NTRCI

NATIONAL TRANSPORTATION RESEARCH CENTER, INCORPORATED
University Transportation Center

Project U17: Trusted Truck® II (Phase C)

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16. Abstract

The states conduct close to 750,000 roadside inspections of commercial vehicles per year. Even with this seemingly large number of inspections, the states are still being overwhelmed with the burden of performing inspections in a fashion that ensures the carriers are complying with safety regulations without impacting the profitability of the carriers. In the first Trusted Truck® project Volvo helped demonstrate the ability to perform brake inspections wirelessly between the vehicle and the state's roadside infrastructure.

The first two phases of the Trusted Truck® II project built off of that initial project to further explore the concept of building a relationship of trust with commercial vehicles and motor carriers through wireless roadside inspections and compliance along with ways that would help enhance the efficiencies of the carriers. The goal will be to move closer to defining a mechanism for performing wireless roadside inspections (WRI).

This third phase focused mainly on preparation work for the final Phase D. Phase C of the Trusted Truck® project was a preparatory step that delivered the system architecture specification, a demonstration of the system prototype during a bypass operation, and a plan to introduce the Trusted Truck® Management Center to industry and government.

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List of Definitions

ACRONYM	DEFINITION
CMRS	Commercial Mobile Radio Service
FOC	Fleet Operations Center
HOS	Hours of Service
NTRCI	National Transportation Research Center, Inc., University Transportation Center
OBE	On-Board Equipment
OEM	Original Equipment Manufacturer
SDMS	Safety Data Message Set
TCP/IP	Transmission Control Protocol / Internet Protocol
TTMC	Trusted Truck® Management Center
TTMS	Trusted Truck® Message Set
UDP	User Datagram Protocol
UT	University of Tennessee
VTEC	Volvo Technology
VMS	Volvo Message System
VOLPE	John A. Volpe National Transportation Systems Center
WCF	Windows® Communication Foundation

Executive Summary

Phase C of Trusted Truck® II successfully developed the implementation plan and system architecture for the final Phase D development project. In addition, the project team successfully demonstrated in the laboratory the addition of data encryption to the TTMC interfaces to ensure secure delivery of sensitive vehicle or driver data using the internet.

The following is the list of deliverables completed in Phase C of the project and included in this final report:

- Phase C System Requirements Specification (SRS) Document
- Trusted Truck® System Architecture Document
- Phase D Implementation Plan
- Lab demonstration of TTMC working prototype including the encryption technology

Chapter 1 – General Overview

Background

The states conduct close to 750,000 roadside inspections of commercial vehicles per year. Even with this seemingly large number of inspections, the states are still being overwhelmed with the burden of performing inspections in a fashion that ensures the carriers are complying with safety regulations without impacting the profitability of the carriers. In the first Trusted Truck® project Volvo helped demonstrate the ability to perform brake inspections wirelessly between the vehicle and the state's roadside infrastructure.

The first two phases of the Trusted Truck® II project built off of that initial project to further explore the concept of building a relationship of trust with commercial vehicles and motor carriers through wireless roadside inspections and compliance along with ways that would help enhance the efficiencies of the carriers. The goal will be to move closer to defining a mechanism for performing wireless roadside inspections (WRI).

This third phase will focus mainly on preparation work for the final phase. Phase C of the Trusted Truck® project was a preparatory step toward Phase D, such that Phase C delivered the system architecture specification, a demonstration of the system prototype during a bypass operation, and a plan to introduce the Trusted Truck® Management Center to industry and government.

Project Team

The organizations that took part in this phase of the project are the following:

- National Transportation Research Center, Inc., University Transportation Center
- University of Tennessee
- Volvo Technology of America

Project Description

The main task of Phase C was to develop the implementation plan and system architecture development in preparation for the final Phase D development project. A goal of Phase C was to leverage the work on data encryption. This will add encryption to the TTMC interfaces to ensure secure delivery of sensitive vehicle or driver data. A lab demonstration of the TTMC with additional encryption was completed to demonstrate the integration.

The following is the list of deliverables for the Phase C project:

- Phase C System Requirements Specification (SRS) Document
- Trusted Truck® System Architecture Document
- Phase D Implementation Plan
- Lab demonstration of TTMC working prototype including the encryption technology
- A final report

Chapter 2 – Phase C Activities

This chapter summarizes work done during Phase C which includes continued development of the Trusted Truck® concept and development of the Phase D Plan including a field demonstration of the concept.

Requirements

The high-level requirements for Phase C included the following:

- Specify the System Architecture
- Generate a Detailed Plan for Phase D
- Demonstrate the TTMC Prototype

The System Architecture Specification and Phase D Plan are attached as appendices in this document.

System Architecture

The system architecture specification work done in this phase was needed to define the interaction of the major system components, including the interfaces between a vehicle, and the servers operated by the FOC, TTMC, and VOLPE. The following architectural elements were specified:

Functions: Data sources, processing, security

Deployment: How the functionality is distributed across the system

Interfaces: Available commands and responses

Messages: Ordering and formatting

Communication: Wireless standard, network protocols

Use Cases: Transactions, signal flow sequences

Message Set

In order to define the architecture there was a need to gather functional requirements, and to obtain advanced information on WRI-related initiatives, and as yet undefined interfaces. This information would provide the basis for a determination of the TTMS, and the best data items to include there. This allowed the TTMS to exceed the minimum requirement of the SDMS and provide specific data items that while not required, were of some interest to the government and whose use was not objectionable to the private sector.

Communication Path

After some discussion with those involved in WRI initiatives, and consideration of the needs of the target market (specific states), CMRS was deemed sufficient for use as the communication path in the Phase C demonstration. Part of the consideration here was the fact that CMRS compatible equipment was currently available for use (truck HW). This however posed no restriction to the use of DSRC in Phase D, if that choice were to be made.

Data Security

A strong measure of data security was required in order to gain the trust of the private sector, including owners and OEMs who would strongly prefer to see itemized data transported securely across networks, and not made available to third-parties. UT had completed a project, just prior to Phase C, to design and test encryption algorithms that are specially formulated for this application. Based on standard encryption methods, the calculations were subdivided in a new way to allow efficient execution on the sparse processors typically found on existing vehicles.

In Phase C, security was implemented to the point at which the TTMS was encrypted and transmitted to the TTMC using a fixed session key. Phase D will see the full implementation in which the OBE and TTMC exchange security credentials (certificates), validate them, and then generate a new encryption (session) key for each bypass.

Network Protocol

Based on VTEC wireless communication experience, and studies performed at VTEC, the decision was made to use UDP, as opposed to TCPIP as the network transport protocol. The use of this protocol allowed more efficient, less processor-intensive operation on the vehicle by reducing overhead communication. To allow guaranteed delivery of these messages, the WTP was also implemented.

Based on server-side implementations previously used at VTEC, a decision was taken to implement server communication based on WCF. This provides a basic, commonly used interface for server-interoperability.

These choices for network communication are in keeping with the non-functional project requirement of using non-proprietary processing and standard protocols where possible.

Phase D Plan

One of the major accomplishments in this phase was the generation of a detailed plan that will be used to define all aspects of the Trusted Truck® concept. This plan describes how to provide an introduction to the concept, as well as detailed technical information, and general guidance for the stakeholders in the private sector so that Trusted Truck® can quickly be realized as a viable business entity.

Thus it was decided that the plan must include certain items:

- Specify video content and message
- Specify the Certificate of Trust
- Specify instructions on how to create a Trusted Truck®
- Specify inspection data items, sourcing and handling of data

The implementation and technical issues that will be resolved in Phase D include the following:

- Specify detailed use cases for all transactions that occur in the system between TTMC, VOLPE, VMS, and OBE.
- Complete the TTMC implementation.
- Complete the VMS implementation to the point that data obtained at the VMS can be added to the truck data before sending to the TTMC, and that a bypass indication is returned to the OBE. (Phase C functionality is limited to passing the encrypted OBE data to the TTMC only.)
- Complete the OBE implementation to the point that data security certificates can be exchanged, verified, and used to generate the session key. (Phase C functionality is limited to encryption of the OBE data with a fixed session key.)
- Specify and implement a means by which a bypass sequence can be manually triggered. This will serve as a convenient means to verify the TTMC from the roadside, or as a pre-trip inspection.
- Specify exactly how timestamps will be used in the system.
- If CMRS (comm. Channel B) is used, specify the process used to update vehicles with the latest list of geofence coordinates.
- Specify the process used to update the root-certificate at TTMC and OBE.
- Perform system integration between OBE, VMS, and TTMC.

Demonstration

The Phase C implementation was demonstrated on July 15, 2009. The demo was carried out using an actual vehicle on a public roadway:

- An 18-wheel research truck was used to collect inspection data from tractor, trailer, and driver.
- Those data were assembled into an inspection message, encrypted, and transmitted over a public wireless network (AT&T).

- That message was received at the prototype VMS server operating at a Volvo facility.
- The message was then processed using a fleet-specific application, to separate fleet-private data from the encrypted message.
- The encrypted payload was then transmitted over the internet to the prototype TTMC server operating at UT.
- The inspection message was successfully decrypted and viewed at the TTMC server interface.

Chapter 3 – Summary and Conclusions

Phase C successfully implemented the data security component into the prototype Trusted Truck® Management Center which was demonstrated in the laboratory at the University of Tennessee with the Trusted Truck® operating in North Carolina at the Volvo research facility. In addition the work plan for Phase D was completed.

