).

4 Acceptance Test Results and Analysis

The acceptance test results and analysis can be found in the Acceptance Test Reports for each task (References [4], [5], [6], and [7]).

5 System Hardware

5.1 OBE Wiring Diagrams

The CVII OBE wiring diagrams can be found in Reference [8]. This drawing contains wiring schematics for the Test Truck, Maintenance Vehicle (Task 5), and the Passenger Vehicle (Phase 2). Each of these schematics also includes connector pinouts and parts lists with costs.

5.2 NYS Maintenance Vehicle Installation Kits

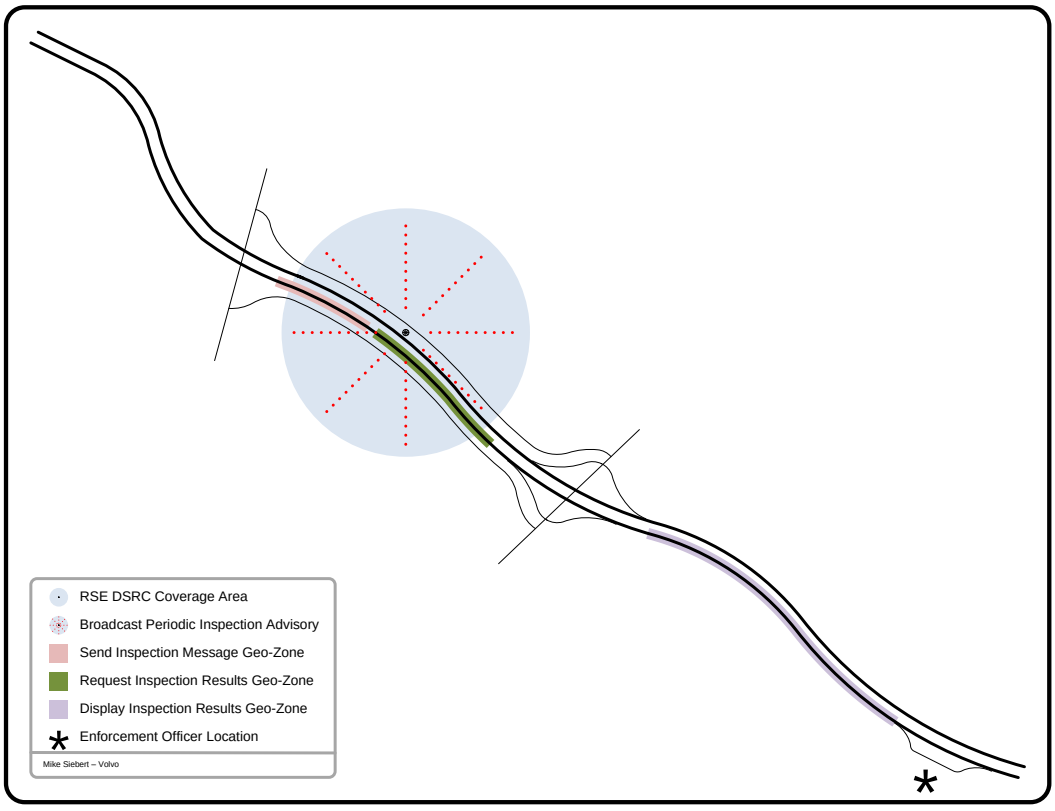
The system block diagram, wiring schematics, enclosure design, installation instructions, equipment lists with costs, and connector pinouts for the OBE Installation Kits used for NYS Maintenance Vehicle installs can be found in Reference [9].

6 Wireless Roadside Inspection

The Wireless Roadside Inspection is the most complex application implemented in the CVII Project. The ConOps defines the operation and requirements for a selection of tools which can be used to perform a wireless roadside inspection, but does not define how to use those tools. This section provides an overview of the operation of the wireless roadside inspection tools and a selection of possible scenarios in which the tools could be used.

6.1 WRI Operation

The operation of the WRI application is summarized in the following figure and detailed below.



6.1.1 Inspection Advisory Broadcast

The GBS creates an Inspection Advisory message which contains geo-zones which define where the:

- Vehicle sends an Inspection Message to the GBS

- Vehicle requests the Inspection Results

Optionally, if results do not need to be displayed to the driver, the Request Inspection Results Geo-Zone can be omitted.

The GBS must periodically (5 to 10 second intervals) send the Inspection Advisory message to the appropriate RSE which will broadcast the advisory to any equipped vehicles within range.

6.1.2 Inspection Message Transmission

If the Send Inspection Message Geo-Zone in a received Inspection Advisory is satisfied, the OBE will attempt to transmit an Inspection Message to the GBS via the RSE. The GBS must acknowledge receipt of the Inspection Message since the OBE will continue to retry the transmission until it is acknowledged or the Send Inspection Message Geo-Zone is no longer satisfied.

