Untethered Trailer Tracking and Control System

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

December 2005

Foreword

The Federal Motor Carrier Safety Administration (FMCSA) has been investigating methods to improve carrier security, particularly in the area of hazardous materials security. The transportation of hazardous materials is the largest security risk area within the motor carrier industry, with more than 800,000 shipments of hazardous materials transported each day in the United States. In 2004, FMCSA completed a comprehensive Hazardous Materials Security Field Operational Test that included an element to test a basic untethered trailer tracking (UTT) system. This system provided trailer position and identification information to a dispatcher on a regular basis. The House of Representatives Report 107-722, *Department of Transportation and Related Agencies Appropriations Bill, 2003,* stated that further development of existing trailer tracking systems was essential.

This final project report on the UTT system provides information that can be used by motor carriers and the public sector emergency response and enforcement communities, regarding the potential security, safety, and operational efficiency benefits of commercially available trailer tracking technologies. Motor carriers could choose to purchase and implement this technology to improve overall safety, security, and operational efficiency. The emergency response and enforcement community could adopt and use the commercially available technology to better respond to potential security incidents involving trailers, such as preventing trailers from being used as weapons of mass destruction.

FMCSA conducted a national pilot test to develop and test a UTT system with the expanded functions specified in the congressional report. This document does not supersede an earlier report on the subject.

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This program was administered through the Federal Motor Carrier Safety Administration (FMCSA). The FMCSA Program Manager is Ms. Amy Houser.

16. Abstract

The security of truck operations is a major component of a secure national transportation system. Commercial motor vehicles are not only potential targets of attack, but they can also be used as a means of transferring destructive materials within the country and as weapons to attack other targets. The House of Representatives Report 107-722, Department of Transportation and Related Agencies Appropriations Bill, 2003, stated that further development of existing trailer tracking systems was essential. As a result, FMCSA conducted a pilot test of an untethered trailer tracking (UTT) system with the expanded functions specified in the congressional report. For this project, FMCSA worked in partnership with a review team comprised of governmental and industry participants for expert opinions and review for this project.

The purpose of this pilot test was to test a UTT system that meets specific functional requirements and improves the safety and security of trailers and shipments at each phase of its movement. The UTT system included: near real-time trailer identification; accurate time of connection and disconnection activities; location and mapping of trailers; geo-fencing to identify a risk area or unscheduled trailer movement; remote sensing of a loaded or empty trailer; and security of the cargo door.

The pilot test was conducted using three operational scenarios. Scenario 1 involved national truckload delivery of standard dry van deliveries. Scenario 2 involved a national truckload delivery of high value retail clothing and electronics. Scenario 3 included the regional truckload of Class 1.1 – 1.6 Explosives. Each scenario included 25 trailers, with various combinations of UTT system components installed on the trailers. Following a period of specification, systems design, and prototype testing, the UTT technologies were then installed and tested on the trailers over a 3-month period per scenario from October 2004 through January 2005. Data from field testing, staged tests, and expert opinions were collected to determine the functionality of the UTT system and potential improvements in security, safety and efficiency through the use of the UTT system.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lbs)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m2	cd/m2
		FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	Yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lbs)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

Acknowledgments

The Untethered Trailer Tracking (UTT) System Pilot Test was administered by the Federal Motor Carrier Safety Administration's (FMCSA) Technology Division. Managed by Ms. Amy Houser of FMCSA, the UTT System Pilot Test included multiple developmental and operational phases. The report was improved with input from government, public sector, and transportation industry professionals. FMCSA established a partnership with a review team comprised of participants from the Transportation Security Administration (TSA), Federal Highway Administration (FHWA), Maritime Administration (MARAD), Pipeline and Hazardous Materials Safety Administration (PHMSA), and Department of Defense (DOD). We would like to thank and recognize the support provided by the following individuals:

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In addition, an independent panel comprised of public and private sector stakeholders listed below were consulted for their expert opinions about the UTT system and explosive shipments. We appreciate the contributions of this group.

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Jami McClellan, Zurich North America
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Chet Friday, Beneto Transport
Tobin Kueper, Cyanco
Chuck McHugh, Shell Chemical LP
Ray Riley, Miller Transporters

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Elaine Chaudoin, J.B. Hunt
Jay Folladori, Landstar
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Sam Gill, Skybitz

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EXECUTIVE SUMMARY

On September 11, 2001, a new era of security awareness emerged as a result of terrorist attacks on the United States. These attacks emphasized the critical importance of a secure national transportation system. The security of truck operations is a major component of this system. Reducing the vulnerability of truck operations is vital. Commercial motor vehicles are not only potential targets of attack, but they can also be used as a means of transferring destructive materials within the country and as weapons to attack other targets.

The Federal Motor Carrier Safety Administration (FMCSA) has been investigating methods to improve carrier security, particularly in the area of hazardous materials security. The transportation of hazardous materials is the largest security risk area within the trucking industry, with more than 800,000 shipments of hazardous materials transported each day in the United States. In 2004, FMCSA completed a comprehensive Hazardous Materials Safety and Security Field Operational Test that included an element to test a basic untethered trailer tracking (UTT) system. This system provided trailer position and identification information to a dispatcher on a regular basis.

The House of Representatives Report 107-722, *Department of Transportation and Related Agencies Appropriations Bill, 2003,* stated that further development of existing trailer tracking systems was essential:

> *Truck trailers pose a significant potential security threat since they provide an easy means to transport dangerous cargos. In addition, the inability to track freight movements causes inefficiencies in the intermodal freight transportation system, increasing operating costs and congestion, and decreasing safety, economic competitiveness, and air quality. While commercially available technology can track a trailer when it is tethered to a cab, commercially available technologies are needed to track and control an untethered trailer. Within the funds provided for FMCSA's limitation on administrative expenses and high priority initiative program, the Committee has provided the funding to leverage existing technology and develop an untethered trailer tracking and control system that will provide real-time trailer identification, location, geo-fencing, unscheduled movement notification, door sensors, and alarms.*

As a result, FMCSA conducted a national pilot test of a UTT system with the expanded functions specified in the congressional report. For this project, FMCSA worked in partnership with a review team comprised of participants from the Transportation Security Administration (TSA), Federal Highway Administration (FHWA), Maritime Administration (MARAD), Pipeline and Hazardous Materials Safety Administration (PHMSA), and Department of Defense (DOD). Also, an expert panel comprised of stakeholders from Landstar, J.B. Hunt, Geologic Solutions, and Skybitz provided expert opinions and advice for this project. Another independent group of experts provided their opinions about security-related vulnerabilities of trailers containing shipments of explosives.

In the United States, there are an estimated 2.5 to 3 million dry van trailers, yet UTT systems are installed on only about 2 percent of these trailers. Moreover, the trucking industry uses approximately three times as many trailers as tractors; therefore, loaded and empty trailers sitting unwatched can be subject to both theft and terrorism. Cargo and equipment can be stolen as an economic crime or used as a weapon of mass destruction (WMD).

The lack of in-transit visibility has resulted in security risks and inefficient use of available trailers sitting unwatched and subject to both theft and terrorism. When a trailer is removed from its dropped location and erroneously moved or parked, the trucking company typically conducts lengthy searches to locate it. Also, trucking companies may often subcontract to other trucking companies to haul certain loads for them, thereby losing trailer visibility at the switch. Furthermore, shippers may not inform trucking companies when trailers are empty, which can cause an unnecessary delay in returning the trailer for productive use.

The UTT system can reduce these vulnerabilities by addressing the potential threats of stolen trailers, which could be used to convey weapons of mass destruction and the theft of hazardous materials cargo, which could result in catastrophic releases. In addition, the UTT system can also address the threat of cargo sabotage – where cargo, such as food products could be contaminated. The increased visibility provided by the UTT system can also potentially deter and detect interception or diversion of tractor-trailers en route – where unauthorized personnel could gain access to trailers, cargo, and important information for illicit purposes.

In addition to security benefits, the UTT system can improve operational efficiency. Trucking companies frequently buy excess trailers to ensure their availability for their most expensive assets – tractors. Due to a lack of manpower and adequate trailer storage facilities, these trailer stockpiles may be either inaccurately accessed or unknowingly disbursed at various locations. Trailer stockpiling also creates additional inefficiencies, such as constant inventory checks (yard checks), extra maintenance, extra parking space, erroneous pickups, and theft, which deplete the trucking company's resources. These unnecessary costs can be significantly reduced through improved asset management using a UTT system.

The purpose of this pilot test was to test a UTT system that meets specific functional requirements that could improve the safety and security of trailers and shipments at each phase of its movement – pick up, delivery, receipt, and storage. The UTT system included:

- Near real-time trailer identification
- Accurate time of connection and disconnection activities
- Location and mapping of trailers
- Geo-fencing to identify a risk area
- Unscheduled movement notification
- Remote sensing of a loaded or empty trailer
- Cargo and door sensors
- Alerts

A systems engineering process was followed to test the UTT system. Interim reports were developed within each project phase and information from these interim reports is consolidated in this document.

First, the concept of operations interim report defined the UTT system user environment by providing information about how each user interacts with the system and the user's unique operational conditions. The concept of operations described three operational scenarios addressing different segments of the trucking industry:

- The Truckload Scenario 1 involved a national truckload delivery of standard dry van deliveries.
- The High Value Scenario 2 involved a national truckload delivery of high value retail clothing and electronics.
- The Explosives/HAZMAT Scenario 3 included the regional truckload of Class 1.1 – 1.6 Explosives.

The primary focus of the three different scenarios was on deploying the systems in ways that optimized the safety, utilization, and security. Each scenario included 25 vehicles, with various combinations of UTT system components installed on the trailers.

Next, the UTT system functional requirements report described the features and functions used to define the UTT system and its operational functionality. Additional input from key individuals and companies in the transportation industry was incorporated in the requirements with an emphasis on mapping the system requirements to the three scenarios.

Then, the UTT system design interim report specified the physical and logical architecture of the UTT technology subsystems and defined the detailed interface requirements between the technology subsystems. The system design included a system specification; a subsystem design section that summarized the design architecture by technology and scenario; and a test specification section.

Prior to the pilot test, the UTT system was installed on a prototype test vehicle to demonstrate the functionality of the technology components, data collection schemes, and procedures. The prototype test vehicle operated for 45 days to test all systems and data collection processes. A prototype test checklist was created to verify the operation of individual components of the UTT system.

Following the prototype test, the pilot test plan was finalized for testing the combinations of technologies for the UTT systems in the three scenarios. The pilot test plan included the following major test elements:

- **Pre-Test Implementation:** Activities performed prior to the installation, training of the pilot test participants, and problem reporting and tracking.
- **Test Scenarios:** Detailed test conditions per scenario and technologies deployed in each scenario.

- **Test Procedures and Data Collection:** Detailed description of the specific test activities and data collection.

The UTT system pilot test was conducted from October 2004 through January 2005. During the pilot test, data was collected by:

- Automatic technology data collection during operations in the field
- Daily manual logs for recording baseline carrier operations
- Interviews to determine participant perceptions of the technology
- Automatic and documented data collection of staged events

Nine on-site visits were also conducted during the test period. The purpose of these site visits with pilot test participants was to collect functional data. Qualitative participant user reactions were collected throughout the test, capturing a wide range of user attitudes, perceptions, reactions, and recommendations gained through several months of exposure and usage of the UTT system.

During daily operations and staged technology testing, the UTT system functioned with few recorded failures. In the area of security benefits, the testing showed that the UTT system has the potential to reduce inherent trailer and shipment vulnerabilities to theft by increasing current levels of cargo and equipment visibility. Also, use of the UTT system has the potential to improve operational efficiency through improved asset management.

1 INTRODUCTION

1.1 Background

Following the terrorist events of September 11, 2001, both the Federal Motor Carrier Safety Administration (FMCSA) and the trucking industry have been working toward secure motor carrier operations, particularly in the area of hazardous materials transportation. Reducing the vulnerability of truck operations to acts of violence is vital, since trucks could be identified as potential targets of attack, utilized as a means of transferring destructive materials within the country, and used as weapons to attack other targets.

In 2003, the House of Representatives Report 107-722, *Department of Transportation and Related Agencies Appropriations Bill, 2003,* stated:

> *Truck trailers pose a significant potential security threat since they provide an easy means to transport dangerous cargos. In addition, the inability to track freight movements causes inefficiencies in the intermodal freight transportation system, increasing operating costs and congestion, and decreasing safety, economic competitiveness, and air quality. While commercially available technology can track a trailer when it is tethered to a cab, commercially available technologies are needed to track and control an untethered trailer. Within the funds provided for FMCSA's limitation on administrative expenses and high priority initiative program, the Committee has provided the funding to leverage existing technology and develop an untethered trailer tracking and control system that will provide real-time trailer identification, location, geo-fencing, unscheduled movement notification, door sensors, and alarms.*

As a result, FMCSA conducted a national pilot test to test a UTT system with the functions specified in the congressional report. For this project, FMCSA worked in partnership with a review team comprised of participants from the Transportation Security Administration (TSA), Federal Highway Administration (FHWA), Maritime Administration (MARAD), Pipeline and Hazardous Materials Safety Administration (PHMSA), and Department of Defense (DOD). Also, an expert panel comprised of stakeholders from Landstar, J.B. Hunt, Geologic Solutions, and Skybitz provided expert opinions and advice for this project. Another independent group of experts provided their opinions about security-related vulnerabilities of trailers containing shipments of explosives.