The following is the list of deliverables completed:

- Phase C System Requirements Specification (SRS) Document
- Trusted Truck® System Architecture Document
- Phase D Implementation Plan
- Lab demonstration of TTMC working prototype including the encryption technology
- A final report

Appendix A

System Requirements Specification

General Information

What is the purpose of this document?

This document describes the NTRCI Trusted Truck® 2 system requirements.

Who should read this document?

Anyone associated with the NTRCI Trusted Truck® 2 project.

How is this document organized?

This document is generated from requirements housed in Caliber RM requirements management tool.

How do you receive more information?

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Revision History

Issue	Date	Author	Changes
1.0	31 Aug 2007	Paul Muschick	Originated
1.1	19 Oct 2007	Paul Muschick	Customer comments after inspection station visit
1.2	24 Oct 2007	Paul Muschick	Aligned with presentation
1.3	07 Nov 2007	Paul Muschick	Added tire temperature and IFTA number to inspection data
1.4	28 Nov 2007	Paul Muschick	Changed wording involving “bypassing the inspection station”
1.5	11 Dec 2007	Paul Muschick	Added missing requirements from SDD to provide a more complete picture and updated graphics
1.6	12 Dec 2007	Paul Muschick	Added automatic inspection criteria, replaced “RSC” with “TTMC,” and introduced the Bypass Notifier
2.0	08 Aug 2008	Paul Muschick	Added year 2 features (driver login, trailer TPM, tractor and trailer weight, and shipment info)
2.1	08 Aug 2008	Paul Muschick	Added missing trailer eStroke brake information (implemented in year 1)
2.2	14 Aug 2008	Paul Muschick	Added trailer “electronic seal” status and shipment weight, removed “Notification Dismissal” requirement
2.3	25 Mar 2009	George Bitar	Added description of Phase C requirement for Data Security.

Reference Documents

Standard Documents

[1] VTEC Online BMS

[2] 6980-01 VTEC-US BMS Supplement

Customer Applicable Documents

[3] 6980-01793-13 TT2 Statement of Work

Terminology

Abbreviations/ Definitions

DSRC	Dedicated Short Range Communications
GPS	Global Positioning System
GSM	Global System for Mobile communcations
HMI	Human Machine Interface
NOK	Not OK - A negative condition or response (the opposite of "OK")
NTRCI	National Transportation Research Center, Inc.
OBC	On-Board Component - The hardware and software in the vehicle
TTMC	Trusted Truck® Management Center which is part of the RSC that receives the inspection data from the OBC, responds to the vehicle with the inspection result, and if necessary, notifies the Bypass Notifier
VIN	Vehicle Identification Number
VTEC	Volvo Technology Corporation
VTEC-US	Volvo Technology Corporation-United States

System Requirements

Overview

The system shall be designed to facilitate a "wireless inspection" of a commercial vehicle as it approaches an inspection station. The concept encompasses vehicle data that can provide a profile of the vehicle that determines whether it is "trusted" enough to bypass the station or otherwise must enter the inspection station along with the general population (i.e. all other non-"Trusted Trucks").

A graphical system overview is below.

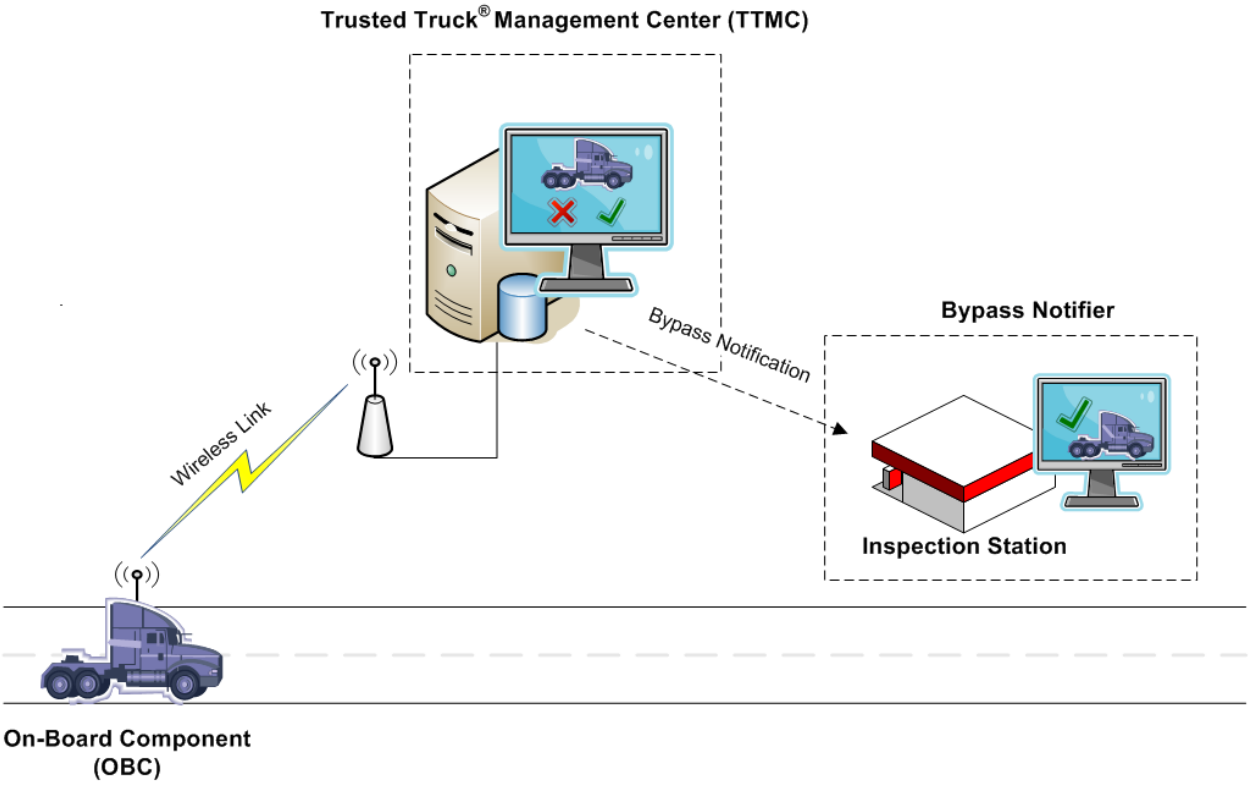

Figure A- 1. Diagram. System Overview.

The system contains three parts: the On-Board Component (OBC), the Trusted Truck® Management Center (TTMC) and the Bypass Notifier. The On-Board Component resides in the vehicle, the TTMC resides at a (potentially) off-site location, and the Bypass Notifier resides at the inspection station. The OBC and the TTMC are communicating via a wireless communication link, while the TTMC and the Bypass Notifier use a wire link.

The TTMC will display the inspection data, received from the OBC, to the user and allow the user to respond with the approval or disapproval for bypassing the inspection station. The Bypass Notifier, when triggered by the TTMC, will provide notification to the inspection station's personnel when a “trusted” vehicle is cleared to bypass the inspection station. Additionally, the TTMC will be designed to support possible future functions that could enable historical records for each vehicle to establish "trust" in the vehicle and/or carrier with regard to inspections, leading to an incentive for vehicle operators to keep their vehicles' safety and maintenance standards high. As a further benefit, a future function of the TTMC will provide vehicle operators with notification of failed wireless inspections. This will assist vehicle operators in keeping their vehicles' safety and maintenance standards high.

On approaching the inspection station, the OBC will collect inspection data from the vehicle's electronic systems and transfer the inspection data to the TTMC. The OBC will also provide a notification to the vehicle driver regarding the approval or disapproval of bypassing the inspection station (i.e. the result of the wireless inspection), as received from the TTMC . If the vehicle must enter the inspection station, the inspection station personnel are not notified of the failed wireless inspection and the vehicle is treated no differently than the general population (i.e. all other non-"Trusted Trucks").

Wireless Link

The OBC and TTMC shall communicate wirelessly via GSM according to the following diagram.

Figure A- 2. Diagram. Wireless Link.

Sending of Inspection Data

When the vehicle approaches the inspection station, the OBC shall send vehicle and driver data to the TTMC. The approach distance at which this action is triggered shall be determined through testing in order to give ample time for the TTMC to analyze the received inspection data and respond to the vehicle, potentially allowing the vehicle to bypass the inspection station.

Vehicle Data

The OBC shall provide the following vehicle-related information to the TTMC:

- Vehicle Identification Numbers (VIN) for the tractor and trailer
- US Department of Transportation number (US DOT#)
- License plate number and issuing state abbreviation for the tractor and trailer
- International Fuel Tax Agreement (IFTA) number
- Identifying description of the tractor (color, type [daycab or sleeper] and make [Volvo])
- Identifying description of the trailer (type, color if applicable)
- Tractor tire pressure and temperature
- Trailer tire pressure and temperature
- Tractor weight
- Trailer weight
- Tractor lighting OK/NOK
- Fire extinguisher presence and operational OK/NOK
- Tractor Anti-lock Braking System OK/NOK
- Tractor brake system condition as reported by MGM's eStroke system
- Trailer brake system condition as reported by MGM's eStroke system

Driver Data

The OBC shall provide the following driver-related information to the TTMC:

- Commercial Driver’s License number (CDL#)
- Current seat belt usage

Programmable Data

The following data shall be programmable without modifying the software in the OBC:

- Vehicle Identification Numbers (VIN) for the trailer
- US Department of Transportation Number (US DOT#)
- International Fuel Tax Agreement (IFTA) number
- License plate number and issuing state abbreviation for the tractor and the trailer
- Identifying description of the tractor (color, type [daycab or sleeper] and make [Volvo])

- Identifying description of the trailer (type, color if applicable)
- Commercial Driver's License number (CDL#)

Inspection Data Response

The TTMC shall provide approval or disapproval for bypassing the inspection station to the OBC after receiving the OBC's vehicle and driver data, giving the driver ample time to enter or bypass the inspection station. The TTMC's response may be generated manually by the user, or automatically by the TTMC.

