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Concept of Operations

C030588 CVII Task 10

Task 10 builds on the base CVII infrastructure developed in Tasks 2, 3, 4, and 5 providing a vehicle alert application for commercial vehicles approaching railroad grade crossings.

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1 General Information

This document describes the concept of operations and requirements for Task 10 of the NYSDOT CVII Project.

1.1 Document Contacts

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1.2 Revision History

Issue	Date	Author	Changes
1.0	12/06/2011	Purser Sturgeon II	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 2.1 – 15 Sep 2009
- [3] NYS CVII DSRC Message Set
Southwest Research Institute – Purser Sturgeon
Issue 1.0 – 20 Aug 2010
[Based on SAE J2735 DSRC Message Set Dictionary]
- [4] DMCU/Vehicle Gateway Interface Definition
Southwest Research Institute – Mike Brown
Issue 1.0.10 – 07 Apr 2011

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- [5] 6980-02821-01-04 State-of-the-Art Review on Information and Warning Strategies
Volvo Technology – Paul Piamonte
Issue 1.0 – 09 Oct 2009
- [6] 6980-02941-01-05 C030588 CVII Task 2 Concept of Operations
Volvo Technology – Mike Siebert
Issue 1.1 – 12 Dec 2009
- [7] SAE J2540-2 – ITIS Phrase List
Society of Automotive Engineers
Issue 2002-02, Revised 2009-11

1.4 Abbreviations

BSM	Basic Safety Message
ConOps	Concept of Operations
CVII	Commercial Vehicle to Infrastructure Integration
DOT	Department of Transportation
DMCU	5.9 GHz DSRC Mobile Communications Unit
DSRC	Dedicated Short-Range Communications
ECU	Electronic Control Unit
GPS	Global Positioning System
HVI	Human Vehicle Interface
IP	Internet Protocol
ITIS	International Traveler Information Systems
N/A	Not Applicable
NYS	New York State
NYS DOT	New York State Department of Transportation
RSE	Roadside Equipment
RSA	Roadside Alert Message
SAE	Society of Automotive Engineers
SwRI	Southwest Research Institute
TGW	Volvo Telematics GateWay
VII	Vehicle to Infrastructure Integration
VTEC	Southwest Research Institute

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1.5 Requirement Identifier

Req TASK10-001/1.0: Requirement Identifier

The requirement identifier for this specification shall be TASK10.

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2 Task 10 Concept

2.1 Background

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

Task 10 builds on the base CVII infrastructure developed in Tasks 2, 3, 4, and 5, providing a vehicle alert application for commercial vehicles approaching railroad grade crossings.

2.2 Objectives

The objectives of Task 10 are to develop and demonstrate a CVII application which enables the exchange of vehicle status data via the SAE J2735 Basic Safety Message (BSM) and a railroad grade crossing system that monitors vehicles approaching a railroad grade crossing. The CVII application will alert the commercial vehicle driver when the vehicle is approaching a railroad grade crossing when a train is approaching. Once it is determined that the vehicle is not slowing down enough to stop before it reaches the grade crossing, a message will be sent directly to the vehicle indicating that additional measures should be taken to alert the driver.

The specific activities required for Task 10 are:

- Develop a vehicle alert application
 - Use messages defined in the VII message set which are compatible with existing VII applications
 - Generate and send the BSM from the commercial vehicle
 - Receive the messages from the roadside indicating an approach to a railroad grade crossing
 - Receive the messages from the roadside indicating that advanced driver warnings are necessary
 - Notify the driver through the user interface of the approaching railroad grade crossing
 - Generate additional warnings to the driver when the vehicle is not slowing down soon enough to stop before the railroad grade crossing
 - Complete acceptance test of the application
- Develop a roadside railroad grade crossing monitoring application
 - Generate and send alert messages to vehicles when a train is approaching the crossing