Truck trailers are the primary freight delivery equipment asset in the transport of non-containerized freight in the United States. In the trucking industry, the trailer to tractor ratio is in excess of 3:1, suggesting a trailer utilization rate between 30 and 35 percent. The lack of in-transit visibility has resulted in security risks and inefficient use of available trailers sitting unwatched and subject to both theft and terrorism. When a trailer is removed from its dropped location and erroneously moved or parked, the trucking company typically conducts lengthy searches to locate it. Also, trucking companies may often subcontract to other trucking companies to haul certain loads for them, thereby losing trailer visibility at the switch. Furthermore, shippers may not inform trucking companies when trailers are empty, causing an unnecessary delay in the return of the trailer for productive use.

The UTT system can reduce these vulnerabilities by addressing the potential threats of stolen trailers, which could be used to convey weapons of mass destruction (WMD) and the theft of hazardous materials (HAZMAT) cargo, which could result in catastrophic releases. In addition, the UTT system can also address the threat of cargo sabotage, where cargo, such as food products, could be contaminated. The increased visibility provided by the UTT system can potentially deter and detect interception or diversion of tractor-trailers en route – where unauthorized personnel could gain access to trailers, cargo, and important information for illicit purposes.

In addition to security benefits, use of the UTT system can improve operational efficiency. Trucking companies frequently buy excess trailers to ensure their availability for their most expensive assets – tractors. Due to a lack of manpower and adequate trailer storage facilities, these trailer stockpiles may be either inaccurately accessed or unknowingly disbursed at various locations. Trailer stockpiling also creates additional inefficiencies, such as constant inventory checks (yard checks), extra maintenance, extra parking space, erroneous pickups, and theft, which deplete the trucking company's resources. These are unnecessary costs that can be significantly reduced through improved asset management by using a UTT system.

Inadequate in-transit visibility of freight could also add to the inefficient use of our nation's roadway infrastructure. This inefficiency is manifested by increased congestion and reduced air quality, which could lead to increased operational costs for the trucking and logistics industries. As a result, these increased operational costs further reduce our nation's economic competitiveness. In particular, the lack of visibility of trailers results in inefficiencies due to inadequacies in scheduling; equipment shortages; the necessity for adding slack to the overall freight transportation timeline; and the need to add unnecessary empty miles to reposition equipment.

1.2 The Untethered Trailer Tracking System Pilot Test Purpose

The purpose of the UTT system pilot test was to test a UTT system that meets specific functional requirements and improves the safety and security of trailers and shipments at each phase of movement – pick up, delivery, receipt, and storage. As a result, FMCSA conducted a pilot test to develop generic voluntary requirements for a UTT system using as a model a proprietary system that includes the specific capabilities defined in the *House of Representatives Report 107-722,* and field test a system that meets these requirements. The FMCSA UTT System Pilot Test followed the FMCSA Hazardous Materials Safety and Security Field Operational Test[1] and expanded the scope of testing UTT system technologies.[2]

Working with three participating motor carriers, Science Applications International Corporation (SAIC) and QUALCOMM conducted the UTT system test. The QUALCOMM TrailerTRACS

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[1] The collection of FMCSA reports that define the effort and provide evaluation results on the HAZMAT Safety and Security Field Operational Test can be accessed on FMCSA's website at: http://www.fmcsa.dot.gov/safety-security/hazmat/fot/index.htm

[2] The original HAZMAT FOT (trailer-tracking portion) focused on positioning and trailer connections and disconnections. The UTT Pilot Test added route monitoring, alarms, geo-fencing, and configurable cargo and door sensors.

system was selected as the UTT system for the testing effort; however, the information about this system may be applicable to other UTT systems.

1.3 The Untethered Trailer Tracking Concept

Untethered trailer tracking is one solution that addresses the efficiency and security problems previously cited. This solution is comprised of a set of communications and computer technologies for tracking a trailer independent of a truck tractor. UTT systems require a power source and power management strategy for long periods of inactivity, since trailers are stored in terminals for periods of weeks or months. Typically, a UTT system uses satellite-tracking Global Positioning System (GPS) technology, supplemented by either satellite or cellular communications technologies. As shown in Figure 1, a variety of in-transit events can be monitored by the UTT system, thus providing a means to integrate the trailer assets into a trucking company's overall logistics management system.

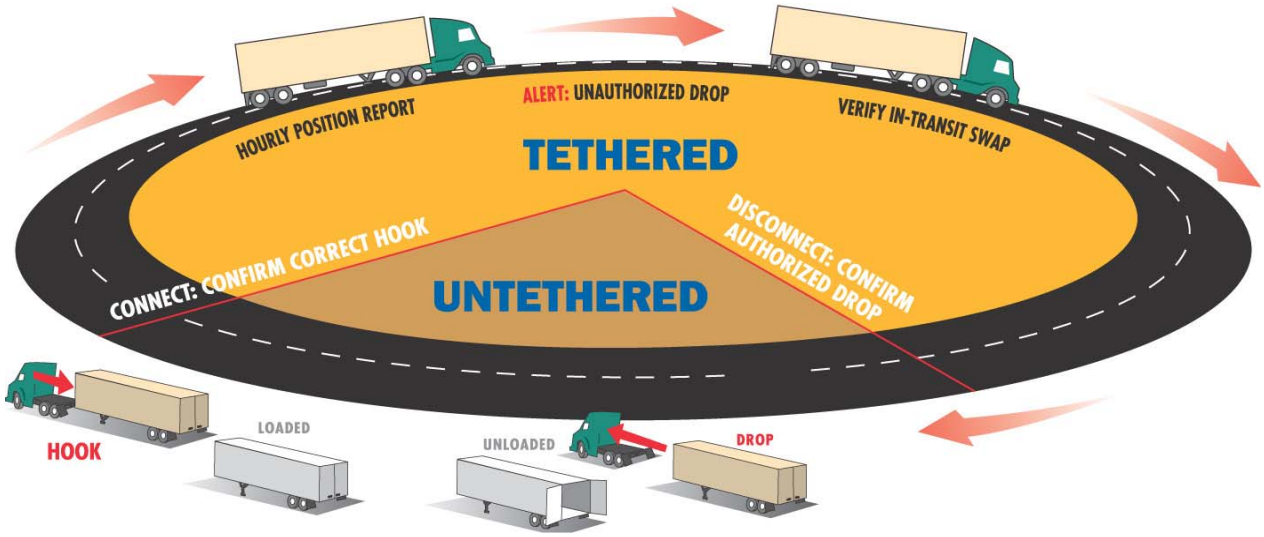

Figure 1: Trailer-Tracking System Chain of Events

There are an estimated 2.5 to 3 million dry van trailers in the United States today; however, only about 2 percent have UTT systems. The deployment of UTT technologies is expected to increase significantly in the near future, since several UTT systems are currently in the marketplace. Some of these UTT systems include:

- QUALCOMM's TrailerTRACS
- General Electric's VeriWise
- GeoLogic Solution's TrailerMax
- Terion's FleetView 3 Trailer Management System
- SkyBitz's Global Location System

- TransCore's GlobalWave
- Teletouch Communication's VisionTrax
- AirlQ's Refrigerated Trailer Tracking Solution

Mr. Sam Gill, an industry consultant who has followed the evolution of vehicle tracking closely, stated that 2005 "could be a banner year . . . Trailers are the last frontier of asset management in the trucking industry."[3]

1.4 Untethered Trailer Tracking System Overview

A UTT system generates trailer position information with every message and status report, which is provided to a dispatcher's computer. The untethered trailer positioning information is collected through various sensor devices that monitor the trailer to which they are attached. Position information can be user-configured to be generated and sent at predetermined time intervals, and it can also be generated and sent upon demand from the dispatcher's computer. The position reporting frequency is configurable, and the UTT terminal has a store and forward capability.

The UTT System Pilot Test involved the following requirements:

- Near real-time trailer identification
- Accurate time of connection and disconnection activities when used with a tractor-based communications system
- Location and mapping of trailers
- Geo-fencing to identify a risk area
- Unscheduled movement notification
- Remote sensing of a loaded or empty trailer
- Cargo and door sensors
- Alerts

To address these requirements, specific technologies and/or processes were integrated into the UTT system. Table 1 provides a mapping of these functional requirements and the associated technologies/processes.

[3] Strah, Thomas, "Tracking the Trailer," *Transport Topics*, I-Tech Supplement, February 21, 2005.

Table 1: Mapping of Requirements to Technologies/Processes

No.	Requirement	Wireless Satellite In-Cab Communication System	Wireless UTT System	Connection/Disconnection Functionality	Trailer Cargo Sensor	Trailer Door Sensor	UTT Remote Geo-Fencing	Mapping Application (TrailerTRACS/Web)	Third-Party Integration	Host Application
1	Near real-time trailer identification		X	X					X	X
2	Accurate time of connection and disconnection activities	X	X	X						X
3	Location and mapping of trailers		X					X	X	
4	Geo-fencing to identify a risk area		X				X			
5	Unscheduled movement notification		X				X			
6	Remote sensing of a loaded or empty trailer		X		X					
7	Door sensors		X			X				
8	Alarms[4]		X	X					X	X

Whether or not a trailer is untethered or tethered to a tractor with or without a tractor-based mobile communications system, the trailer-based UTT system allows a trucking company to track a trailer's location, status, and cargo by providing the trailer's position. The trailer's position can be configured to be reported to a trucking company as often as every 2 minutes; however, as the frequency of the positioning report is increased, messaging costs increase. As a result, while en route, a tractor-trailer with a mobile communications system on the tractor typically utilizes that system for positioning information at a more cost effective rate, such as one position per hour. When the tractor-based mobile communications system is not working or available, the UTT system can track the tractor-trailer en route with more frequent updates of positions. The UTT system is a critical stand-alone location tracking system for untethered trailers.

[4] For the purposes of this Final Report and to maintain consistency with the UTT system TrailerTRACS Web application, the term "alert" is used in place of "alarm". The only exception is where "alarm" is used in Table 1 to directly map to the House of Representatives Report 107-22, which designates that an untethered trailer tracking and control system will provide "…unscheduled movement notification, door sensors, and alarms.".

One functionality tested in the pilot test was to capture connection and disconnection events and transmit notifications via the UTT system cellular communications to dispatchers. The event notifications provide details of the connection and disconnection event, including position, time, status, and identification data to a cellular network. This functionality was enabled through the use of a satellite-based mobile communications system on the tractor for the trailer connection and disconnection event only.

The UTT system may also be configured to establish geo-fence boundaries around individual UTT system terminals that transmit event notifications to dispatchers if the trailer violates the geo-fence. A geo-fence is an electronic boundary that a user can create to monitor trailer location and movement. Geo-fences may be created, viewed, and edited visually on a web-based interactive map. For example, a user could locate a trailer on a map and draw a geo-fence around the trailer position by clicking and dragging a mouse. The geo-fence may be assigned to a trailer or to groups of trailers. Geo-fences may also be removed or deactivated for trailers or groups of trailers at any time.

Once the geo-fence is set and configured to provide an alert, the UTT system will send a notification to the user if the trailer crosses the geo-fence boundary. The UTT system will send an alert when a trailer exits or enters the boundary through an email or pager notification. Since the UTT system provides a trailer specific geo-fencing capability, it is unaffected by separate geo-fences of nearby trailers.

The UTT system also provides an on-board geo-fence with event-driven exception reporting. Exception-driven reporting will allow the UTT system to monitor trailer position and check for geo-fence breaks frequently, but only send a message if a geo-fence break is detected. Frequent checking for geo-fence breaks without sending frequent messages lowers messaging costs and increases battery life.

As a part of the UTT system, an ultrasonic cargo sensor detects the presence of cargo in the trailer by indicating if the trailer is unloaded or loaded. A cargo event is defined as the transition from completely unloaded to partially or completely loaded or vice-versa. The UTT system terminal wakes up to check the cargo status at a predefined frequency. Utilizing event-driven exception reporting, a status message is sent only when the cargo status changes.