Automatic Inspection Response Criteria

When the TTMC is configured to automatically generate inspection responses, the TTMC shall use the following criteria to determine if the vehicle is approved to bypass the inspection station.

At the instance the "wireless inspection" is performed, the vehicle shall not have:

- A driver whom is not logged-in
- One of more tires with a pressure condition reported as "extreme over pressure" or "extreme under pressure" by the vehicle's tire pressure monitoring system.
    - The following conditions are allowed for any number of tires: "over pressure", "under pressure", "error indicator" and "not available".
- One or more brake assemblies reported as "non-functioning", "overstroke", or "dragging brake".
    - The following condition is allowed for any number of brake assemblies: "sensor error".
- One or more brake assemblies reported as having "0% lining remaining".
    - The following condition is allowed for any number of brake assemblies: "10% lining remaining".

      Note: The fire extinguisher presence and operational status, tractor ABS status, and driver seal belt usage data items are not part of the automatic inspection criteria.

Driver Notification

The OBC shall notify the driver of the TTMC's approval or disapproval for bypassing the inspection station.

Inspection Data Display

The TTMC shall display the inspection data provided by a new vehicle approaching the inspection station.

Lookup of Additional Information

The TTMC shall combine the inspection data received from the vehicle with additional information as retrieved from a data store. The relationship between the received inspection data and the additional information is provided in the following table.

Table A- 1. Information Lookup Items.

Driver's CDL#	First and Last Name
	Residential Address
	DMV Photograph
Tractor's USDOT#	Carrier's Name
	Carrier's Contact Information
	Carrier's Logo
Tractor's VIN	Make
	Model
	Year
	Type/Style
	Primary and Secondary (if applicable) Colors
Trailer's VIN	Shipment – Origin Address
	Shipment – Destination Address
	Shipment – Name/Description
	Shipment – Quantity
	Shipment – Weight

Bypass Approval Notification

The TTMC shall trigger the Bypass Notifier to notify the inspection station's personnel when a "Trusted Truck" has been allowed to bypass the inspection station. The notification allows the bypassing truck to be positively identified and prevents needless interception by law enforcement personnel.

Bypass Disapproval Concealment

The TTMC shall not provide a notification to the inspection station's personnel when a vehicle is not approved to bypass the inspection station (i.e. fails the wireless

inspection). The "untrusted" vehicle is not to be flagged or examined any differently than a vehicle of the general population.

Driver Authentication

The driver shall have successfully authenticated him/her-self with the TTMC in order to establish the vehicle as a Trusted Truck®. A vehicle without an authenticated driver shall not be trusted.

Data Security

All data transmitted from the OBC for use by the TTMC shall be encrypted in accordance with "Trusted Truck Crypto Document", Scott Livingston, November 13, 2008. This will ensure that no modification is possible by the OEM or third parties.

Guaranteed Delivery

The data transmission shall be implemented over a transport that includes guaranteed delivery (e.g. WTP, TCP).

Platform Independence

The encryption of data shall be implemented in a way to exclude any dependence on the platform hardware or software.

Transport Independence

The encryption of data shall be implemented in a way to exclude any dependence on the transport layer (e.g.UDP , TCP).

Appendix B

System Architecture Document

Document Information

What is the purpose of this document?

This document provides a comprehensive architectural overview of the non-Volvo proprietary elements of the Trusted Truck® 2 platform demonstration system, as built, using a number of different architectural views to depict different aspects of the system. It is intended to capture and convey the significant architectural decisions which have been made on the system.

This document will not address requirements associated with the Trusted Truck® project, the overall functionality, or the detailed use cases associated with it. It will also not detail Volvo proprietary information.

How is this document organized?

The System Architecture Document defines the overall architecture of applications participating in the Trusted Truck® concept as of the end of the Phase C project.

A table is included which equates Safety Data Message Set elements as defined by FMCSA to the various data elements included in the Trusted Truck® messaging structure, including the data type and the data source within the solution.

Terminology

Abbreviations

CVSA – Commercial Vehicle Safety Alliance
FMCSA – Federal Motor Carrier Safety Administration
Volpe – John A. Volpe National Transportation Systems Center
TTMS – Trusted Truck® Message Set
SDMS – Safety Data Message Set
TTMC – Trusted Truck® Management Center
FOC – Fleet Operations Center
EOBR – Electronic On-Board Recorder
HOS – Hours of Service Log
CMV – Commercial Motor Vehicle

Architectural Description

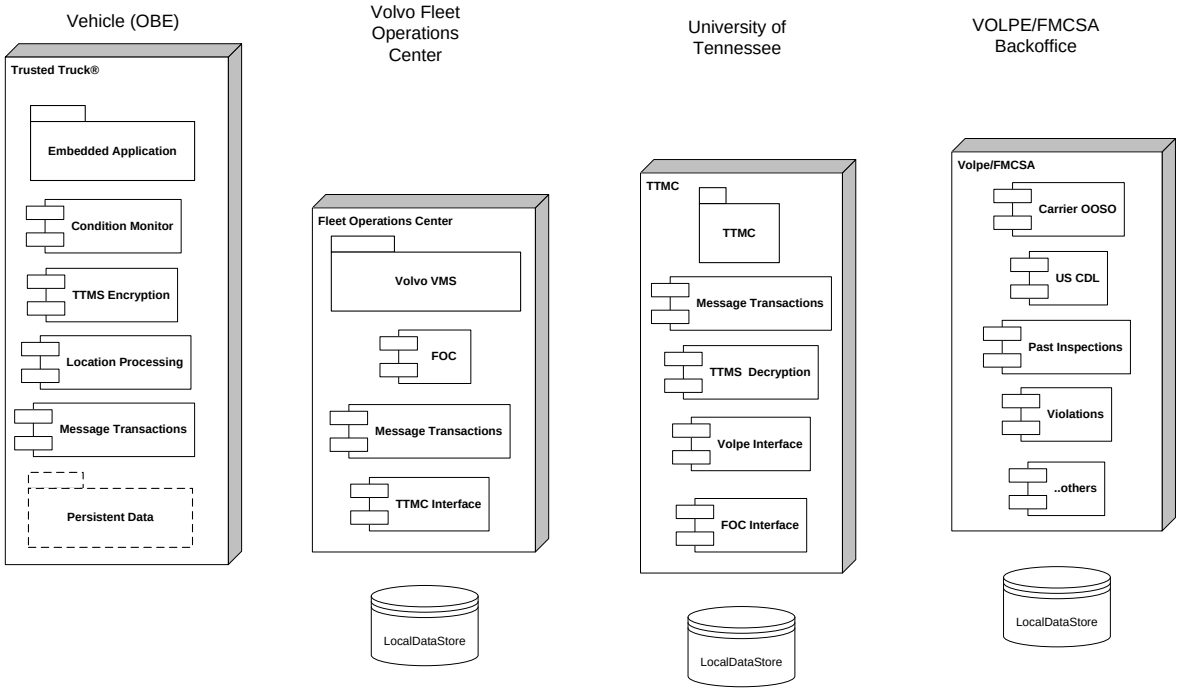

Figure B- 1. Diagram. Deployment View.

On-Board Equipment (OBE)

OBE consists of one or many embedded applications responsible for collecting sensor and other information while the truck is deployed, keeping track of the trucks current position, and when appropriate, packaging and transmitting that information via telematic gateway to the Fleet Operations Center (FOC). These applications are specific to the original equipment manufacturer, and shall be considered proprietary from the perspective of this document. In addition, an embedded application is responsible for providing a method for entering the driver's identification, a PIN in this demonstrator package. The PIN is encapsulated into a message and transmitted for the purpose of driver identification as part of the Trusted Truck® philosophy.

The Phase C project added data encryption to the data transfer between the OBE and TTMC such that the OBE can perform encryption, but only the TTMC can perform decryption. A simple implementation has been included in Phase C, but a more robust version will be implemented in Phase D.

Fleet Operations Center (FOC)

This application is responsible for transacting data between the Volvo back office and the truck. It also provides the interface to the TTMC application being written by the University of Tennessee. This application has the responsibility of receiving an encrypted packet from the truck, adding information associated with the vehicle, driver, and payload, then transacting all

the information with the TTMC, and represents the core of potential commercial services that might be offered by Volvo for fleet customers interested in taking advantage of the Trusted Truck® philosophy.

The Trusted Truck® Management Center consists of two applications: TTMC and BypassNotifier. TTMC is responsible for providing a user interface to the inspecting officer to manually decide if a truck should be trusted, and thus be allowed to bypass the physical inspection station, or not. All inbound messages from the "trusted" truck are received by TTMC, including the TrustedTruck2Message, and the DriverAuthenticationMessage.

When a TrustedTruck2Message is received, the data is added to the internal inspection list making it available to the inspector. When an inspection has been processed, a TrustedTruck2Message is returned to the truck with Inspection Response, a Boolean value, set appropriately.