6.1.3 Request Inspection Results

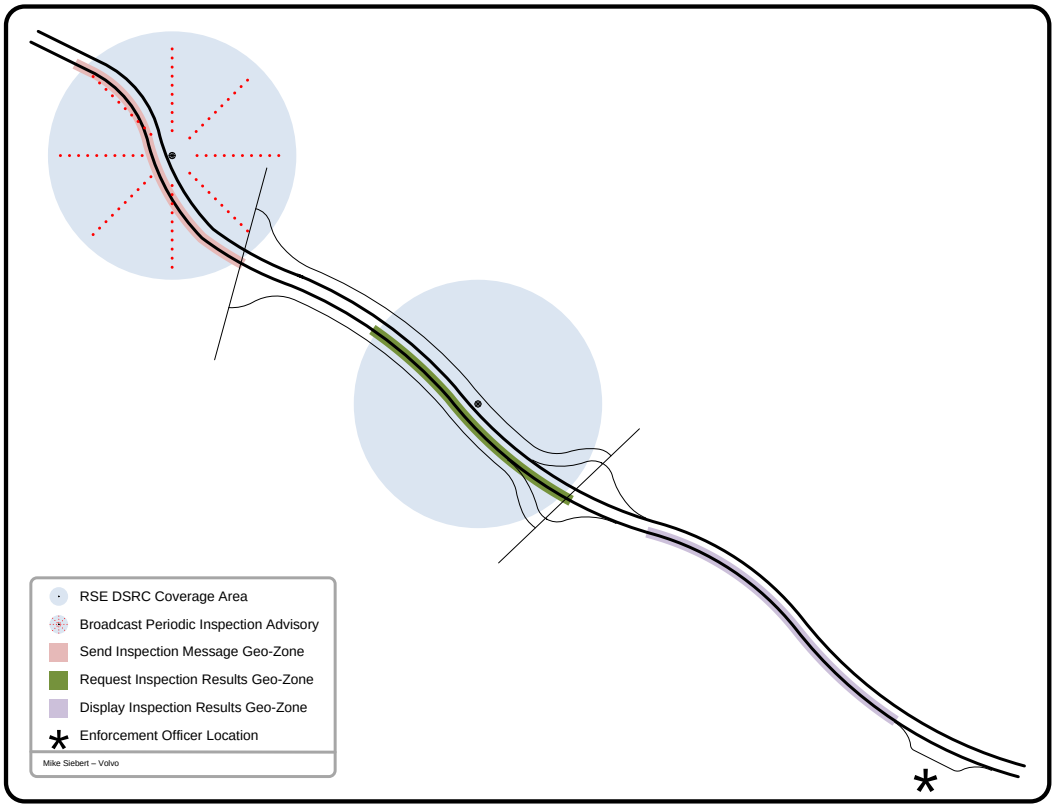
Once the Inspection Message has been successfully sent, if the Request Inspection Results Geo-Zone is satisfied, the OBE will attempt to request inspection results from the GBS. If the GBS has inspection results ready, it replies with an Inspection Results message. The OBE will continue to retry the request until the Inspection Results message has been received or the Request Inspection Results Geo-Zone is no longer satisfied.

6.1.4 Display Inspection Results

If the Display Inspection Results Geo-Zone in the received Inspection Results message is satisfied, the OBE will display the inspection results to the driver. The content of the message displayed to the driver is defined within the GBS allowing for a large number of possible operational scenarios.

6.1.5 Multiple RSE Alternatives

To support DSRC load balancing and/or GBS processing delays, the CVII WRI Function can take advantage of the geo-zone definitions to support a variety of physical configurations such as the two-RSE configuration shown below:



These geo-zone definitions can also allow for a large number of possible operational scenarios.

6.2 WRI Scenarios

A number of potential WRI scenarios were identified to ensure that the CVII WRI application design would be adequate to support future needs. As a result, each of the scenarios defined in the following paragraphs can be supported by the tools developed for the CVII WRI application on this project.

6.2.1 Fixed Inspection Station Bypass

This scenario provides a bypass function for fixed inspection stations by using the DSRC WRI Service to collect inspection information from approaching commercial vehicles and to provide driver instructions based on the results of the wireless inspection.

6.2.2 Temporary Inspection Station

This scenario supports a temporary inspection station by using the DSRC WRI Service to collect inspection information from approaching commercial vehicles and to direct deficient vehicles safely into a temporary inspection location selected by the enforcement officer (e.g. Rest area).

6.2.3 Mobile Vehicle Inspection

This scenario supports a mobile vehicle inspection service by using the DSRC WRI Service via a Mobile DSRC RSE installed in the enforcement officer's vehicle to collect inspection information from commercial vehicles in the immediate vicinity of the officer. Deficient commercial vehicles are identified to the officer who must then locate and pursue the vehicle to conduct a roadside inspection. For this scenario, the officer can be parked on the roadside or moving, but the Mobile DSRC RSE must have an active connection to the GBS via a wireless backhaul modem.

6.2.4 Selected Vehicle Inspection

This scenario allows an enforcement officer to select a commercial vehicle and request that inspection information be collected from the selected vehicle by using the DSRC WRI Service via an Enforcement DSRC OBE located in the officer's vehicle. If the commercial vehicle is deficient, the enforcement officer can pursue the vehicle to conduct a roadside inspection. For this scenario, the enforcement officer's vehicle must have an active connection to the GBS via a wireless backhaul modem.

6.2.5 Virtual Vehicle Inspection

This scenario provides an un-manned virtual vehicle inspection station by using the DSRC WRI Service to collect inspection information from approaching commercial vehicles, identifying deficient vehicles, and notifying the driver and fleet safety officer of any violations.