As another part of the UTT system, a magnetic door sensor monitors for an open or closed door event on the trailer. A door event is defined as the transition from open to closed or from closed to open. The trailer door sensor can work in conjunction with the cargo sensor, so that only those door state changes that might affect cargo are sent to the user. For example, it is possible to configure the system to send door open events if there is cargo in the trailer and to ignore door open events if the trailer is empty. For the pilot test, only trailers with a single set of doors were monitored, and a door opening alert was sent when the trailer was loaded.

An overview of these technologies is shown in Figure 2 and described in Section 2.

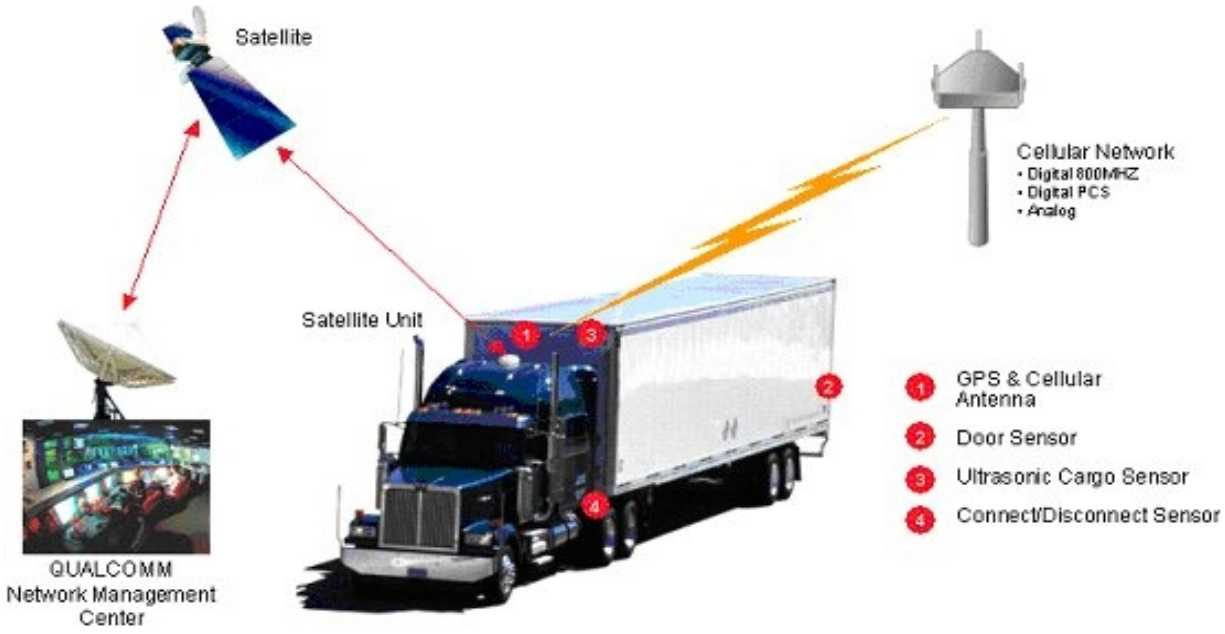

Figure 2: UTT System Concept

2 TECHNOLOGIES

The UTT system pilot test included a variety of technologies consisting of hardware, software, and network subsystems. This section provides descriptions of these technologies.

2.1 Terrestrial Untethered Trailer Tracking System Terminal and Antennae

The TrailerTRACS UTT system provides trailer identification and position information to the carrier on a regular basis. During the pilot test, a UTT system terminal device was installed on all trailers (see Figure 3). This terminal contains a code division multiple access (CDMA) digital third generation wireless (3G) cellular modem module with the following tri-mode capability:

1. CDMA 3G digital service
2. Roaming digital service using asynchronous data over CDMA
3. Analog cellular service

The main benefit of using a tri-mode capability is to increase the terrestrial coverage area. Although service to Mexico and Canada is possible, access is dependent on the availability of cellular service in these areas.

Figure 3: TrailerTRACS UTT System Terminal

Trailer identification is established via position reports sent from the UTT terminal on the trailer. The UTT terminal monitors the GPS for its location, checks other on-board sensors (cargo, door or auxiliary), and sends this information over the air (OTA). Trailer position is established via the GPS. The terminal is user-configurable to wake-up to check for positions at customer-defined

intervals. Once the position has been established, the coordinates are reported to the user at predetermined intervals. The latitude/longitude is provided so the motor carrier personnel can view the position on a map with reference to highways, streets, intersections, or customer-defined landmarks.

The information presented to the user includes the trailer ID and trailer type as well as the customer Standard Carrier Alpha Code (SCAC). The user can view the host software to find the latest trailer location and status on a map. Location is displayed relative to predefined landmarks or street or highway intersections. If the latest scheduled report is not sufficiently current, the user can request an update from the terminal. The request will be answered immediately if the terminal is awake; otherwise, the request will be queued until the next scheduled wake-up time. Vehicle position information is generated with every message. Position information can be generated upon demand from the dispatch computer, and position reporting frequency is configurable. The UTT terminal has a store and forward capability.

Using this UTT system, the carrier defines the trailer-based geo-fence area to be monitored and alert configurations using the TrailerTRACS/Web application. The configurations are sent OTA from the carrier's site to be stored on the UTT terminal. Unscheduled trailer movement notification (trailer-based geo-fencing) and position monitoring capabilities allow the user to define a monitoring area. The trailer terminal also provides remote sensing of the trailer cargo and door status throughout all phases of operation in combination with the cargo and door sensors.

The TrailerTRACS UTT system contains a battery pack and charging circuitry. When the trailer is disconnected from a tractor, the UTT system's rechargeable battery provides power for at least 30 days, assuming the user-defined configurations are set to their defaults. Battery recharging occurs when the trailer is connected to a tractor with the ignition turned on. Power is supplied to the UTT terminal via pin 7 on the J560 7-way connector that supplies power to the trailer. This same connection provides a communication path between the UTT terminal and the satellite tracking system on the tractor for the trailer connection and disconnection functionality. The UTT system's battery is fully rechargeable in 6 hours or less when connected to a typical 12-volt tractor power supply system and the ignition is turned on. The UTT terminal has the capability to inform the customer when the battery requires recharging or replacement, and the date the battery was last replaced.

The UTT system includes a stealth antenna to provide communications through its 800/1900 MHz cellular antenna and positions from a GPS antenna, shown in Figure 4. The UTT system's antenna was designed for installation on a metal or fiberglass-roofed trailer without drilling or cutting into the roof. Overall antennae height is 1 inch or less.

Figure 4: UTT System Antenna

2.1.1 Ultrasonic Cargo Sensor

As shown in Figure 5, an ultrasonic cargo sensor (cargo sensor) detects the presence of cargo in the trailer. A cargo event is defined as the transition from “empty” to “not empty” status, or from “not empty” to “empty” status. Cargo status checks are set at predetermined configured times, but messages are only sent OTA to indicate when the cargo status state changes from “empty” to “not empty” or visa versa. The terminal wakes up to check the cargo status at a predefined frequency, and depending on user-defined settings, may or may not send a message with that information.

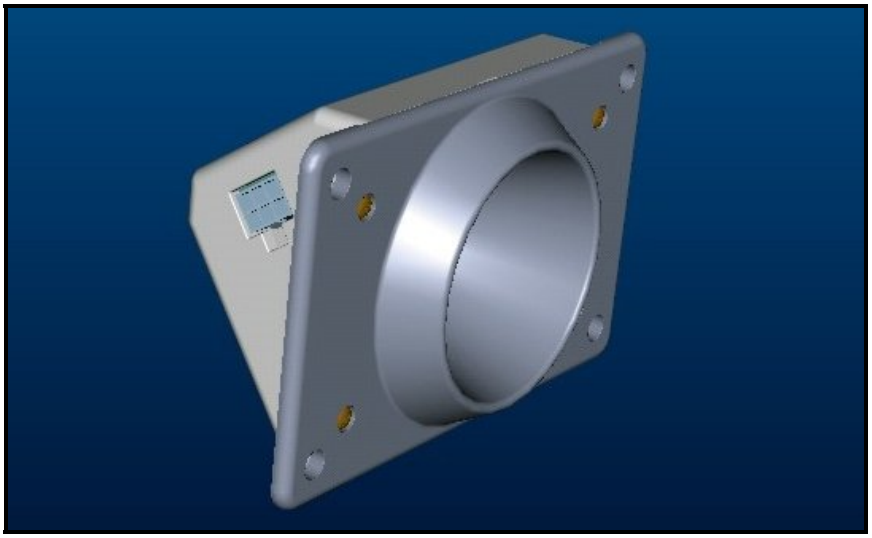

Figure 5: Ultrasonic Cargo Sensor

An erroneous detection could occur if, for example, a person walks into the trailer at the moment the sensor is taking a cargo status reading. In this case, assuming the person exits the trailer, a second status check would show the true unloaded state of the trailer. Cargo events are validated

to decrease the probability of erroneous state detections. To validate the cargo events, the cargo sensor performs a recheck at predefined intervals, and will repeat the rechecks for a predefined number of times. All of the recheck readings need to be the same before the new cargo state is sent in a message to the carrier.

During the pilot test, the cargo status was configured to be checked every 30 minutes, and a status change message was sent to the dispatcher following the detected status change, plus one 5-minute check/validation to prevent false positive messages. The alert notification for the cargo status change includes the event time, event location, and cargo status. The cargo sensor senses cargo in excess of 2' x 2' x 2' placed anywhere in the trailer 20 feet aft of the nose wall. The cargo sensor does not detect the presence of a pallet or load that is not within 20 feet of the trailer nose wall.

During the pilot test, the majority of truckload cargo was loaded starting from the nose of the trailer, which allowed the cargo sensor to sense the “not empty” event in a timely manner and to delay sensing until all cargo was removed. The UTT terminal woke up at a predefined frequency (30-minute default) to the check cargo status. However, the cargo event can be configurable to be sent immediately upon validation, saved and sent with the next planned status message, or disabled.

Figure 6: Door Sensor

2.1.2 Door Sensor

As shown in Figure 6, the magnetic trailer door sensor monitors whether a trailer door is opened and/or closed. A door event is defined as the transition from opened to closed or from closed to open for a predefined period of time. The door sensor default setting is configured to send door opening events only if the cargo sensor sensed a loaded trailer; however, this setting is configurable where door opening events can be sent without regard to cargo status.

Door events can be configured to be sent immediately upon validation, saved and sent with the next planned status message, or disabled. The validation process involves configurable cargo rechecks by the system where a message is generated and sent following the predetermined number of status checks.

During the pilot test, the door sensor was configured to trigger an event if the door event went from closed to open and remained open for a configurable time ranging from 5 seconds to 60 minutes.

2.2 Tractor Power and Satellite Tracking System Interface

The tractor power and satellite tracking system interface includes the electrical and mechanical connections between the UTT terminal and the trailer. The connector is a standard 7-way plug (7 pin) that the driver hitches up to the trailer from the tractor to supply power to the trailer lights. This connection enables the UTT terminal to draw power from the tractor battery when connected. When disconnected from the tractor, the UTT terminal draws power from the UTT system's rechargeable battery in the trailer. The connector also provides a communication path between the UTT terminal and the satellite-based mobile communications tracking system on the tractor for trailer connection and disconnection functionality.

When the UTT system-equipped trailer interfaced with a tractor equipped with the satellite-based mobile communications tracking system for this pilot test, the UTT terminal provided connection and disconnection information to the carrier's on-site personnel. The cross-carrier visibility information includes: trailer owner's Trailer Identification (ID), Trailer Name, and Auxiliary (Aux) ID; and the tractor owner's Tractor ID, Tractor Name, and Aux ID.

The tractor-based mobile communications system is not considered an integral part of a UTT system; however, it is required for the QUALCOMM UTT system to provide disconnection and connection information. Other UTT systems on the market may not require both tractor and trailer based mobile communications systems for the connection and disconnection notification capability.

2.2.1 Tractor Mobile Communications Terminal

In combination with the UTT system, tractors were equipped with the OmniTRACS wireless satellite-based mobile communications systems to provide trailer connection and disconnection events and some messaging capabilities in the pilot test. Both systems integrated with the GPS were required for the connection and disconnection functionality in the pilot test. Through these systems' terminals, the carrier receives event and alert notifications for trailer connection and disconnection events. In addition, these systems' terminals also provide position updates. When the tractor is tethered to the trailer, the trailer identification is sent to the tractor terminal via the 7-way connector interface.

There is direct communication between the UTT terminal and the tractor terminal when the connection and disconnection feature is enabled and configured. A configuration is needed on both the UTT and tractor terminals. The UTT terminal is configured to post its terminal ID (unified address) onto pin 7 when it detects power. The tractor terminal is configured to look for the trailer ID when the tractor is connected to the trailer's 7-way connector interface. When the

tractor terminal detects a connection, it displays the UTT system ID on the driver's display and sends a connection or disconnection message OTA. The UTT system's TrailerTRACS/Web application displays the connection or disconnection message, UTT system ID, and UTT system name (stenciled trailer name).