If the response was an approval to bypass, a Vehicle InspectionMessage is formatted from the data and sent to the BypassNotifier. This application is intended to display the fact that a bypass was granted thus preventing enforcement officer intervention.

Trusted Truck® Management Center (TTMC)

During the course of the Phase C project, VTEC delivered a functional TTMC application with source code and an example of an interface that could be used between FOC and TTMC. However, UT is in the process of building the TTMC at the time of this writing. It is expected to have essentially the same feature set as that demonstrated during Phase B.

Volpe/FMCSA

Some investigation was performed by VTEC relating to the nature of the data and interfaces associated with the Volpe/FMCSA systems. Volpe has implemented XML-based web services (Hall, 2004). This implies that the most likely strategy for interface with the Volpe infrastructure will be accomplished in this manner.

Data Associated with Trusted Truck®

During Phase B and C, the project aimed primarily at the SDMS (The Johns Hopkins University Applied Physics Laboratory, 2008). During Phase C, the concept of the TTMS was developed, that being the data specifically transmitted from the truck to the FOC. Work was also completed to identify additional data items that would be interesting for inclusion in the product delivered both from the FOC to the TTMC, but also from the TTMC to FMCSA.

Trusted Truck® Message Set

The information delivered from the truck in encrypted form is packaged according to the TTMS Schema as shown in Figure B- 9. The entire schema is included in the three pages following Figure B- 9. The equation between the TTMS and the SDMS is defined in Table B- 1.

In order to improve the marketability of the Trusted Truck® concept to FMCSA, additional information that would be of value to the government, yet not sensitive to fleets was investigated. Four items found in the CVSA inspection system, namely, the annual vehicle inspection required by FMCSA; the drivers medical card; driver skill evaluation (when available); and drug and alcohol status could be supplied with the Trusted Truck® certificate of inspection both in the prototype and by typical fleets, and thus add credibility to the certificate of inspection. The medical card information will be managed by FMCSA in 2012, further simplifying the process of delivering the information (US Department of State, 2008). For the Phase D demo, however, a medical card will be included as will the FMCSA annual inspection, both delivered as "supplemental data" from the FOC to the TTMC.

Since all data may not be available from all CMV's at once, and more data will be available in the future and added to SDMS and TTMS, it may be desirable to implement a Trusted Truck® level of inspection based loosely on the CVSA strategy. Since the Certificate of Inspection must be negotiated with state and local governments, we will discover the desirability of this during Phase D.

Data Delivered to FMCSA – Certificate of Trust

FMCSA will receive a Certificate of Trust from the TTMC each time any given vehicle meets 100% of the inspection requirements associated with the certificate of trust. FMCSA receives nothing when a given vehicle is electronically inspected and found to be not in compliance.

Enhanced Data for FMCSA

TTMC should be prepared to deliver a number of statistical reports to FMCSA. These reports should focus on general statistics about populations of vehicles, the percentage failing the Trusted Truck® inspection, the distribution of causes of failure, etc. Examples of this information will be delivered as part of the Phase D project.

Enhanced Data for Fleets

Part of the incentive for fleets to participate should be to access reports specific to their fleet. Such reports may include fleet summaries of what failures occurred on fleet trucks, how the fleet compares to the general population of Trusted Trucks®, etc. Examples of this information will be delivered as part of the Phase D project.

Trusted Truck® Message Flow

The figure below details the message flow of data between the truck, the FOC, and the TTMC. An open issue is whether the TTMC must request supplementary information or if it is delivered with the encrypted report from the truck. Also, the return of the decrypted data for purposes of comparison to the fleet report from the truck is not described. These are considered to be open issues based on the completion of the TTMC by UT during the end of Phase C.

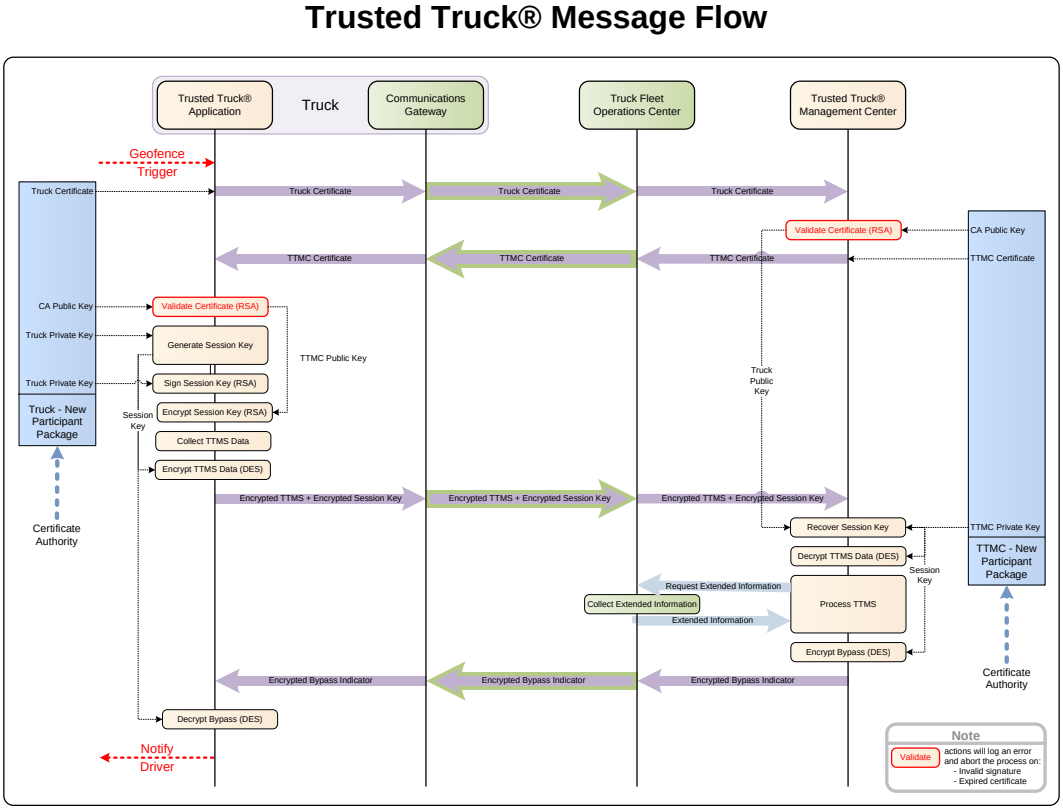

Figure B- 2. Diagram. Trusted Truck® Message Flow.

Implementation View

VTEC.Evolution.Messages

Class BaseServiceMessage is the base class for all messages transacted through the Volvo Messaging Server, and is the only member of the package.

BaseServiceMessage
-ObsAlias : uint -ServiceId : int -ServiceVersion : int
+BaseServiceMessage() : BaseServiceMessage

Figure B- 3. Display. BaseServiceMessage.

VTEC.Evolution.Messages.TrustedTruck2

The serialization and deserialization of this structure forms the basis of the TrustedTruck2 message. Note that BaseServiceMessage is the base class for this structure.

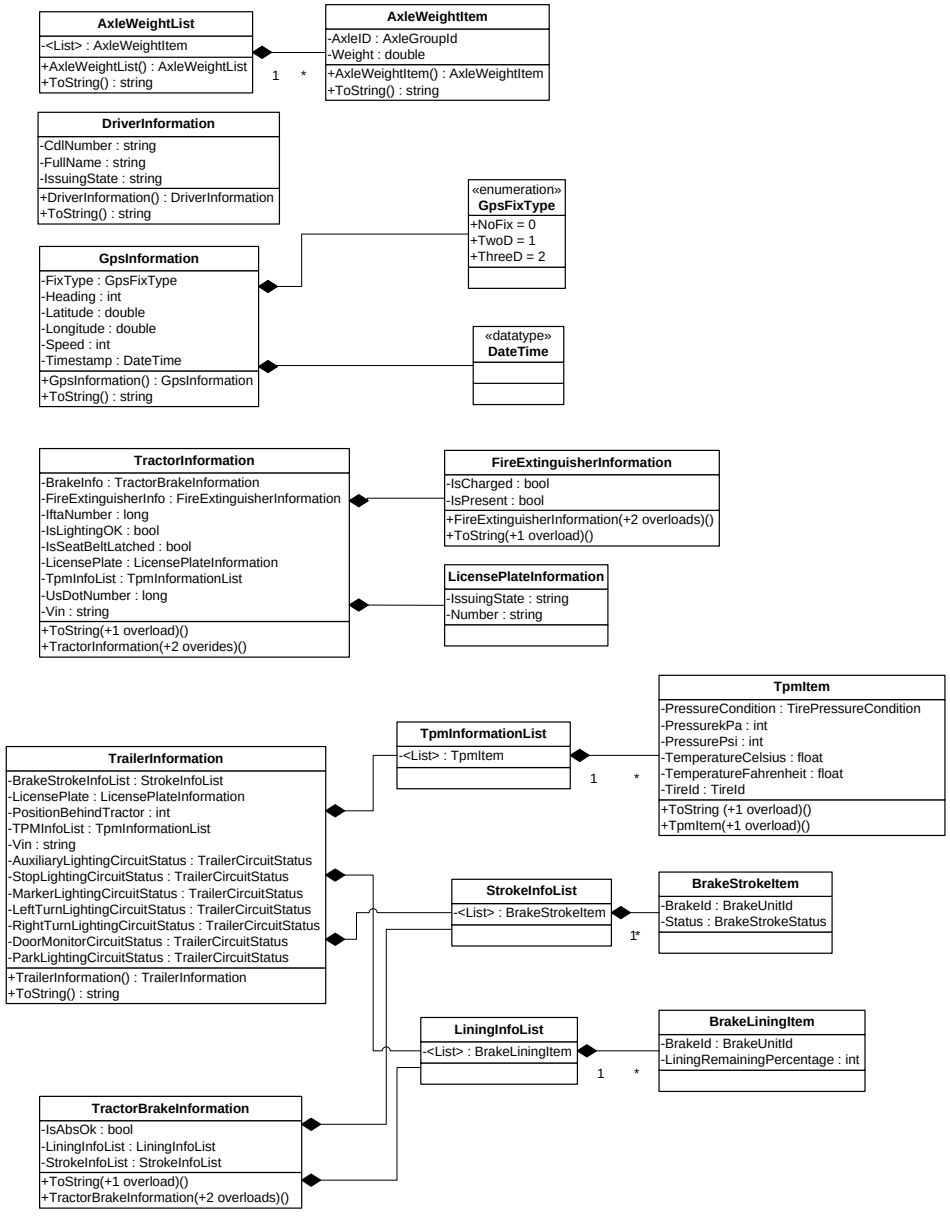

Figure B- 4. Display. TrustedTruck2.InspectionMessage.