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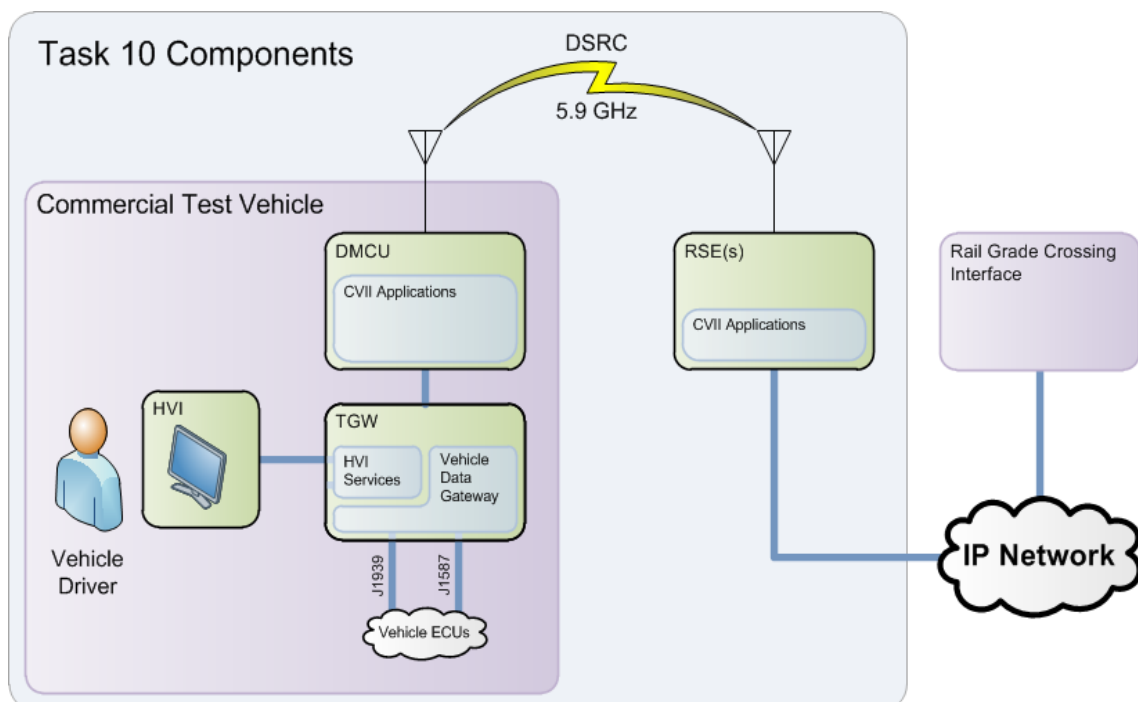
- Receive BSMs from vehicles approaching the railroad grade crossing
- Monitor received BSMs to identify vehicles that are not slowing down in time to stop at the grade crossing when it is active
- Generate and send a message to specific vehicles indicating that a railroad grade crossing violation is imminent

2.3 System Overview

The following components are utilized in Task 10:

- Commercial Test Vehicle includes:
 - DMCU
 - TGW
 - HVI
- Roadside includes:
 - RSE(s)
 - Laptop/embedded PC to simulate the railroad grade crossing system

The figure below shows the relationships between the components.