The tractor mobile communications system works in conjunction with the motor carrier's dispatch systems, which provide the status for connection and disconnection detection. The tractor mobile communications system also provides tractor position updates and tractor-trailer position updates when the tractor is tethered to the trailer. These tractor and/or tractor-trailer positions are automatically displayed to the dispatcher at a regular frequency for viewing the tractor's location on a map through a web-based application. Position information includes the latitude, longitude, and time stamp, which allows the dispatcher to track the tractor or tractor-trailer combination and view the position history of its location at a particular time during the route. The system includes a driver interface unit for two-way text communications.

As shown in Figure 7, the OmniTRACS wireless satellite-based mobile communications system features include:

- Direct two-way data communication between the driver and the carrier with a driver interface unit for two-way text communications; free form, macro (formatted text messages), or binary messages (converted to binary form)
- Position of the tractor and time and date of the transmitted message
- Integration to third-party devices on the tractor and carrier site
- Integration to the carrier's back-office systems

Other than the trailer connection and disconnection functionality, the aforementioned features of the OmniTRACS system were not tested in the pilot test for the UTT system.

Figure 7: Tractor Mobile Communications Terminal

2.3 Network Communications

2.3.1 Untethered Trailer Tracking Wireless Terrestrial Communications

During the pilot test, the UTT system terrestrial communications links were provided over commercial carrier networks in the following frequencies: 800-MHz Amps, 800-MHz CDMA, and 1900-MHz CDMA. As shown in Figure 8, the UTT terminal utilized this terrestrial communications link for communicating with the fleet management center:

- The trailer terminal wakes-up at a pre-set time to send a message to the carrier. The terminal generates the message on the trailer terminal and retrieves a new GPS position.
- The trailer terminal sends the message to the terrestrial network.
- The terrestrial network sends the message to the Network Operations Center (NOC).
- The NOC sends the message to the UTT system (TrailerTRACS) web server.
- The message is displayed on the UTT system (TrailerTRACS) web browser.

If the UTT system's terminal is out of coverage for any reason, it is designed to maintain its messages. When cellular service is returned to the UTT terminal, it will forward the stored messages. The terminal has a buffer size to store 30 days of data.

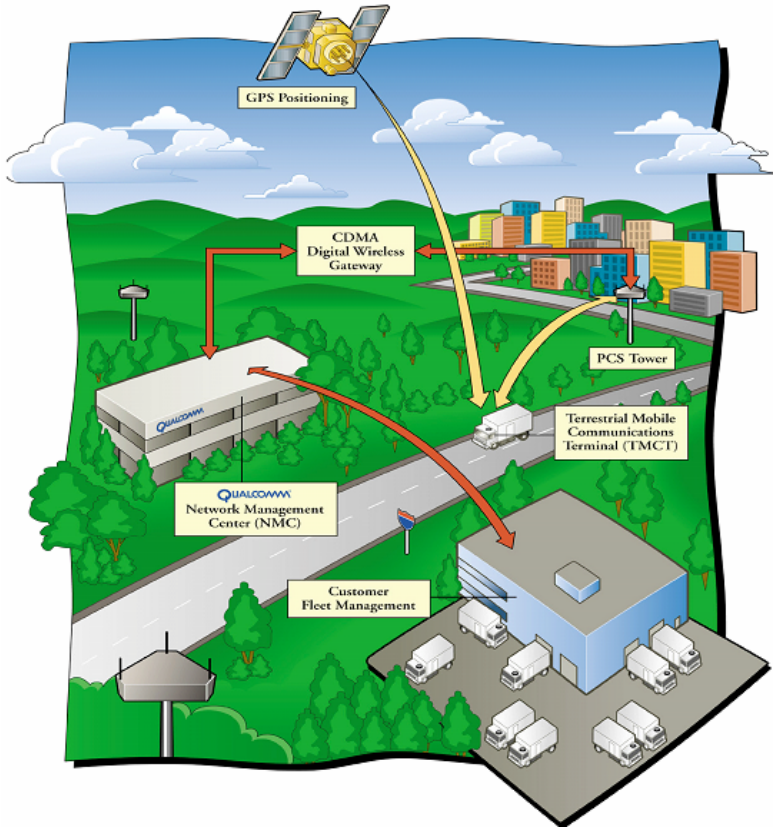

Figure 8: TrailerTRACS UTT System Wireless Terrestrial Communications

2.3.2 Tractor-Based Wireless Satellite Communications

For the pilot test, the satellite communications link was provided over a private Ku-band satellite for the tractor-based mobile communications and tracking system. Information was sent from the customer fleet management center to the Network Operations Center (NOC) via the internet. As shown in Figure 9, the information was transmitted to the communications satellite and down to the tractor's wireless satellite mobile communications terminal. The messaging from the tractor returned to the customer fleet management center in the opposite direction. During the pilot test, only the trailer connections and disconnections were tested in conjunction with the UTT system.

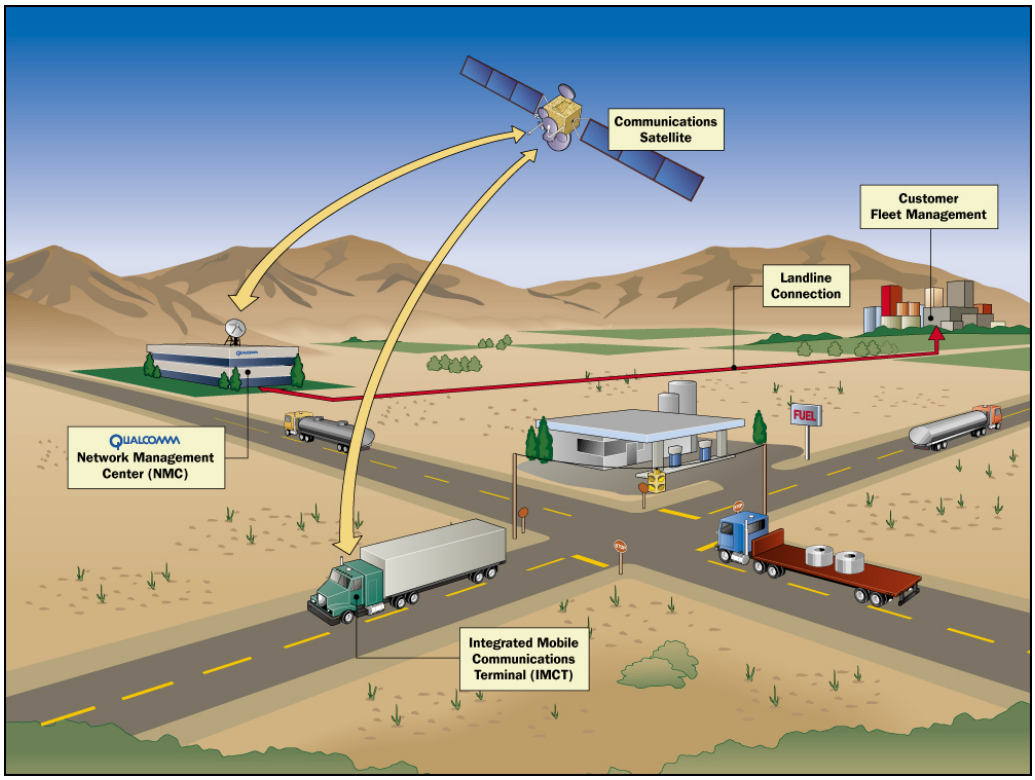

Figure 9: Wireless Satellite Communications

2.3.3 Network Operations Centers

For the pilot test, all messages and positions from the terrestrial and satellite communications were routed through the QUALCOMM NOC (Figure 10) in San Diego, CA, with a back-up NOC located in Las Vegas, NV. NOC and technical hotline support is operated 24 hours/7 days a week.

Figure 10: Network Operations Center

2.4 Customer Site Applications and/or Untethered Trailer Tracking System-Provided Hosted Web Applications

The UTT terminal uses TrailerTRACS/Web or TrailerTRACS/Green Screen (GS) as the carrier's site application to interface to the UTT system. The carrier can choose between a web-based application and a character-based green screen. In the pilot test, the web application was used at each carrier location.

The TrailerTRACS/Web application provides continuous position reports, a positive tractor-trailer ID with every trailer connection and disconnection, and sensor alerts regarding door and cargo status. The TrailerTRACS/Web application also provides the trailer-based geo-fencing capability.

As shown in Figure 11**,** the software provides a map interface with street-level maps for the United States, Canada, and Mexico. Additional mapping information included cargo event locations, door event locations, and historical positions on maps.

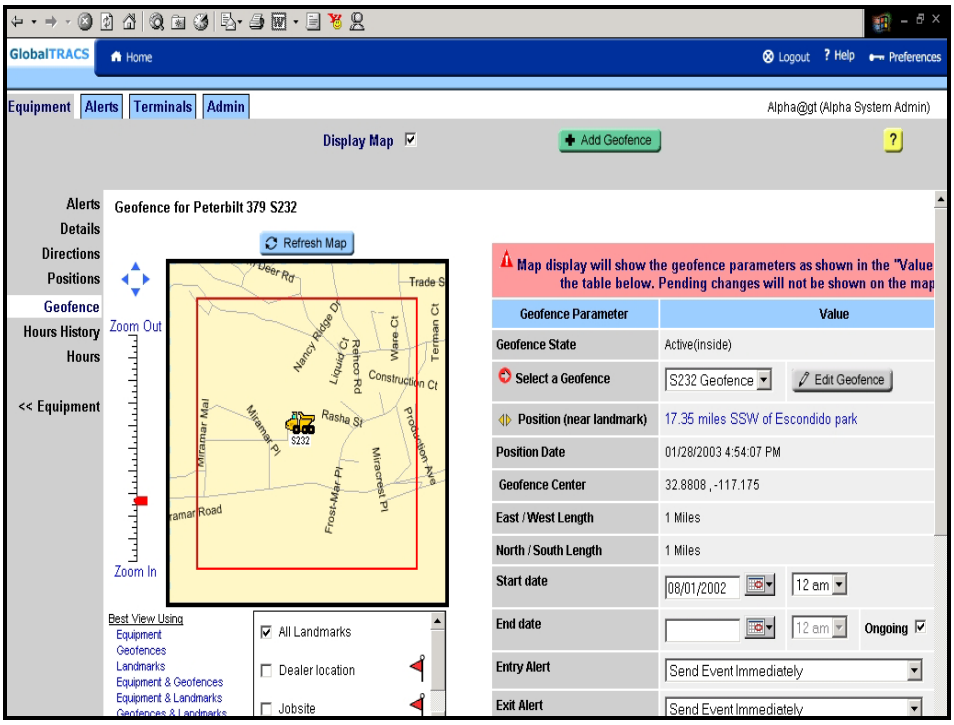

Figure 11: Web Host Interface

2.5 Untethered Trailer Tracking System Field Service Tool

The UTT system field service tool is a field support application that was hosted on portable data assistants (PDAs) and interfaced with the UTT terminal. During the installation of the UTT system for the pilot test, the tool was used by installers and mechanics to configure and verify the correct terminal installation. Following the installation, the tool was used for diagnostic functions. The tool provided a method to configure and verify that all interfaces and auxiliary hardware functioned properly, including the door sensor, cargo sensor, and user-configurable inputs and outputs (customer number, trailer number). The tool also was used to verify that the UTT terminal communicated with the NOC; show the rechargeable battery's voltage; display the received signal strength indication (RSSI); verify correct functioning of the GPS antenna; and display the UTT system's serial number.

In addition, a battery-powered, read-only diagnostic tool was used to check the health and status of the UTT terminal via the 7-way connector interface.

2.6 Untethered Trailer Tracking System Costs

As configured for this pilot test, Table 2 shows the UTT system costs per trailer. These costs represent only the trailer-based technology and not the cost of the tractor-based tracking and communications capabilities.

Table 2: UTT System Costs per Trailer

Set-Up Items	Costs Per Trailer
UTT System terminal, assembly, and battery	$600
Sensors-cargo ($75) and door ($75)	$75 to $150
Mounting hardware	$80
Installation costs	$300
Total Initial UTT System Costs	**$1,055 to $1,130**
The satellite communications terminal for the tractor, antenna, communications unit, and keyboard. (NOTE: This satellite-based mobile communications system on the tractor is needed for the tractor-trailer connection and disconnection information.)	$2,000
Monthly Service Fees	
Message fees and service agreement	$12

Approximate installation times for the UTT system are listed below:

- UTT system terminal (no sensors): 2 hours
- UTT system terminal with cargo sensor: 2 hours and 15 minutes
- UTT system terminal with door sensor: 4 hours
- UTT system terminal with door and cargo sensors: 4 hours
- Antennas: 1 hour and 45 minutes

Battery replacement cost is approximately $30, plus 1 hour and 30 minutes for installation.