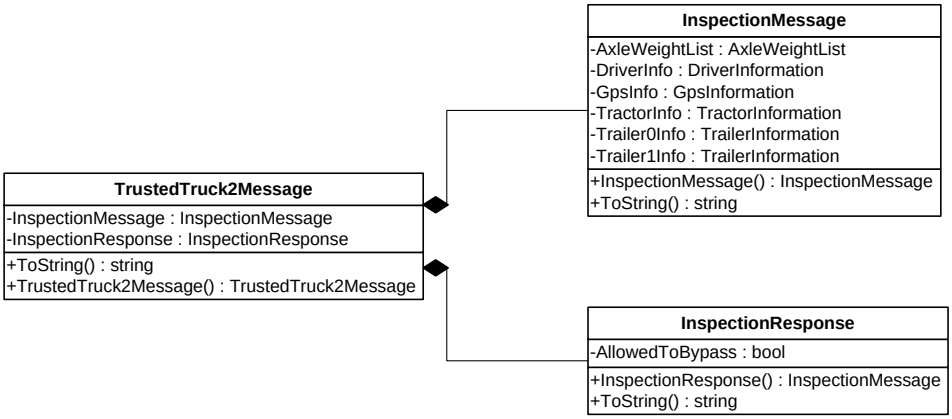

Figure B- 5. Display. TrustedTruck2Message.

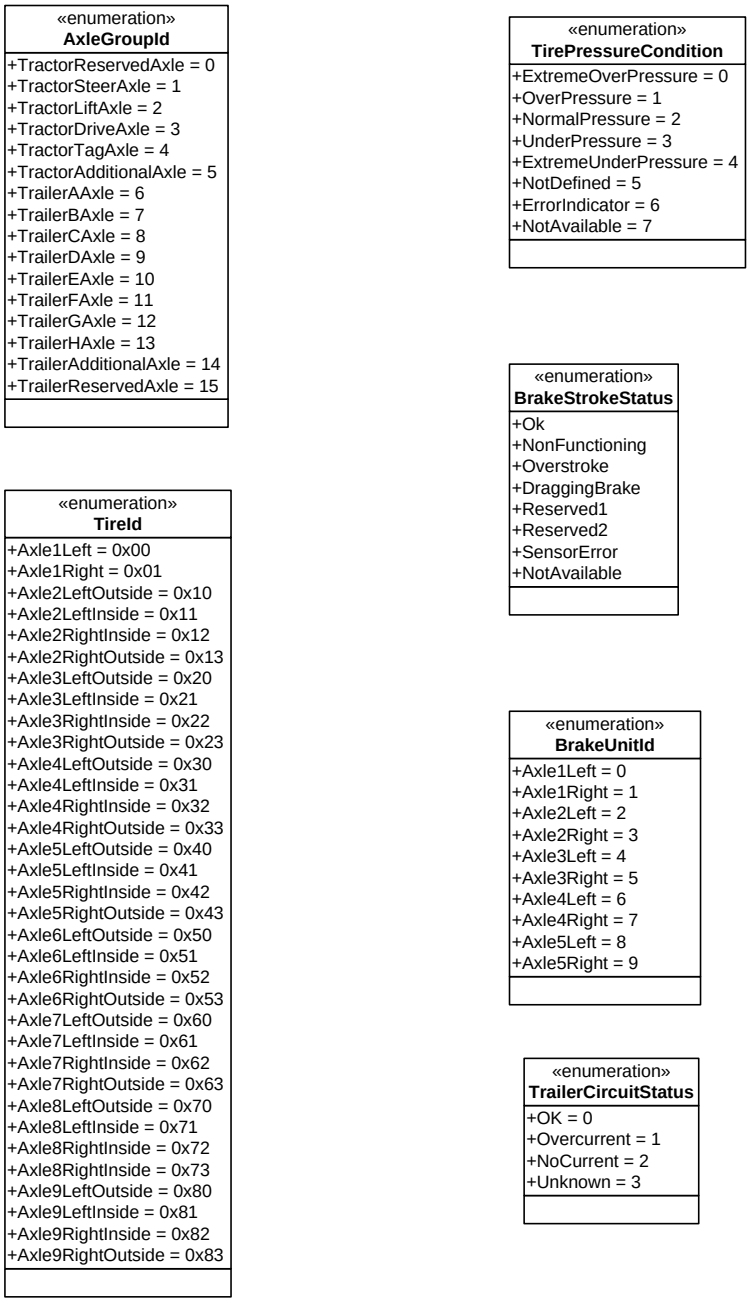

Figure B- 6. Display. Enumerations used within TrustedTruck2.InspectionMessage.

VTEC.TrustedTruck2.BackOffice

Classes defined in this structure are the basis for messages passed within the TTMC.

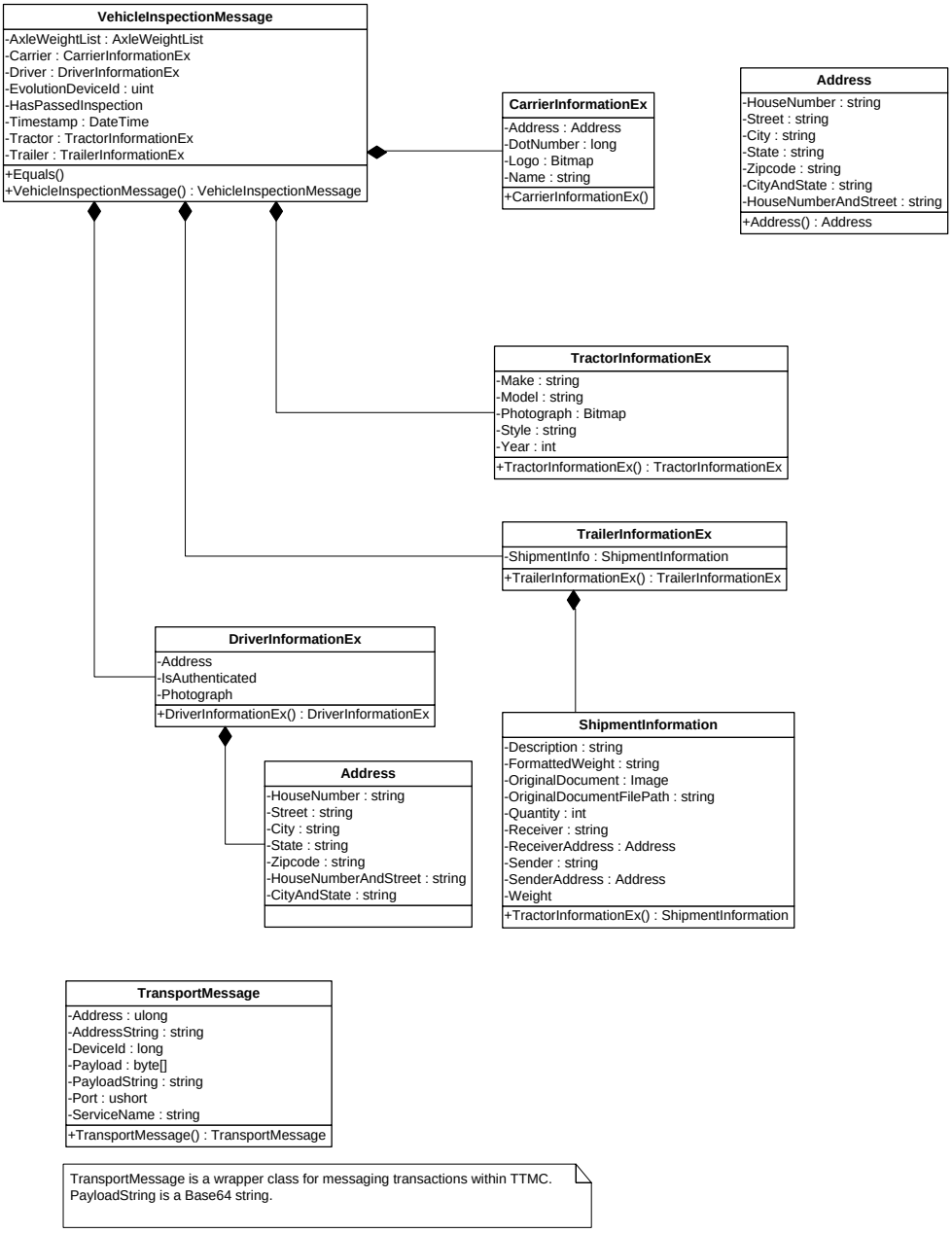

Figure B- 7. Display. VehicleInspectionMessage.