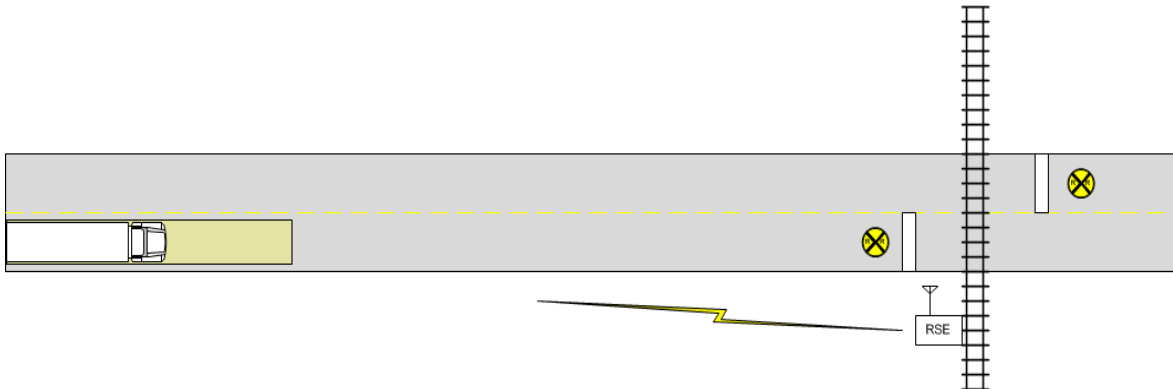


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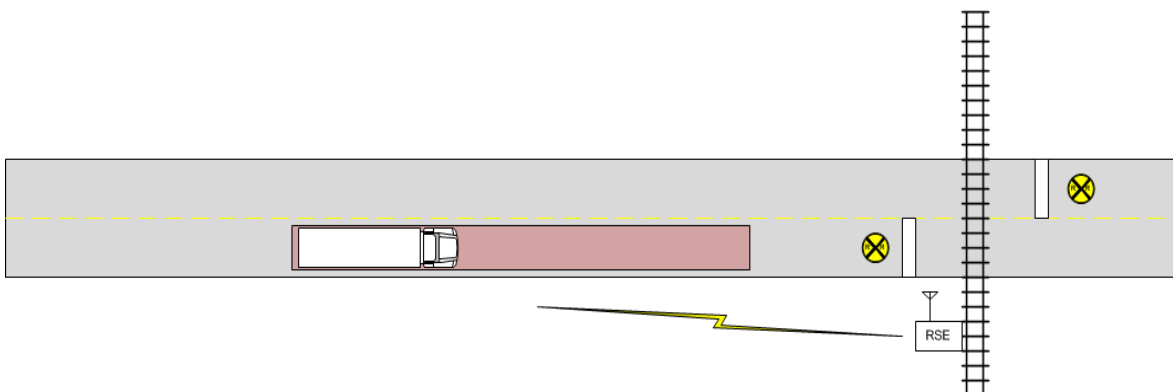
2.4 Operational Scenarios

The Commercial Vehicle will continually broadcast the BSM while the system is running. When a train is detected approaching the railroad grade crossing, the roadside system will broadcast a Roadside Alert Message (RSA). The roadside system will monitor BSMs received from vehicles and identify vehicles approaching the crossing. When an approaching vehicle is identified as not preparing to stop for the crossing, the roadside system will send a message to the appropriate vehicle(s) indicating that advanced measures should be taken to stop the vehicle.

The following figure shows a vehicle approaching a railroad grade crossing. When a train is approaching, the system at the grade crossing will begin broadcasting an RSA to nearby vehicles notifying them of the train.