3 SYSTEM DESIGN

The UTT system design includes the field service tool, mobile, network, hub, and host segments shown in Figure 12. The UTT system design involves near real-time trailer locations via terrestrial communications and visibility into the trailer events and alerts.

- The **Field Service Tool Segment** is a software package that operates on a handheld computer. This segment communicates with the trailer terminal for configuration and diagnostic purposes.
- The **Mobile Segment** interfaces with the equipment being tracked. This segment consists of the trailer terminal and the tractor terminal.
- The **Network Segment** provides a communications link to the mobile segment. This segment consists of the wireless and landline network equipment, the satellite network for tractor terminal, and the CDMA digital wireless gateway.
- The **Hub Segment** stores and forwards communications between the mobile terminals and the customer, billing, and account maintenance. The hub consists of the Network Operations Center.
- The **Host Segment** consists of the customer interface for trailer terminal and long-term data storage for the customer. A third-party interface can be included in the host segment.

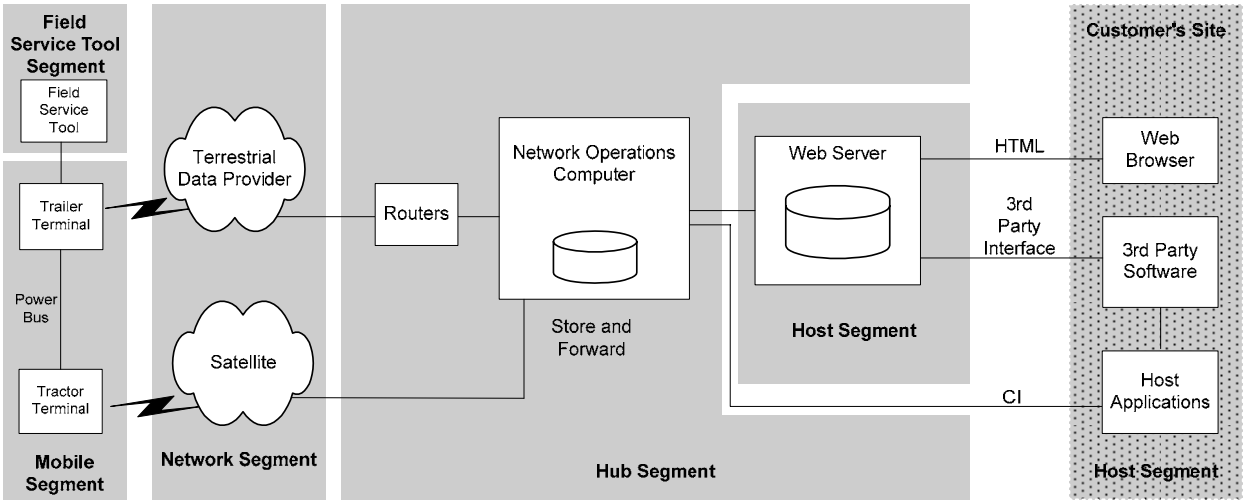

Figure 12: UTT System Design Summary

4 SCENARIOS

For the pilot test, three scenarios were developed with different shipment types regarding various levels of security and safety needs:

- Scenario 1 involved a national truckload carrier's standard dry van deliveries.
- Scenario 2 involved a national truckload carrier's transportation of high value retail clothing and electronics.
- Scenario 3 involved a regional truckload carrier's transportation of Class 1.1 – 1.6 Explosives.

UTT system technologies were installed in 25 trailers and tractors in each scenario, and tested for 3 months. This test period provided data showing that a UTT system could improve different levels of safety and security for various shipments from origin to destination. The carriers in all three scenarios had previously used the satellite-based mobile communications system on all of their tractors prior to the commencement of the UTT pilot test, as well as the tractor-based mobile communications system as a part of their daily operations.

A summary of each scenario is summarized in Table 3.

Table 3: Scenario Development

Scenario	Description	UTT System Components
1	Truckload/Dry Van	• Wireless satellite communication • UTT mobile terminal • Trailer cargo sensor • UTT web application/mapping • Geo-fencing
2	High Value	• Wireless satellite communication • UTT mobile terminal • Trailer cargo sensor • Trailer door sensor • UTT web application/mapping • Geo-fencing
3	Explosives/HAZMAT	• Wireless satellite communications • UTT mobile terminal • Trailer cargo sensor • Trailer door sensor • UTT web application/mapping • Geo-fencing

4.1 Operational Environment

The operational environments portraying the pilot test participating motor carriers' typical operations in each scenario are outlined below.

4.1.1 Scenario 1: Truckload/Dry Van

Scenario 1 of the pilot test includes trailer tracking of the Truckload/Dry Van portion of the trucking industry. Loads transported by this carrier are general dry freight containing electronics, clothing, and potatoes. Although the loads and routes vary throughout the season, cargo is delivered throughout the 48 states. The trailers are untethered primarily at the participant's headquarters terminal, in addition to region-wide customer locations.

The Scenario 1 participant owns a fleet of new and late model conventional tractors (600+) and 1,300 53-foot van trailers. Each tractor is equipped with a satellite-based mobile communications system. The participant's trailers are older, and some trailers are leased. The drivers work an average of 12 days on with 2 days off.

For all deliveries, the drivers are required to proceed directly to their destination. If drivers are carrying high-value loads, they are not allowed to disconnect their trailer from the tractor except at authorized terminals. Trailers can be dropped at the shipper's site where they have often remained for 3 to 10 days at a time before they are picked up. At any given time, up to 25 trailers can be sitting idle and unavailable to the carrier at a customer's site. In addition, the parent company may periodically use these idle trailers without authorization, which adds to the difficulty of the carrier locating the trailers. During the pilot test, the average length of haul was 564 miles, yet in certain instances, dedicated teams were used for longer hauls. The shippers and consignees varied for this scenario throughout the pilot test.

4.1.2 Scenario 2: Truckload/High Value

Scenario 2 of the pilot test includes trailer tracking of the Truckload/High Value portion of the trucking industry. Loads transported by this motor carrier are general dry freight containing retail clothing, electronics, and food. This participant is an irregular route truckload motor carrier operating in the 48 contiguous states with over 60 locations across the United States and additional points in Canada. The fleet's equipment consists of 1,300 trucks and 2,900 trailers of which 62 percent have air ride. All of the trailers are constructed of sheet metal and aluminum posts. The inside of the trailers are lined with plywood. Historically, the test participant had experienced losses when trailer doors were not closed properly, which resulted in water damage to the cargo and trailer. All 1,300 tractors are equipped with satellite-based mobile communications systems.

In Scenario 2, the drivers are permanently assigned to their tractors, but owner-operators are also used. Loads are usually dropped at the Mexican border where a Mexican carrier picked up the load, yet in some instances, authorized Mexican carriers transported trailers into Mexico.

In the test participant's yard, located approximately 2 miles from their administrative offices, trailers can sit on a pad in the yard for 30 days or more. Security at the participant's facility is good, since the lot is fenced and covered by closed circuit television (CCTV) cameras. All

tractors and trailers entering the yard are inspected. When a tractor trailer leaves the yard, it passes through two gates. At the first gate, the driver's ID and manifest are verified, and at the second gate, a photo of the driver, the trailer, and the tractor are taken. Records are held for 7 days.

The trailer inventory is handled manually by checking the trailers in the yard twice a day. Then, the inventory sheet is faxed to a customer service clerk who compares the faxed inventory sheet to an inventory maintained on the computer. Approximately five to six hours can be spent to determine whether or not a trailer was missing. In most instances, missing trailers occurred when an authorized driver takes the wrong trailer due to a transposed trailer number in the inventory.

During the pilot test, the drivers drove an average of 789 miles per trip. These drivers were required to use a kingpin lock when the trailer was dropped and to padlock all doors. The carrier also reversed the bolts in the trailer doors and spot-welded the bolts for higher security. In some instances, the shippers sealed or locked the trailer doors, and the drivers were not authorized to drop the trailer without obtaining permission from the dispatchers. The shippers and consignees varied for this scenario throughout the pilot test. Approximately 6,000 to 10,000 loads total were transported by this carrier per month, and operations extended into both Canada and Mexico.

4.1.3 Scenario 3: Explosives/Hazardous Materials

Scenario 3 of the pilot test includes trailer tracking of the HAZMAT/Explosives portion of the trucking industry. Sixty percent of the trailers are used for DOD movements. The trailers are usually picked up from the shipper by an interim driver and driven to a safe haven area for staging or transfer to an over-the-road driver. The remaining 40 percent of trailers are used for general load traffic. The loads vary throughout the season and are delivered throughout the 48 states. The participant's companies specialize in the over-the-road transportation of military munitions, commercial explosives, and radioactive materials from 15 terminals located across the United States. Centralized dispatch is performed at its corporate location. Over-the-road shipments of commercial explosives are typically delivered to blasting sites and bin storage. Over 200 of the test participant's tractors are equipped with a satellite-based mobile communications system. The participant also has over 500 dry van trailers.

In the pilot test, the drivers were permanently assigned to tractors and averaged 928 miles per trip. Approximately 1,800 to 2,000 loads were transported by this carrier per month. Drivers used a kingpin lock when the trailer was dropped and padlocked the doors. During the pilot test, the trailers were untethered at the participant's headquarters terminal and at the participant's customer locations within the Midwest and Eastern states. The consignees varied for this scenario.

4.2 Architecture by Scenario for the Pilot Test

This section describes the technology architecture for each operational scenario in the pilot test, which includes:

- A description of the UTT system technologies and functions tested.
- The configurable parameters by system component, as applicable.

- A description of the operational flow, including a diagram and itemized steps. (The operational flow describes the flow of information between the vehicle components, network components, and participant systems. The system components utilized in a specific message flow are shaded gray.) Each flow contains:
  - Daily operations
  - Alerts
- A physical architecture for each scenario.

4.3 Scenario 1: Truckload/Dry Van

4.3.1 Technologies Tested

The following technologies were tested in this scenario:

UTT System

- Terrestrial UTT terminal
- Ultrasonic cargo sensor
- Cellular and GPS stealth-mounted antennas
- Tractor power connection

Tractor Mobile Communications System

- Satellite mobile communications terminal

Host

- Tractor system host application
- Trailer-tracking host application with geo-fencing capabilities associated with the trailer

4.3.2 Functionality Tested

The following functions were tested in this scenario:

Trailer Location

- Find empty versus loaded trailers
- Find a specific trailer or all trailers at a specific customer site
- Monitor “unauthorized” usage of trailers by customer

Tractor Assignment

- Assign the tractor to a specific trailer
- Send a message to a driver with trailer pickup location

- Verify the trailer is authorized for shipping
- Monitor the load status of the trailer to ensure it is consistent with the participant's manifest

Connection and Disconnection Monitoring

- Verify that the driver connects the correct tractor to the correct trailer (empty or loaded)
- Verify that drops are at authorized locations
- Monitor for unauthorized drops

Tracking of Trailer

- Monitor the route of the trip with hourly tractor positions and daily trailer positions
- Monitor route deviations manually
- Monitor risk areas with geo-fencing

4.3.3 Configuration

The configurations for Scenario 1 are presented in Table 4. For this scenario, the UTT system sent a status report every 24 hours. The status report included two key pieces of information: the trailer's current location and the cargo status.

Table 4: Scenario 1 – Trailer Terminal Configuration

Parameter	Value
Position reporting interval	Once per day
Preset wake interval	2 hours
Trailer ID, Type, Standard Carrier Alpha Code (SCAC)	User-defined
Connections and disconnections	Enable
Cargo check interval	30 minutes
Cargo-event messaging	Send immediately
Cargo validation interval	10 minutes
Cargo validation rechecks	3
Geo-fence messaging	Send immediately
Geo-fence check interval	1 hour
Geo-fence size	User-defined
Geo-fence center position	User-defined

There are two types of configurable intervals: wake-up and validation. Wake-up intervals are defined as an interval that the UTT system wakes up and checks for a variety of events.

- **Preset Wake-up.** The UTT system wakes up to check whether there are any new incoming messages to process. For this scenario, this interval was set to every 2 hours.
- **Cargo Check.** The UTT system wakes up to check if the cargo status has changed. For this scenario, this interval was set to every 30 minutes.
- **Geo-fence Check.** The UTT system wakes up to check whether a geo-fence has been breached. For this scenario, this interval was set to every hour.

Validation intervals are defined as an interval that the UTT system uses to ensure that a state change has actually occurred.

- **Cargo Validation Interval.** If a cargo reading indicates that a state is not the same as the previous state, the UTT system will perform a recheck after waiting the pre-defined interval. This is done to minimize false positive state changes. For this scenario, the pre-defined interval was set to 10 minutes.
- **Cargo Validation Rechecks.** If a cargo reading indicates that a state is not the same as the previous state, the recheck may be configured to repeat a number of times before sending a message about the state change. For this scenario, the recheck was set to three times.