VTEC.Evolution.Messages.DriverAuthentication

Classes defined in this structure are the basis for messages passed between TTMC and the trusted truck to authenticate the driver.

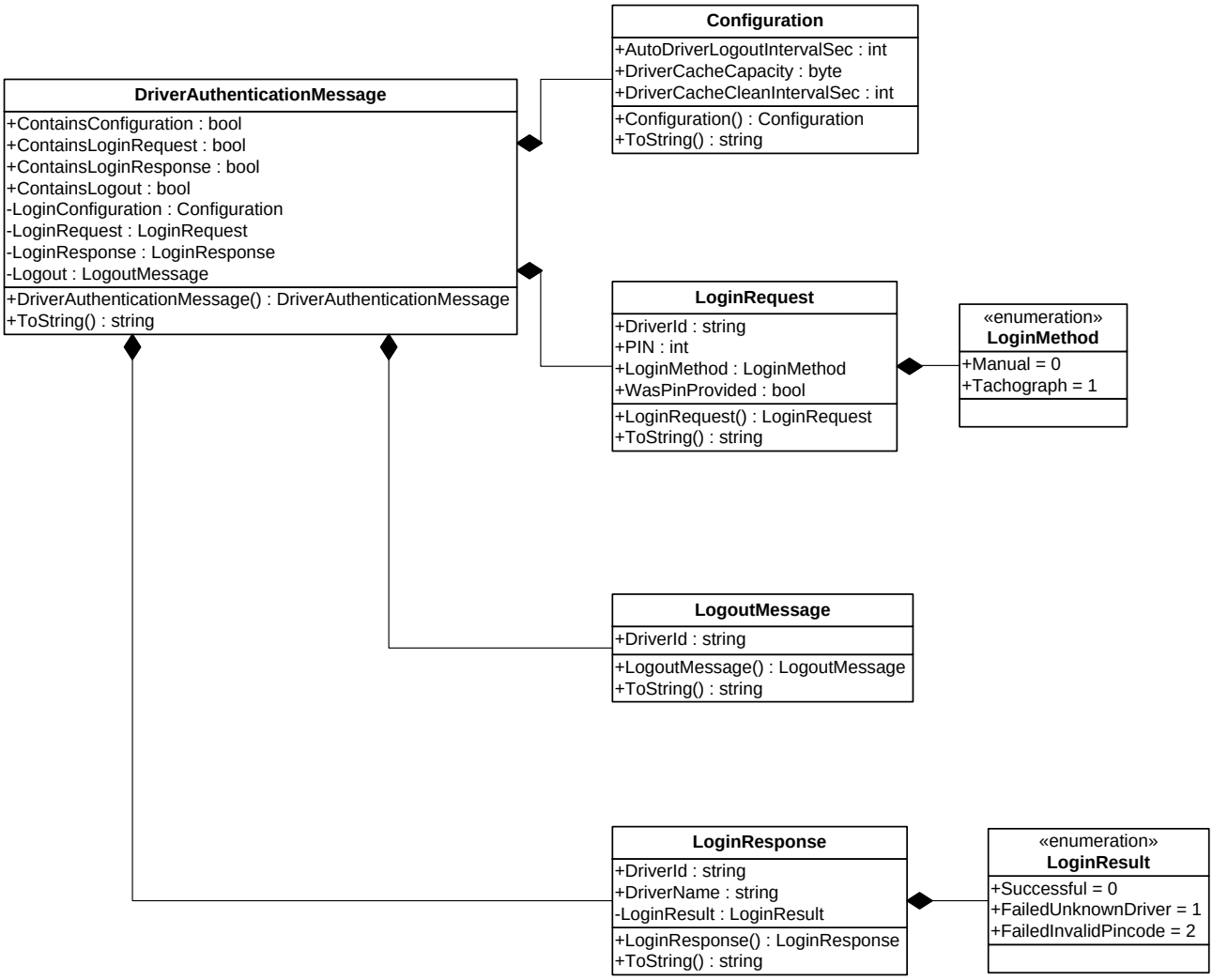

Figure B- 8. Display. DriverAuthenticationMessage.

Table B- 1. Correlation of Trusted Truck® to SDMS .

SDMS Entity	*SDMS Data Item*	*Trusted Truck® Data Identifier*	*Data Type*	*Notes*
Carrier	USDOT number	TrustedTruck2Message.InspectionMessage .TractorInfo.UsDotNumber	long	Local FOC Data Store
Carrier	Company name	VehicleInspectionMessage.Carrier.Name	string	Local FOC Data Store
Vehicle	Tractor Vin	TrustedTruck2Message.InspectionMessage .TractorInfo.Vin	string	embedded persistent data store
Vehicle	Tractor license plate jurisdiction	TrustedTruck2Message.InspectionMessage .TractorInfo.LicensePlate.IssuingState	string	Local FOC Data Store
Vehicle	Tractor license plate ID	TrustedTruck2Message.InspectionMessage .TractorInfo.LicensePlate.Number	string	Local FOC Data Store
Vehicle	Tractor unit number	Not Available		
Vehicle	Brakes, Tractor	TrustedTruck2Message.InspectionMessage .TractorInfo.BrakeInfo	TractorBrakeInformation	on-board sensor
Vehicle	Brakes, Trailer 1	TrustedTruck2Message.InspectionMessage .Trailer0Info.BrakeStrokeInfoList	TrailerInformation	on-board sensor
Vehicle	Brakes, Trailer 2	TrustedTruck2Message.InspectionMessage .Trailer1Info.BrakeStrokeInfoList	TrailerInformation	on-board sensor
Vehicle	Tire pressure, Tractor	TrustedTruck2Message.InspectionMessage .TractorInfo.TpmInfoList	TractorBrakeInformation	on-board sensor
Vehicle	Tire pressure, Trailer 0	TrustedTruck2Message.InspectionMessage .Trailer0Info.TpmInfoList	TrailerInformation	on-board sensor
Vehicle	Tire pressure, Trailer 1	TrustedTruck2Message.InspectionMessage .Trailer1Info.TpmInfoList	TrailerInformation	on-board sensor
Vehicle	Vehicle location	TrustedTruck2Message.InspectionMessage .GpsInfo	GpsInformation	Satellite communication
Vehicle	Weight	TrustedTruck2Message.InspectionMessage .AxleWeightList	AxleWeightList	on-board sensor
Vehicle	Date	TrustedTruck2Message.InspectionMessage .GpsInfo.Timestamp	DateTime	on-board sensor
Vehicle	Time	TrustedTruck2Message.InspectionMessage .GpsInfo.Timestamp	DateTime	on-board sensor
Vehicle Status	Lighting	TrustedTruck2Message.InspectionMessage .TractorInfo.isLightingOK	Boolean	on-board sensor
Vehicle Status	Safety belt	TrustedTruck2Message.InspectionMessage .TractorInfo.isSeatBeltLatched	Boolean	on-board sensor
Driver	Jurisdiction	TrustedTruck2Message.InspectionMessage .DriverInfo.IssuingState	string	Local FOC Data Store
Driver	License ID	TrustedTruck2Message.InspectionMessage .DriverInfo..CdlNumber	string	Local FOC Data Store
Driver	First name	TrustedTruck2Message.InspectionMessage .DriverInfo.FullName	string	Local FOC Data Store
Driver	Last name	TrustedTruck2Message.InspectionMessage .DriverInfo.FullName	string	Local FOC Data Store
Driver	PIN/ID	VehicleInspectionMessage.Driver.isAuthenticated	Boolean	PIN number is not available
Driver Co-driver	Jurisdiction	Not Available		
Driver Co-driver	License ID	Not Available		
Driver Co-driver	First name	Not Available		
Driver Co-driver	Last name	Not Available		
Driver Co-driver	PIN/ID	Not Available		
Driver Log event data	Sequence ID	Not Available		
Driver Log event data	Status code	Not Available		
Driver Log event data	Date	Not Available		
Driver Log event data	Time	Not Available		