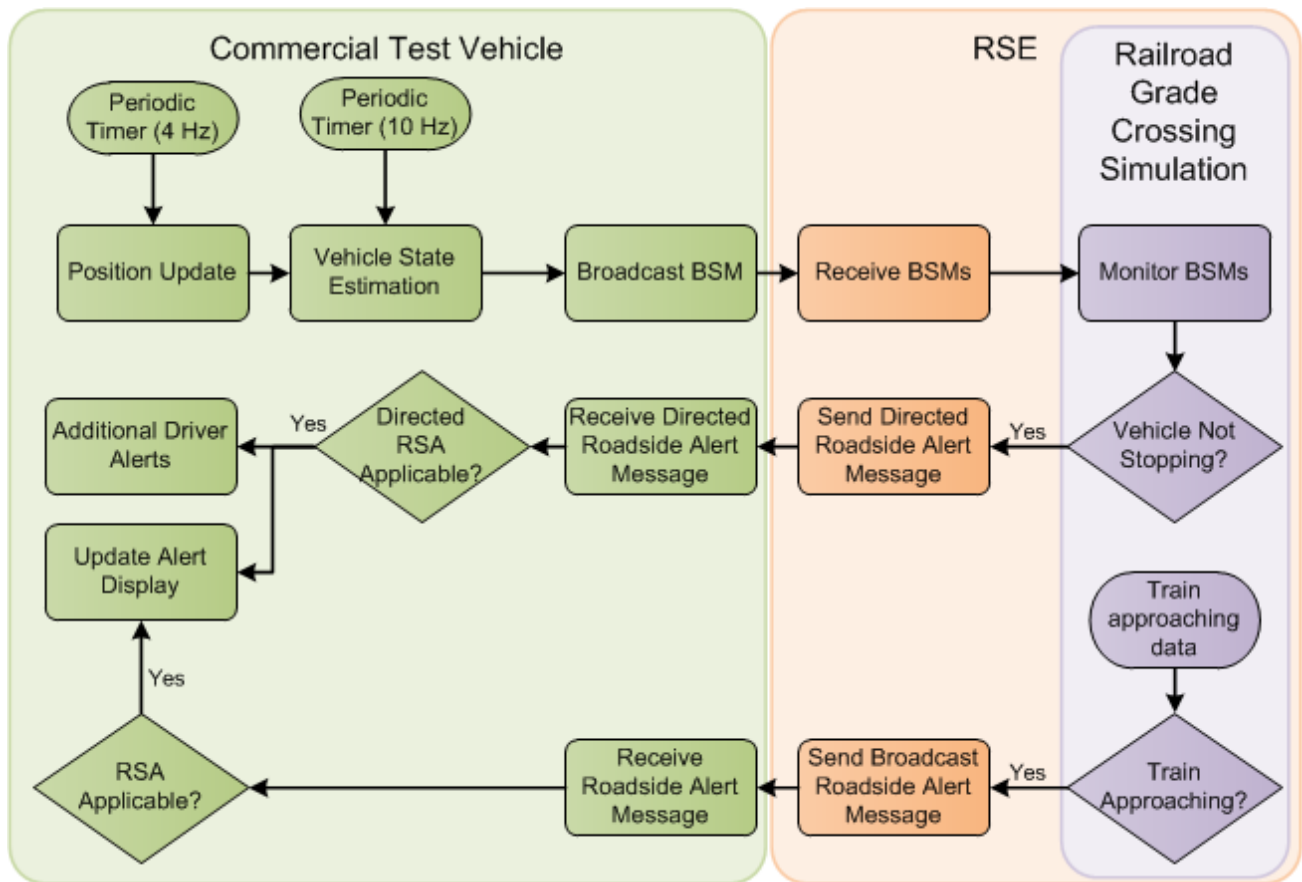


The following figure shows a vehicle continuing to approach the grade crossing after the RSAs have been broadcast. The system at the grade crossing will monitor BSMs from the vehicle, and if the position, speed, and size of the vehicle indicate that the vehicle will not safely clear the crossing prior to the train approaching and is not preparing to stop before reaching the crossing, an additional RSA message will be sent to that specific vehicle indicating an urgent need to stop the vehicle.



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The BSM is defined in the SAE J2735 message set to provide a complete, succinct, real-time message that describes each vehicles current dynamics, including speed, heading, and location. The following figure shows the overall flow of the BSM broadcast and monitoring process at a high level.



The detailed use cases for the service are detailed in the following paragraphs.

2.4.1 Vehicle State Estimation Use Case

Triggers:

- Periodic timer (default: 10 Hz)

Use Case:

- A position vector update is generated at a minimum of 4Hz and will allow sufficient accuracy of vehicle position to be determined. The exact positional accuracy required will be determined during initial testing.

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- The DMCU uses a dead-reckoning algorithm on the latest position vector updates to estimate the vehicle state at a 10 Hz Frequency. This operation is necessary as the BSM is intended to be broadcast at 10 Hz.
- The use case ends.

2.4.2 Broadcast BSM Use Case

Triggers:

- The system in the vehicle is started.

Use Case:

- The DMCU starts up and receives a valid GPS fix.
- The DMCU Broadcasts the BSM over DSRC at 10 Hz until the system is stopped.
- The use case ends.

2.4.3 Receive BSM Use Case

Triggers:

- BSM is received by the roadside system at the railroad grade crossing.

Use Case:

- The RSE:
 - Analyzes the BSM and determines if it is from a currently known vehicle.
[Alternative: BSM is from a previously unknown vehicle]
 - Updates the existing BSM for the vehicle.
- The use case ends.

Alternative: BSM is from a previously unknown vehicle

- Stores the BSM for the new vehicle.
- The use case ends.

2.4.4 Broadcast Roadside Alert Use Case

Triggers:

- Periodic Timer (10 Hz - default)
- Train approaching

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Use Case:

- The RSE:
 - Receives data indicating that a train is approaching the grade crossing.
 - Broadcasts the Roadside Alert Message with information available about the approaching train.
- The use case ends.

2.4.5 Monitor BSM Use Case

Triggers:

- Periodic Timer (10 Hz)

Use Case:

- The RSE:
 - [Alternative: No train is approaching]
 - Monitors the stored BSMs to identify vehicle(s) that are in regions of interest and have movement vectors of interest.
 - Determines that a vehicle is not preparing to stop in time for the grade crossing.
 - Sends a directed Roadside Alert Message to the vehicle.
- The use case ends.