For this scenario, the UTT system checked on the cargo status every 30 minutes and, following the initial status check, did three validation rechecks every 10 minutes. The rechecks only occur when the initial status check indicates that a change of state has occurred.

The UTT system also provides an on-board geo-fence with event-driven exception reporting. In this scenario, exception-driven reporting allowed the UTT system to monitor trailer position and check for geo-fence breaks every hour, but sent a message only if a geo-fence break was detected. Frequent checking for geo-fence breaks without sending frequent messages lowers messaging costs and increases battery life.

Connection and disconnection information does not include validation intervals. When the tractor-based mobile communications system detects a trailer connection or disconnection, it sends a message via the 7-way connector interface to the NOC. The NOC then forwards the event to the UTT system's TrailerTRACS web application, alerting the dispatcher of the connection or disconnection. For disconnections, an alert is generated. The dispatcher uses the TrailerTRACS web application to determine if the disconnection was at a valid location, as well as to determine if the cargo status is "not empty" for the applicable trailer.

4.3.4 Logical Architecture and Operational Flow

The architecture and operational flow of information between technologies used in Scenario 1 are shown in Figure 13.

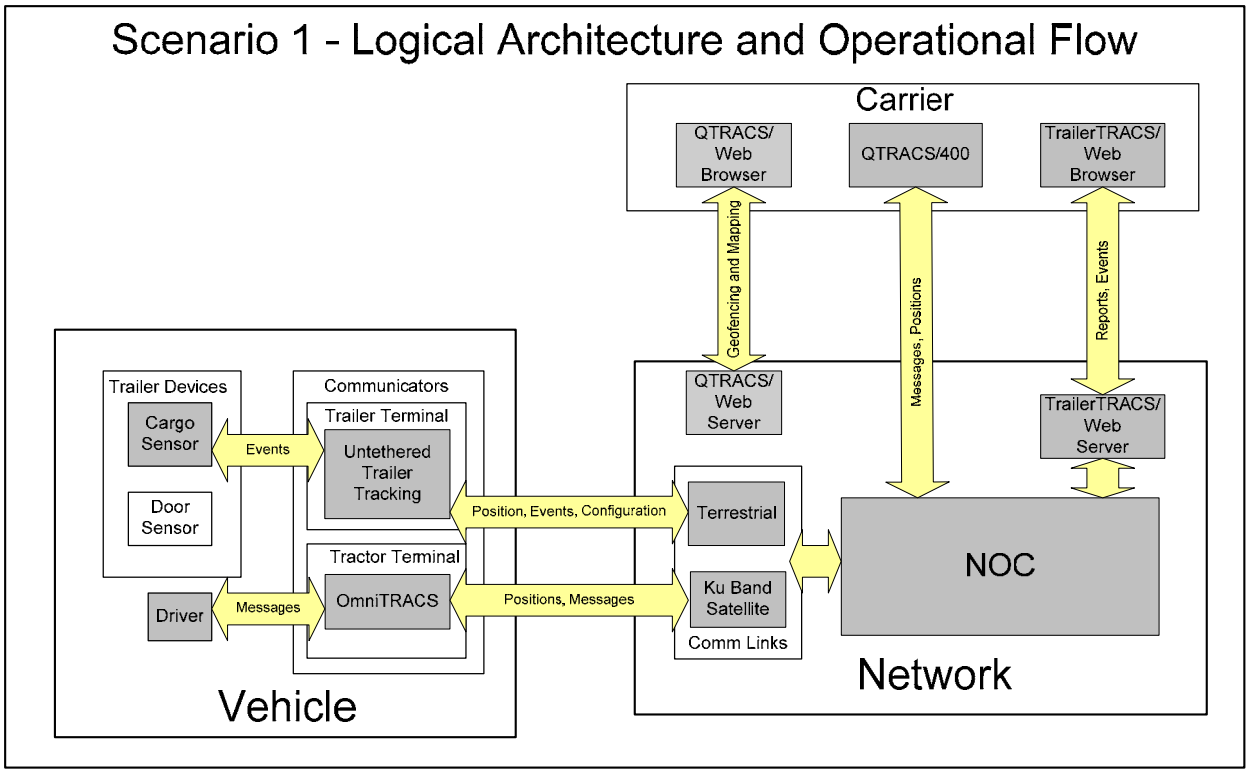

Figure 13: **Scenario 1 – Logical Architecture and Operational Flow**

4.3.5 Daily Operations

This section describes the daily operational procedures that the participants were asked to perform as part of the pilot test.

Daily Operational Procedures

The dispatcher logs onto the UTT system host application in preparation for dispatching drivers to pick up trailers and loads.

Finding Trailer(s)

1. The dispatcher clicks on the "Find Trailer" tab to search for data:
    a. Specific trailer location
    b. Trailers based on cargo status (empty/full)
    c. Trailers near a specific landmark
    d. All trailers

Assigning Trailer(s)

1. The dispatcher assigns a driver to a trailer pickup by creating a load assignment/pickup macro instructing the driver where to pickup the next trailer and load.

2. The satellite-based mobile communications messaging system is used to send the message to the driver.

Connecting Trailer(s)

The driver arrives at a trailer pickup location and the tractor is attached to the assigned trailer:

1. The satellite-based mobile communications terminal detects the connection via the 7-way connector interface to the UTT terminal connected to the tractor.
2. The satellite-based mobile communications terminal sends a connection message to the NOC.
3. The NOC forwards the event to the UTT system host application, alerting the dispatcher of the trailer connection event.
4. The dispatcher verifies that the trailer is connected to the assigned tractor.

Monitoring Trailer(s) En Route

When ready to depart for the destination, the driver sends a "departing macro" to the dispatcher via the satellite-based mobile communications satellite system.

Two mechanisms exist for monitoring the trailer while it is en route:

1. Trailer positioning (default position interval is one position per day):
    a. If the trailer is pulled by a tractor not equipped with a satellite-based mobile communications terminal or the satellite-based mobile communications terminal is not functioning, the dispatcher monitors the trailer's location using the UTT system via the UTT system host application.
    b. The dispatcher modifies the trailer terminal's positioning frequency to be more frequent than the default (e.g., once per hour or once every 6 hours) while en route.
        i. The dispatcher enters the setup configuration for a specific trailer to select the positioning frequency parameter.
        ii. The UTT system host application creates a message and sends it to the trailer terminal via the NOC and terrestrial network.
2. Tractor positioning:
    a. If the trailer is being pulled by a tractor equipped with a functioning satellite-based mobile communications terminal, the dispatcher monitors the trailer's location using the satellite-based mobile communications system via the host application.
    b. The default positioning frequency is once per hour. If the dispatcher needs more frequent positioning, the Mobile Initiated Position Report (MIPR) parameter is modified on the tractor terminal.

Detecting and Disconnecting Trailer(s)

The driver arrives at the destination and disconnects the trailer from the tractor at the designated location:

1. The satellite-based mobile communications terminal detects that the UTT terminal is no longer connected and sends a disconnection message to the NOC.
2. The NOC forwards the disconnection event to the UTT system host application and alerts the dispatcher regarding the trailer disconnection event.
3. The dispatcher verifies that the trailer has been disconnected in an authorized drop location.

Geo-fencing Disconnected Trailer(s)

When the dispatcher receives an alert that a non-empty trailer has been dropped at an authorized location, the dispatcher creates a geo-fence to surround the disconnected trailer:

1. The dispatcher uses the UTT system host application to create or edit a geo-fence.
2. The dispatcher selects the center point for the geo-fence (self-centered, landmark, or latitude/longitude), the east/west and north/south lengths, the geo-fence start/stop time, the enable geo-fence flag, the geo-fence wake-up interval, and the type of geo-fence (exit/enter).
3. The UTT system host application generates a message with the updated information and sends it to the trailer terminal via the NOC and the terrestrial network to the trailer terminal.
4. An "electronic fence" is set around the trailer, which is monitored by the UTT terminal, based on its configuration.
5. Using the UTT system host application, the dispatcher has the option to view the geo-fence on a map.

4.3.6 Alerts

The following security alert was featured in this scenario:

- Trailer disconnection with a not empty load
- Untethered trailer leaves or enters a geo-fenced area

Disconnection with a "Not Empty" Load Alert

The driver disconnects the trailer in the consignee's yard with a load that is awaiting offload:

1. The tractor terminal sends a disconnection message as described in the "Trailer arrives at destination" steps above.

2. The UTT system host application receives a disconnection message and generates an alert to the dispatcher.
3. The dispatcher uses the trailer-tracking host application to determine if the cargo status is "not empty" on the applicable trailer.

Untethered Trailer Geo-fence Alert

1. The driver disconnects the trailer in the consignee's yard and sets a valid geo-fence.
2. The trailer terminal wakes up based on the customer configurable setting – every hour – to determine if a geo-fence violation has occurred.
3. If the trailer has left the geo-fenced area, the trailer terminal sends a geo-fence violation alert to the dispatcher.

4.3.7 Physical Architecture

The physical architecture for Scenario 1 is shown in Figure 14.

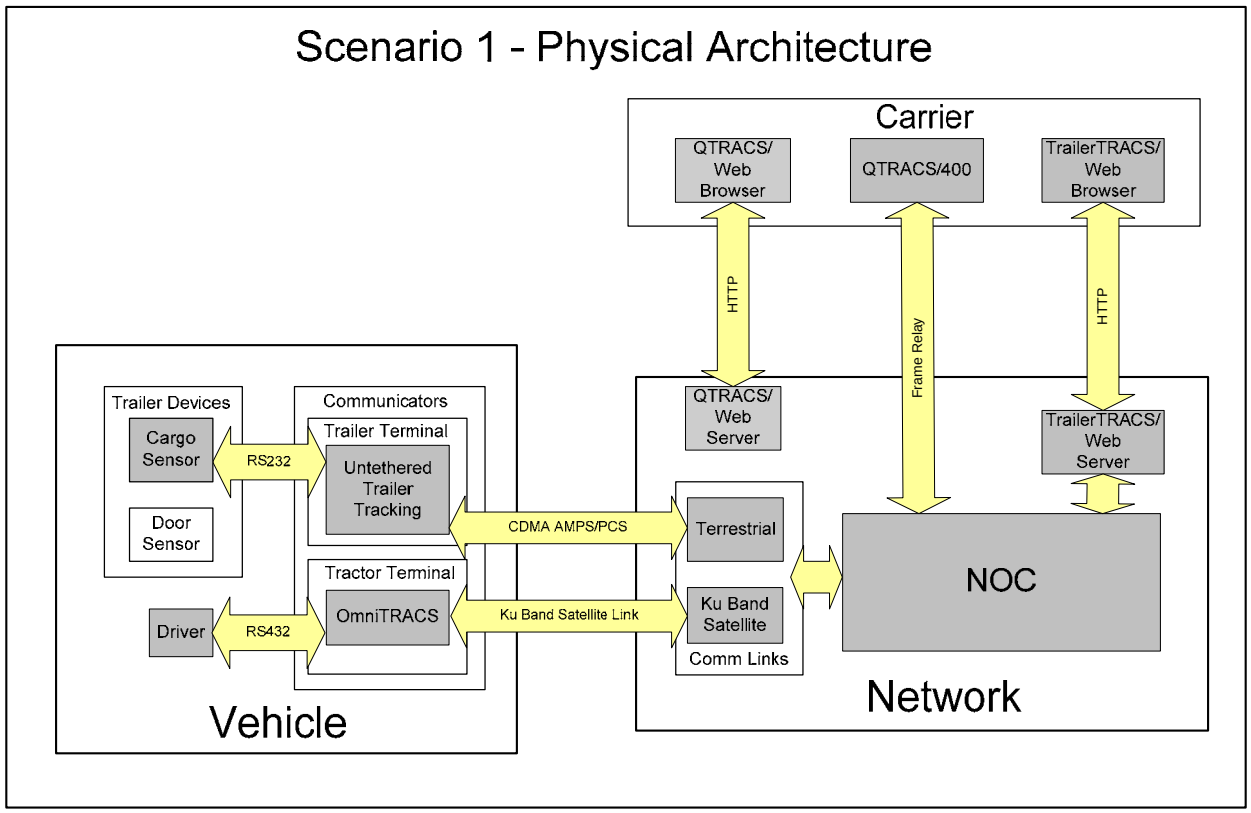

Figure 14: Scenario 1 – Physical Architecture

4.4 Scenario 2: High Value

4.4.1 Technologies Tested

The following technologies were tested in scenario 2:

UTT System

- Terrestrial UTT terminal
- Ultrasonic cargo sensor
- Magnetic door sensor
- Cellular and GPS stealth-mounted antennas
- Tractor power connection

Tractor Mobile Communications System

- Satellite mobile communications tractor terminal

Host

- Tractor system host application
- Trailer-tracking host application with geo-fencing capabilities associated with the trailer

4.4.2 Functionality Tested

The following functions were tested in this scenario:

Trailer Location and Status

- Find empty versus loaded trailers
- Find a specific trailer or all trailers at a specific customer site
- Monitor door sensor activity
- Monitor “unauthorized” usage of trailer by customer

Tractor Assignment

- Assign tractor to empty/full trailer
- Send a message to driver with trailer pickup location
- Verify trailer is authorized for shipping
- Monitor the load status of the trailer to verify it is consistent with the participant’s manifest

Connection and Disconnection Monitoring

- Verify that the driver connects the correct tractor to the correct trailer (empty or loaded)
- Verify that drops are at an authorized location
- Monitor for unauthorized drops

Tracking of Trailer

- Monitor the route of the trip with hourly tractor positions and daily trailer positions
- Monitor route deviations manually
- Monitor risk areas with geo-fencing

4.4.3 Configuration

The configurations for Scenario 2 are shown in Table 5. For this scenario, the UTT system sends a status report every 24 hours. The status report includes three key pieces of information: the trailer's current location, and the cargo and door status.