SDMS Entity	*SDMS Data Item*	*Trusted Truck® Data Identifier*	*Data Type*	*Notes*
Driver Log event data	Latitude	Not Available		
Driver Log event data	Longitude	Not Available		
Driver Log event data	Place name	Not Available		
Driver Log event data	Place distance	Not Available		
Driver Log event data	Total vehicle miles	Not Available		
Driver Log event data	Event update status code	Not Available		
Driver Log event data	status code	Not Available		
Driver Log event data	Error code	Not Available		
Driver Log event data	Update date	Not Available		
Driver Log event data	Update time	Not Available		
Driver Log event data	Update person ID	Not Available		
Driver Log event data	Update text	Not Available		
Driver Log data	24-hour period start time	Not Available		
Driver Log data	Multiday basis used	Not Available		
Equipment Identifier	Equipment ID (e.g., trailer unit #0)	TrustedTruck2Message.InspectionMessage .Trailer0Info.Vin	string	Local FOC Data Store
Equipment Identifier	Equipment ID (e.g., trailer unit #1)	TrustedTruck2Message.InspectionMessage .Trailer1Info.Vin	string	Local FOC Data Store
Equipment Identifier	Equipment license plate jurisdiction, trailer unit #0	TrustedTruck2Message.InspectionMessage .Trailer0Info.LicensePlate.IssuingState	string	Local FOCC Data Store
Equipment Identifier	Equipment license plate jurisdiction, trailer unit # 1	TrustedTruck2Message.InspectionMessage .Trailer1Info.LicensePlate.IssuingState	string	Local FOC Data Store
Equipment Identifier	Equipment license plate ID, trailer unit #0	TrustedTruck2Message.InspectionMessage .Trailer0Info.LicensePlate.IssuingState	string	Local FOC Data Store
Equipment Identifier	Equipment license plate ID, trailer unit #1	TrustedTruck2Message.InspectionMessage .Trailer1Info.LicensePlate.IssuingState	string	Local FOC Data Store
Shipment Identifier	Shipping document number	VehicleInspectionMessage.Trailer.Shipmen tInformation.OriginalDocument	Image	Local FOCC Data Store
Encounter Date/time	MM/DD/YYYY	Not Available		
Encounter Date/time	HH:MM:SS	Not Available		
Encounter Location	Latitude	Not Available		
Encounter Location	Longitude	Not Available		
Encounter Location	Encounter ID	Not Available		
Encounter Location	Triggering event	Not Available		
Transponder Identifier	Serial Number	VehicleInspectionMessage.EvolutionDevice Id		embedded persistent data store

CVSA Inspections

It is assumed that CVSA will issue a new level of inspection to define wireless roadside inspection (WRI). Currently, CVSA defines five levels of inspection as follows:

Table B- 2. CVSA Inspections.

Item	Description	Level I	Level II	Level III	Level IV	Level V
1	Drivers' License	✓	✓	✓		
2	Medical Examiner's Certificate and Skill Performance Evaluation (SPE) Certificate (if applicable)	✓	✓	✓		
3	Alcohol and Drugs	✓	✓	✓		
4	Drivers' Log (Hours-of-Service and Duty Status)	✓	✓	✓		
5	Seatbelt System	✓	✓	✓		✓
6	Vehicle Inspection Report	✓	✓	✓		✓
7	Brake Systems	✓	✓			✓
8*	Coupling Devices	✓	✓			✓
9*	Exhaust Systems	✓	✓			✓
10*	Frame	✓	✓			✓
11*	Fuel Systems	✓	✓			✓
12	Lighting Devices (Brake, Head, and Tail Lamps, Turn Signals, Lamps on Projecting Loads)	✓	✓			✓
13*	Safe Loading	✓	✓			✓
14*	Steering Mechanism	✓	✓			✓
15*	Suspension	✓	✓			✓
16	Tires	✓	✓			✓
17*	Van and Open Top Trailer Bodies	✓	✓			✓
18*	Wheels, Rims, and Hubs	✓	✓			✓
19*	Windshield Wipers	✓	✓			✓
20*	Emergency Exits (for busses)	✓	✓			✓
21	Hazardous Materials Requirements (if applicable)	✓		✓		✓
22	One time special inspection of a particular item				✓	
23	CVSA decal issued for "Pass Inspection" (No Violations/defects found in items 7-21)	✓				

* denotes items that cannot be inspected electronically.

Trusted Truck® Message Set Schema

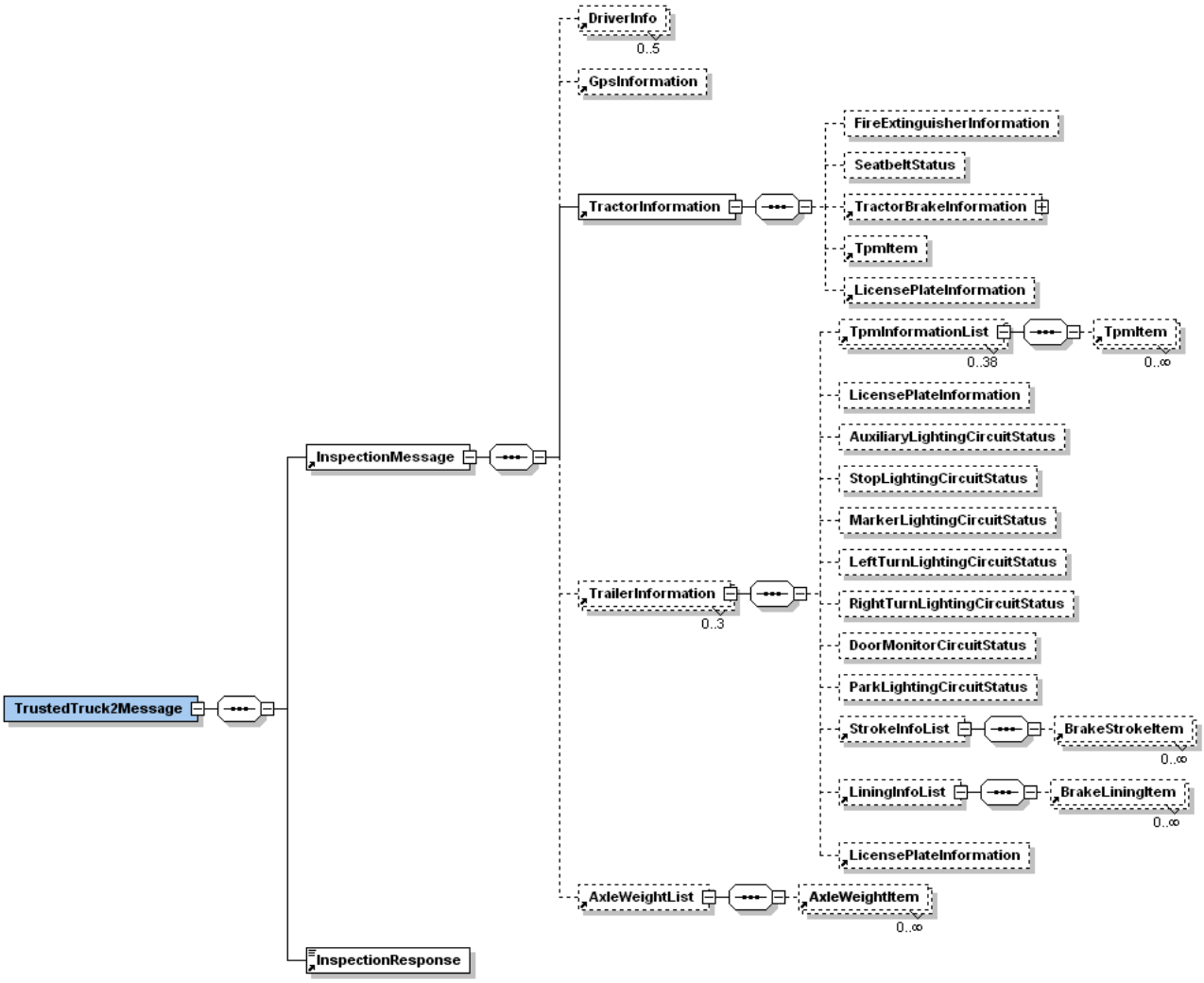

Figure B- 9. Diagram. Trusted Truck® Message Set Schema.

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XML Spy v4.4 U (http://www.xmlspy.com) by Emily C. Williams (Volvo Technology  of America) -->
<!--W3C Schema generated by XML Spy v4.4 U (http://www.xmlspy.com)-->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified">
	<xs:simpleType name="TireId">
		<xs:restriction base="xs:string">
			<xs:enumeration value="Axle1Left"/>
			<xs:enumeration value="Axle1Right"/>
			<xs:enumeration value="Axle2LeftOutside"/>
			<xs:enumeration value="Axle2LeftInside"/>
			<xs:enumeration value="Axle2RightInside"/>
			<xs:enumeration value="Axle2RightOutside"/>
			<xs:enumeration value="Axle3LeftOutside"/>
			<xs:enumeration value="Axle3LeftInside"/>
			<xs:enumeration value="Axle3RightInside"/>
			<xs:enumeration value="Axle3RightOutside"/>
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			<xs:enumeration value="Axle8RightOutside"/>
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			<xs:enumeration value="Axle9LeftInside"/>
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		<xs:restriction base="xs:string">
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			<xs:enumeration value="TractorSteerAxle"/>
			<xs:enumeration value="TractorLiftAxle"/>
			<xs:enumeration value="TractorDriveAxle"/>
			<xs:enumeration value="TractorTagAxle"/>
			<xs:enumeration value="TractorAdditionalAxle"/>
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			<xs:enumeration value="TrailerBAxle"/>
			<xs:enumeration value="TrailerCAxle"/>
			<xs:enumeration value="TrailerDAxle"/>
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			<xs:enumeration value="TrailerGAxle"/>
			<xs:enumeration value="TrailerHAxle"/>
			<xs:enumeration value="TrailerAdditionalAxle"/>
			<xs:enumeration value="TrailerReservedAxle"/>
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		<xs:restriction base="xs:string">
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			<xs:enumeration value="OverPressure"/>
			<xs:enumeration value="NormalPressure"/>
			<xs:enumeration value="UnderPressure"/>
			<xs:enumeration value="ExtremeUnderPressure"/>
			<xs:enumeration value="NotDefined"/>
			<xs:enumeration value="ErrorIndicator"/>
			<xs:enumeration value="NotAvailable"/>
		</xs:restriction>
	</xs:simpleType>
	<xs:simpleType name="BrakeStrokeStatus">
		<xs:restriction base="xs:string">
			<xs:enumeration value="Ok"/>
			<xs:enumeration value="NonFunctioning"/>
			<xs:enumeration value="Overstroke"/>
			<xs:enumeration value="DragglingBrake"/>
			<xs:enumeration value="Reserved1"/>
			<xs:enumeration value="Reserved2"/>
			<xs:enumeration value="SensorError"/>
			<xs:enumeration value="NotAvailable"/>
		</xs:restriction>
	</xs:simpleType>
	<xs:simpleType name="BrakeUnitID">
		<xs:restriction base="xs:string">
			<xs:enumeration value="Axle1Left"/>
			<xs:enumeration value="Axle1Right"/>
			<xs:enumeration value="Axle2Left"/>
			<xs:enumeration value="Axle2Right"/>
			<xs:enumeration value="Axle3Left"/>
			<xs:enumeration value="Axle3Right"/>
			<xs:enumeration value="Axle4Left"/>
			<xs:enumeration value="Axle4Right"/>
			<xs:enumeration value="Axle5Left"/>
			<xs:enumeration value="Axle5Right"/>
		</xs:restriction>
	</xs:simpleType>
	<xs:simpleType name="GpsFixType">
		<xs:restriction base="xs:string">
			<xs:enumeration value="NoFix"/>
			<xs:enumeration value="TwoD"/>
			<xs:enumeration value="ThreeD"/>
		</xs:restriction>
	</xs:simpleType>
	<xs:simpleType name="TrailerCircuitStatus">
		<xs:restriction base="xs:string">
			<xs:enumeration value="OK"/>
			<xs:enumeration value="Overcurrent"/>
			<xs:enumeration value="NoCurrent"/>
```