Alternative: No train is approaching

- The use case ends.

2.4.6 Vehicle Receives Roadside Alert Broadcast Use Case

Triggers:

- RSE broadcasts a Roadside Alert Message.

Use Case:

- The DMCU:
 - Determines that the message is applicable to the vehicle based on the vehicles position, movement, and location of the grade crossing.
 - [Alternative: RSA Message is not applicable]
 - Sends a traveler advisory message to the TGW.

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- The TGW updates the display.
- The use case ends.

Alternative: RSA Message is not applicable

- The use case ends.

2.4.7 Vehicle Receives Directed Roadside Alert Message Use Case

Triggers:

- RSE sends a Roadside Alert Message directed to the specific vehicle.

Use Case:

- The DMCU:
 - Verifies that the message is applicable to the vehicle based on the vehicles position, movement, and location of the grade crossing.
[Alternative: Directed Roadside Alert Message is not applicable]
 - Sends additional message information to the TGW.
- The TGW displays the warning condition to the driver within the constraints of:
 - Driver distraction management
- The use case ends.

Alternative: Directed Roadside Alert Message is not applicable

- The use case ends.

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3 Task 10 Requirements

3.1 General

Req TASK10-002/1.0: Roadside Alert Message

The Roadside Alert Message as defined in Reference [3] shall, as a minimum, contain the following information:

- Roadside Alert:
 - Event Type
 - Description
 - Priority
 - Applicable Headings
 - Extent
 - Position Vector
 - Longitude
 - Latitude
 - Heading
 - Speed
- Vehicle Group Affected

3.2 DMCU Vehicle Alert Application

Req TASK10-003/1.0: Roadside Alert ITIS Codes

The DMCU shall support the following ITIS codes as defined in Reference [7]:

- 11047 - train
- 7186 – prepare-to-stop
- 7182 – turn-off-engine

Req TASK10-004/1.0: Roadside Alert Reception

The DMCU shall be capable of receiving and caching Roadside Alert Messages, defined in Reference [3].

Req TASK10-005/1.0: New Roadside Alert

The DMCU shall analyze each received BSM to determine if it is new prior to caching it.

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Req TASK10-006/1.0: Applicable Roadside Alert

The DMCU shall use the following criteria to analyze each received Roadside Alert to determine if it is applicable prior to generating an advisory for it.

- Event Type
- Extent
- Position Vector
 - Longitude
 - Latitude
 - Heading
 - Speed

Req TASK10-007/1.0: No Longer Applicable Roadside Alert

The DMCU shall remove Roadside Alerts that are no longer applicable from its message cache.

Req TASK10-008/1.0: Display Roadside Alert

The DMCU shall send a Travel Advisory message to TGW when a Roadside Alert Message is applicable, using the protocol defined in Reference [4].

3.3 TGW Alert Application

Req TASK10-009/1.0: Roadside Alert Traveler Advisory Caching

When a Roadside Alert Traveler Advisory is received from the DMCU via the protocol defined in Reference [4], the TGW shall cache the advisory until it is deleted or until the end of the driving cycle.

Req TASK10-010/1.0: Roadside Alert Traveler Advisory Priority

The TGW shall prioritize Roadside Alert Traveler Advisories above J2735 traveler advisories.

Req TASK10-011/1.0: Driver Distraction Management

To the greatest degree possible, the TGW shall support the driver distraction management principles defined in Reference [5].

Req TASK10-012/1.0: Roadside Alert Traveler Advisory Display

Roadside Alert Traveler Advisories shall be automatically displayed to the driver as they are received.

Req TASK10-013/1.0: Roadside Alert Traveler Advisory Clearing

The driver shall be capable of clearing a traveler advisory from the display.

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Req TASK10-014/1.0: Roadside Alert Traveler Advisory Deletion

When a Roadside Alert Traveler Advisory deletion is received from the DMCU via the protocol defined in Reference [4], the TGW shall remove the traveler advisory from the cache and, if applicable, from active display.

Req TASK10-015/1.0: Imminent Collision Roadside Alert

When a Roadside Alert Traveler Advisory signaling an imminent collision is received from the DMCU, the TGW shall issue an audible alert through the HVI.



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