Table 5: Scenario 2 – Trailer Terminal Configuration Settings

Parameter	Value
Position reporting interval	Once per day
Preset wake interval	6 hours
Trailer ID, Type, SCAC	User-defined
Connections and disconnections	Enable
Cargo check interval	30 minutes
Cargo-event messaging	Send immediately
Cargo validation interval	10 minutes
Cargo validation rechecks	3
Door close messaging	Disabled
Door open messaging	Send immediately if cargo status is "Not empty"
Door validation open time	5 seconds
Door validation close time	1 minute
Geo-fence messaging	Send immediately
Geo-fence check interval	1 hour
Geo-fence size	User-defined
Geo-fence center position	User-defined

There are two types of configurable intervals: wake-up and validation. Wake-up intervals are defined as an interval that the UTT system wakes up and checks for a variety of events.

- **Preset Wake-up.** The UTT system wakes up to check whether there are any new incoming messages to process. For this scenario, this interval is set to every 6 hours.
- **Cargo Check.** The UTT system wakes up to check if the cargo status has changed. For this scenario, this interval is set to every 30 minutes.
- **Geo-fence Check.** The UTT system wakes up to check whether a geo-fence has been breached. For this scenario, this interval is set to every hour.

Validation intervals are defined as an interval that the UTT system uses to ensure that a state change has actually occurred.

- **Cargo Validation Interval.** If a cargo reading indicates that a state is not the same as the previous state, the UTT system will perform a recheck after waiting for the pre-defined interval. This is done to minimize false positive state changes. For this scenario, the pre-defined interval was set to 10 minutes.
- **Cargo Validation Rechecks.** If a cargo reading indicates that a state is not the same as the previous state, the recheck may be configured to repeat a number of times before sending a message about the state change. For this scenario, the recheck was set to three times.
- **Door Validation Open/Close.** If the door sensor indicates that a door has opened or closed, the UTT system will wait for a pre-defined interval to ensure that the state has really changed. For this scenario, the open validation time is set to 5 seconds and the close validation time is set to 1 minute.

For this scenario, the UTT system checked on the cargo status every 30 minutes with three validation rechecks every 10 minutes following the initial status check. The rechecks only occur when the initial status check indicates that a change of state has occurred.

If the door is closed, the cargo check is initiated after a 1-minute validation recheck of the door state. If a cargo state change is detected, then an OTA cargo status message will be sent, otherwise, no message will be sent.

If the door is opened and the trailer is “not empty,” an alert will be immediately sent that the door is open with a “not empty” cargo status. The alert will be sent following a 5-second door validation check.

The UTT system also provides an on-board geo-fence with event-driven exception reporting. In this scenario, exception-driven reporting allows the UTT system to monitor trailer position and check for geo-fence breaks every hour, but send a message only if a geo-fence break is detected. Frequent checking for geo-fence breaks without sending frequent messages lowers messaging costs and increases battery life.

Connection and disconnection information does not include validation intervals. When the tractor-based mobile communications system detects that a trailer has a connection or disconnection, via the 7-way connector interface, it sends a message to the NOC. The NOC then forwards the event to the UTT system's TrailerTRACS web application, alerting the dispatcher of the connection or disconnection. For disconnections, an alert will be generated. The dispatcher uses the TrailerTRACS web application to determine if the disconnection was at a valid location, as well as to determine if the cargo status is "not empty" for the applicable trailer.

4.4.4 Logical Architecture and Operational Flow

The architecture and operational flow of information for the technologies used in Scenario 2 are shown in Figure 15.

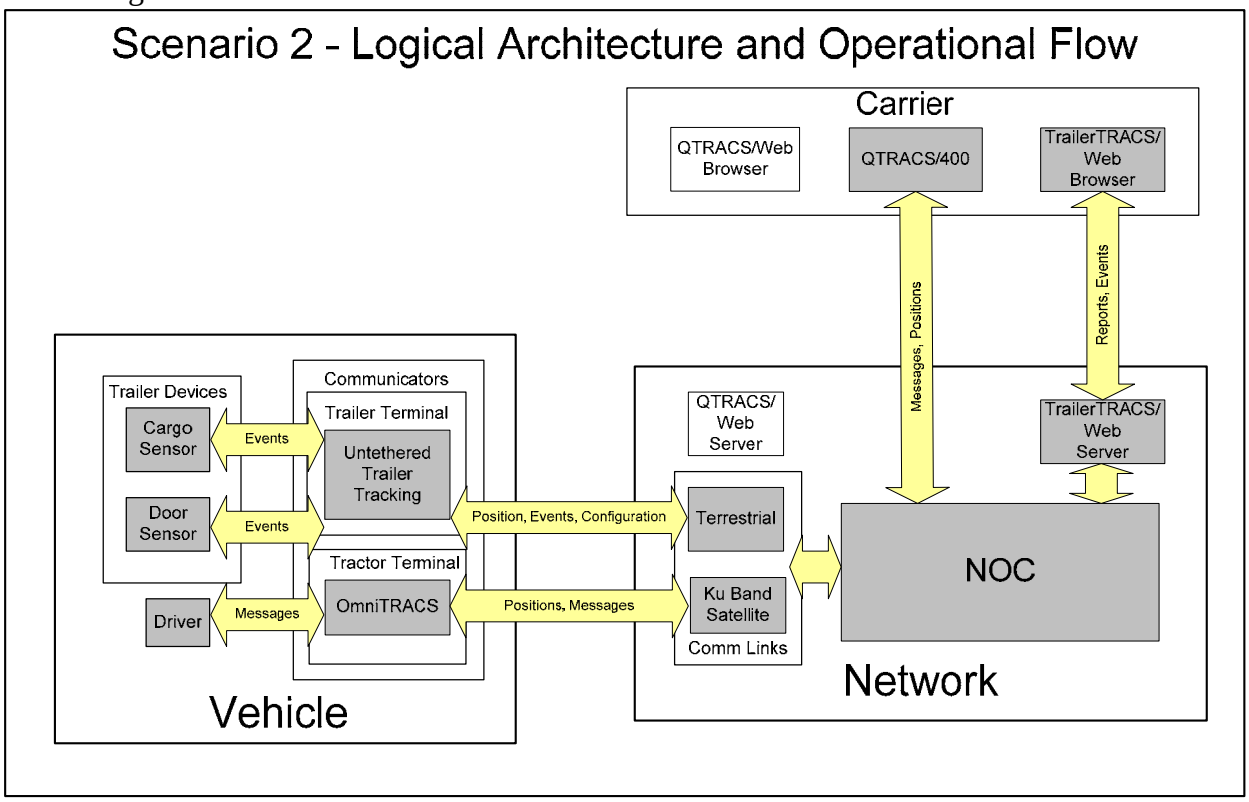

Figure 15: Scenario 2 – Logical Architecture and Operational Flow

4.4.5 Daily Operations

This section describes the daily operational procedures that the participants were asked to perform as part of the pilot test.

Daily Operational Procedures

The dispatcher logs onto the trailer-tracking host application in preparation for dispatching drivers to pick up trailers and loads.

Finding Trailer(s)

The dispatcher clicks on the "Find Trailer" tab to search for desired data:

1. Specific trailer location
2. Trailers based on cargo status (empty/full)
3. Trailers near a specific landmark
4. All trailers

Assigning Trailer(s)

The dispatcher assigns a driver to a trailer pickup:

1. The dispatcher creates a load assignment/pickup macro instructing the driver where to pick up the next trailer and load.
2. The satellite-based mobile communications messaging system is used to send the message to the driver.

Connecting Trailer(s)

The driver arrives at trailer pickup location and attaches the tractor to the assigned trailer:

1. The satellite-based mobile communications terminal detects via the 7-way connector interface that there is an UTT terminal that is connected to the tractor.
2. The satellite-based mobile communications terminal sends a connect message to the NOC.
3. The NOC forwards the event to the trailer-tracking host application, alerting the dispatcher of the trailer connection event.
4. The dispatcher verifies that the trailer is connected to the assigned tractor.

Monitoring Trailer Doors

Upon completing the trailer loading, the trailer door is closed:

1. The door sensor is automatically engaged when the doors are closed.

Monitoring Trailer(s) En Route

When ready to depart for the destination, the driver sends a "departing macro" to the dispatcher via the satellite-based mobile communications system.

Two mechanisms exist for monitoring the trailer while it is en route:

1. Trailer positioning (default position interval is one position per day):
    a. If the trailer is pulled by a tractor not equipped with a satellite-based mobile communications terminal or the satellite-based mobile communications terminal

is not functioning, the dispatcher monitors the trailer's location using the UTT system via the trailer-tracking host application.

b. The dispatcher modifies the trailer terminal's positioning frequency to be more frequent than the default (once per hour or once per every 6 hours) while en route.
    i. The dispatcher enters the setup configuration for a specific trailer to select the positioning frequency parameter.
    ii. The trailer-tracking host application creates a message and sends it to the trailer terminal via the NOC and terrestrial network.

2. Tractor positioning:
    a. If a tractor equipped with a functioning satellite-based communications terminal pulls the trailer, the dispatcher monitors the trailer's location using the satellite-based mobile communications system via the host application.
    b. The default positioning frequency is once per hour. If the dispatcher requires more frequent positioning, the MIPR parameter is modified on the tractor terminal.

Detecting and Disconnecting Trailer(s)

The driver arrives at the destination and disconnects the trailer from the tractor at the designated location:

1. The satellite-based mobile communications terminal detects that the UTT terminal is no longer connected and sends a disconnection message to the NOC.
2. The NOC forwards the disconnection event to the trailer-tracking host application and alerts the dispatcher regarding the trailer disconnection event.
3. The dispatcher verifies that the trailer has been disconnected in an authorized drop location.

Geo-fencing Disconnected Trailer(s)

When the dispatcher receives an alert that a non-empty trailer has been dropped at an authorized location, the dispatcher creates a geo-fence to surround the disconnected trailer:

1. The dispatcher uses the UTT system host application to create or edit a geo-fence.
2. The dispatcher selects the center point for the geo-fence (self-centered, landmark, or latitude/longitude), the east/west and north/south lengths, the geo-fence start/stop time, the enable geo-fence flag, the geo-fence wake-up interval, and the type of geo-fence (exit/enter).
3. The UTT system host application generates a message with the updated information and sends it to the trailer terminal via the NOC and the terrestrial network to the trailer terminal.
4. An "electronic fence" is set around the trailer, which is monitored by the UTT terminal, based on its configuration.

5. Using the UTT system host application, the dispatcher has the option to view the geo-fence on a map.

4.4.6 Alerts

The following security alerts were featured in this scenario:

- Untethered trailer leaves or enters a geo-fenced area
- Trailer disconnection with a “not empty” load
- Trailer door opened with a “not empty” load

Untethered Trailer Geo-fence Alert

1. The driver disconnects the trailer in the consignee’s yard and sets a valid geo-fence.
2. The trailer terminal wakes up based on the customer configurable setting, every hour, to determine if a geo-fence violation has occurred.
3. If the trailer has left the geo-fenced area, the trailer terminal sends a geo-fence violation alert to the dispatcher.

Disconnection with a “Not Empty” Load Alert

The driver disconnects the trailer in the consignee’s yard with a load that is awaiting offload:

1. The tractor terminal sends a disconnection message.
2. The trailer-tracking host application receives a disconnection message and generates an alert to the dispatcher.
3. The dispatcher uses the trailer-tracking host application to determine if the cargo status is “not empty” on the applicable trailer.