```
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                    </xs:restriction>
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                    </xs:complexType>
</xs:element>
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                            <xs:element ref="AxleWeightItem" minOccurs="0" maxOccurs="unbounded"/>
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                    </xs:complexType>
</xs:element>
<xs:element name="DriverInfo">
                    <xs:complexType>
                        <xs:attribute name="CdlNumber" type="xs:string" use="optional"/>
                        <xs:attribute name="FullName" type="xs:string" use="optional"/>
                        <xs:attribute name="IssuingState" type="xs:string" use="optional"/>
                    </xs:complexType>
</xs:element>
<xs:element name="GpsInformation" nillable="true">
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                        <xs:attribute name="FixType" type="GpsFixType" use="optional"/>
                        <xs:attribute name="Heading" type="xs:int" use="optional"/>
                        <xs:attribute name="Latitude" type="xs:double" use="optional"/>
                        <xs:attribute name="Longitude" type="xs:double" use="optional"/>
                        <xs:attribute name="Speed" type="xs:int" use="optional"/>
                        <xs:attribute name="Timestamp" type="xs:dateTime" use="optional"/>
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</xs:element>
<xs:element name="InspectionMessage">
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                            <xs:element ref="TractorInformation"/>
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                                    <xs:attribute name="IsLatched" type="xs:boolean" use="optional"/>
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                            </xs:element>
                            <xs:element ref="TractorBrakeInformation" minOccurs="0"/>
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                        </xs:sequence>
                        <xs:attribute name="isLightingOK" type="xs:boolean" use="optional"/>
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                            <xs:element ref="TpmInformationList" minOccurs="0" maxOccurs="38"/>
                            <xs:element name="LicensePlateInformation" nillable="true" minOccurs="0">
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```

```
                                                                </xs:complexType>
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                                                        <xs:element ref="StrokeInfoList" minOccurs="0"/>
                                                        <xs:element ref="LiningInfoList" minOccurs="0"/>
                                                        <xs:element ref="LicensePlateInformation" minOccurs="0"/>
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                        <xs:element name="LicensePlateInformation" nillable="true">
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                                                </xs:sequence>
                                        </xs:complexType>
                        </xs:element>
</xs:schema>
```

References

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Appendix C

Phase D Implementation Plan

General Information

This document outlines the technical goals for final phase of Trusted Truck® II, the four phase project to Research, Design, Develop and Demonstrate the Trusted Truck® Independent Certification System concept.

Background

The states conduct close to 750,000 roadside inspections of commercial vehicles per year. Even with this seemingly large number of inspections the states are still being overwhelmed with the burden of performing inspections in a fashion that ensures the carriers are complying with safety regulations without impacting the profitability of the carriers. In the first Trusted Truck® project Volvo helped demonstrate the ability to perform brake inspections wirelessly between the vehicle and the state's roadside infrastructure.

The first two phases of the Trusted Truck® II project built off of that initial project to further explore the concept of building a relationship of trust with commercial vehicles and motor carriers through wireless roadside inspections and compliance along with ways that would help enhance the efficiencies of the carriers. The goal will be to move closer to defining a mechanism for performing wireless roadside inspections (WRI).

The third phase focused mainly on preparation work for the final phase, and moved TTMC development from VTEC to the University of Tennessee. In addition, an initial implementation of wireless encryption of the Trusted Truck message set was accomplished. The final phase, in essence, will deliver the complete Trusted Truck® concept, with a concept of operation, an outline of the businesses that might participate in the Trusted Truck® as independent, non-government operations, proposed audit processes, and two complete, end to end, demonstrations.

Trusted Truck® Vision

The vision at the end of Phase D, targeted for July 2010, is to demonstrate a concept of a nationwide system that can improve the efficiency of roadside inspections. The goal is to find an approach that meets the needs of the state and federal regulators to improve road safety, security and efficiency, but also provides incentives to fleet owners and drivers to adopt the system.

This vision will be met through the following project goals during Phase C & D:

- Develop a working prototype of the Trusted Truck® Independent Certification System.
- Develop and demonstrate a *state specific* "Certificate of Trust" validating the tractor, trailer, driver and/or load.
- The concept should be demonstrated in Kentucky as part of the finalization of the Trusted Truck® project, and once more in Greene County, Tennessee, both using the same Certification of Trust.
- Develop a working prototype of a TTMC that includes defining and implementing an interface between the TTMC and the VOLPE/FMCSA WRI back office
- A secondary goal is to show getting additional data from the FMCSA back-office, but should have a simulated interface as a fall back
- Leverage the work within other related WRI activities to develop a business case and document the incentives to improve industry acceptance of the concept
- Outreach to Volvo/Mack customers and contacts to determine their needs and obtain feedback on the concept

Phase D Project Plan

Main Tasks

The main task of Phase D is to execute the implementation plan and system architecture developed during Phase C, and complete two demonstrations of the end to end system.

The following paragraphs detail each of the individual tasks involved in Phase D.

Volvo/Mack Brand Outreach (Volvo)

This task involves describing the Trusted Truck® concept to the brands with the goal being to determine the types of services surrounding WRI that could be secured by the brands, discover the degree of support the brands are willing to provide, both to customers and other potential business partners.

Complete Encryption Strategy (UT Lead, Volvo Support)

The initial implementation was completed and demonstrated in Phase C. In Phase D, certificate management will be added both in the TTMC and the OBE.

Pre-Departure Inspection (Volvo Lead/UT Support)

A means for drivers to perform a wireless inspection prior to departure to ensure that the truck is ready to interact with the Trusted Truck® in a positive manner will be developed. It is felt that the inspection will also be useful as part of the audit process.

Video (Volvo Lead/UT Support

The video will document the entire Trusted Truck® concept.

Implement Interfaces with Volpe (UT Lead, Volvo Support)

Bidirectional interfaces will be constructed between the UT-constructed TTMC. Outbound information will transact the certificate of trust. Inbound data will be agreed to early in Phase D, but may include, for example, CDL information, Out of Service restrictions, etc.

Publication of the final Trusted Truck® Report (Volvo Lead, UT Support)

Specific sections in the final report are described in the Phase D Statement of Work, Section 3.4, Deliverables.

Final Demonstrations (Volvo Lead, UT Support)

VTEC will take the lead to manage invitations and other organization issues associated with the demonstration to be performed during May, 2010. VTEC will not participate in this role for the demonstration planned for September 2010. The demonstration will consist of two drive-by evaluations of the truck, one in which the truck passes inspection. For the second drive-by, the truck will be intentionally faulted such that the inspection fails.

Finally, the pre-departure inspection will be used as part of an audit to ensure that the vehicle is accurately reporting it's status.

Project Team

The University of Tennessee, Volvo Trucks North America, and Volvo Technology of America have been collaborating for over four years on the Trusted Truck® concept, and will finalize this collaboration after Phase D. Significant development work will be carried out at the University of Tennessee by students led by Dr. Elhanany to build the interfaces with Volpe, and to complete the data encryption.

Project Schedule

Task	*Start*	*Finish*
Research Phase	1-Aug-09	31-Dec-09
Design Phase	1-Sep-09	30-Nov-09
Implementation Phase	1-Oct-09	30-Apr-10
Deliverables Phase	1-Jan-10	15-Sep-10
Demonstration Phase	1-May-10	15-Sep-10

Deliverables

- Two demonstrations, May 2010 at a location to be determined, and one in September 2010 in Greene County, Tennessee.
- Artifacts of the final demonstration (story boards and other material)
- Video documenting the entire Trusted Truck® concept
- Final Trusted Truck® Report containing:
    - Concept of Operations
    - Business overview including proposed audit procedures
    - Summary of outreach and other interviews conducted by NTRCI/FMCSA with fleet owners and government
    - Summary of demonstrations