Door Opening Event with a “Not Empty” Load

The trailer door opens:

1. The trailer terminal recognizes that a door opening event has occurred.
2. The trailer terminal determines, based on the trailer configuration, if an alert is required.
3. The trailer terminal generates an alert and sends it OTA to the trailer-tracking host application.
4. The trailer-tracking host application forwards this alert to the dispatcher.

4.4.7 Physical Architecture

The physical architecture and message flow is shown on the next page in Figure 16:

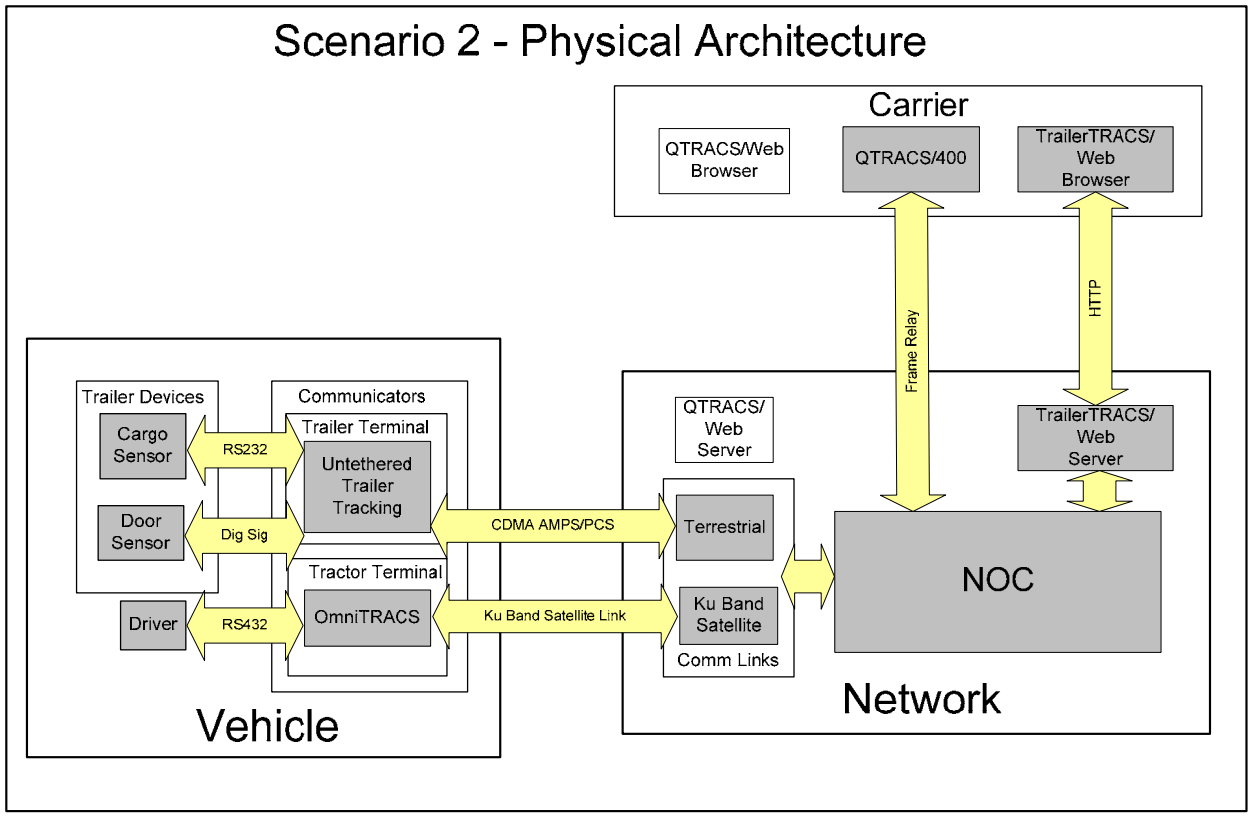

Figure 16: Scenario 2 – Physical Architecture

4.5 Scenario 3: Explosives/Hazardous Materials

4.5.1 Technologies Tested

The following technologies were tested in scenario 3:

UTT System

- Terrestrial UTT terminal
- Electronic door sensor
- Trailer cargo sensor
- Cellular and GPS stealth-mounted antennas
- Tractor power connection

Tractor Mobile Communications System

- Satellite mobile communications terminal

Host

- Tractor system host application
- UTT system host application with geo-fencing capabilities associated with the trailer

4.5.2 Functionality Tested

The following functions were tested in this scenario:

Trailer Location and Status

- Find empty versus loaded trailers
- Find a specific trailer or all trailers at a specific customer site
- Monitor door sensor activity
- Monitor "unauthorized" usage of trailer by customer

Tractor Assignment

- Assign tractor to empty/full trailer
- Send a message to driver with trailer pickup location
- Verify trailer is authorized for shipping
- Monitor the load status of the trailer to verify it is consistent with the participant's manifest

Connection and Disconnection Monitoring

- Verify that the driver connects the correct tractor to the correct trailer (empty or loaded)
- Verify that drops are at an authorized location
- Monitor for unauthorized drops

Tracking of Trailer

- Monitor the route of the trip through the tractor position every 15 minutes
- Monitor route deviations through host-based route monitoring and mapping
- Monitor risk areas with geo-fencing

4.5.3 Configuration

The configuration suggested for Scenario 3 is shown in Table 6. For this scenario, the UTT system sent a status report every 24 hours. The status report included three key pieces of information: the trailer's current location, and the status for the cargo and door sensors.

Table 6: Scenario 3 – Operational Settings

Parameter	Value
Position reporting interval	Once per day
Preset wake interval	6 hour
Trailer ID, Type, SCAC	User-defined
Connections and disconnections	Enable
Cargo check interval	30 minutes
Cargo-event messaging	Send immediately
Cargo validation interval	10 minutes
Cargo validation rechecks	3
Door close messaging	Disabled
Door open messaging	Send immediately if cargo=Not empty
Door validation open time	5 seconds
Door validation close time	1 minute
Geo-fence messaging	Send immediately
Geo-fence check interval	1 hour
Geo-fence size	User-defined
Geo-fence center position	User-defined

There are two types of configurable intervals: wake-up and validation. Wake-up intervals are defined as an interval that the UTT system wakes up and checks for a variety of events:

- **Preset Wake-up.** The UTT system wakes up to check whether there are any new incoming messages to process. For this scenario, the interval was set to every 6 hours.
- **Cargo Check.** The UTT system wakes up to check if the cargo status has changed. For this scenario, the interval was set to every 30 minutes.
- **Geo-fence Check.** The UTT system wakes up to check whether a geo-fence has been breached. For this scenario, the interval was set to every hour.

Validation intervals are defined as an interval that the UTT system uses to ensure that a state change has actually occurred.

- **Cargo Validation Interval.** If a cargo reading indicates that a state is not the same as the previous state, the UTT system will perform a recheck after waiting the pre-defined interval. This is done to minimize false positive state changes. For this scenario, the pre-defined interval was set to 10 minutes.

- **Cargo Validation Rechecks.** If a cargo reading indicates that a state is not the same as the previous state, the recheck may configured to repeat a number of times before sending a message about the state change. For this scenario, the recheck was set to three times.
- **Door Validation Open/Close.** If the door sensor indicates that a door has opened or closed, the UTT system will wait for a pre-defined interval to ensure that the state has really changed. For this scenario, the open validation time was set to 5 seconds and the close validation time was set to 1 minute.

For scenario 3, the UTT system checked on the cargo status every 30 minutes with three validation rechecks every 10 minutes following the initial status check. The rechecks only occurred when the initial status check indicated that a change of state had occurred. If the door was closed, a cargo check was initiated after a 1-minute validation recheck of the door state. A cargo status message was sent only if there was a change in cargo status. A "door open" message was only immediately sent (after a 5-second validation check) if the cargo status was "not empty." If the door was opened and the trailer was "not empty," an alert was sent that the door was open with a "not empty" cargo status.

The UTT system also provides an on-board geo-fence with event-driven exception reporting. In this scenario, exception-driven reporting allows the UTT system to monitor trailer position and check for geo-fence breaks every hour, but send a message only if a geo-fence break is detected. Frequent checking for geo-fence breaks without sending frequent messages lowers messaging costs and increases battery life.

When the tractor-based mobile communications system detects that a trailer has a connection or disconnection, via the 7-way, it sends a message to the NOC. The NOC then forwards the event to the UTT system's TrailerTRACS web application, immediately alerting the dispatcher of the connection or disconnection. For disconnections, an alert will be generated. The dispatcher uses the TrailerTRACS web application to determine if the disconnection was at a valid location, as well as to determine if the cargo status is "not empty" for the applicable trailer.

4.5.4 Logical Architecture and Operational Flow

The architecture and operation flow of data across all technologies used in Scenario 3 are presented in Figure 17.

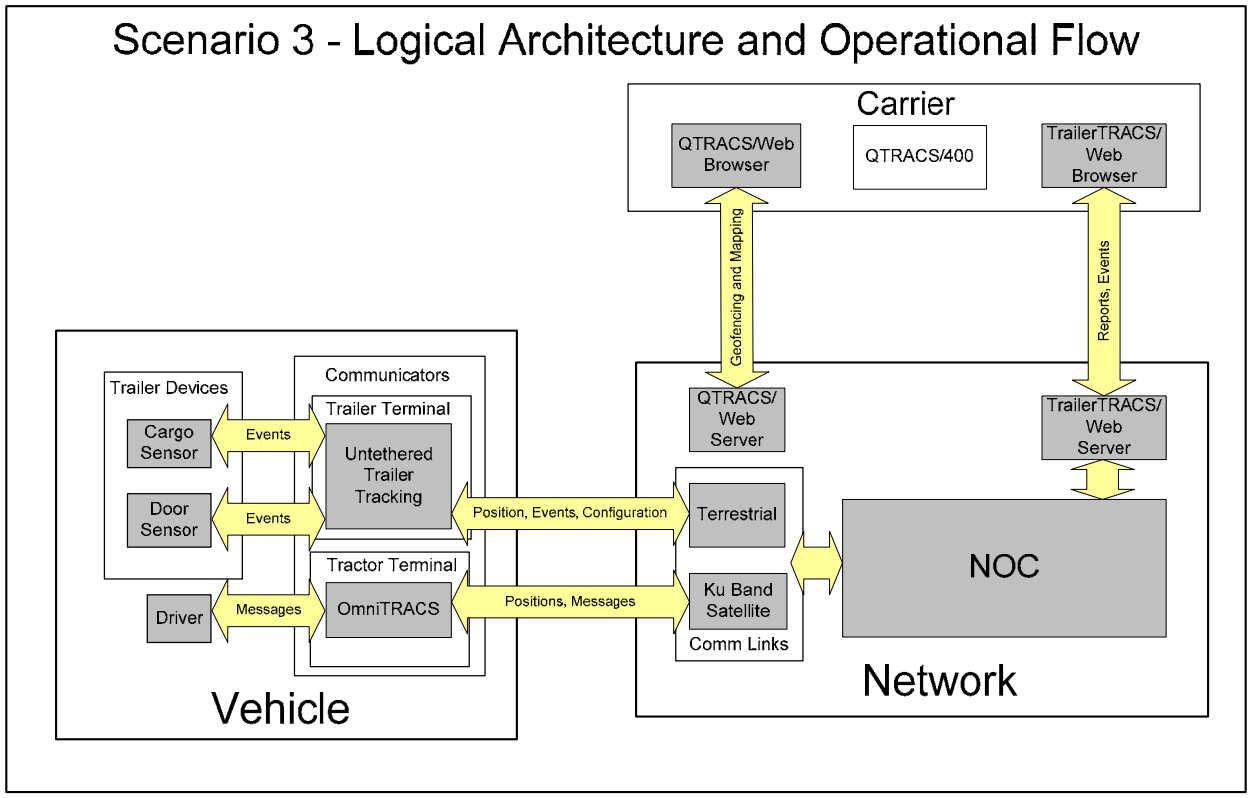

Figure 17: Scenario 3 – Logical Architecture and Operational Flow

4.5.5 Daily Operations

This section describes the daily operational procedures that the participants were asked to perform as part of the pilot test.

Daily Operational Procedures

The dispatcher logs on to the trailer-tracking host application to prepare for dispatching drivers to pick up trailers and loads.

Finding Trailer(s)

1. The dispatcher clicks on the "Find Trailer" tab to search for desired data:
    a. Specific trailer location
    b. Trailers based on cargo status (empty/full)
    c. Trailers near a specific landmark
    d. All trailers

Assigning Trailer(s)

The dispatcher assigns a driver to a trailer pickup:

1. The dispatcher creates a load assignment/pickup macro instructing the driver where to pick up the next trailer and load.
2. The satellite-based mobile communications messaging system is used to send the message to the driver.

Connecting Trailer(s)

The driver arrives at trailer pickup location and attaches the tractor to the assigned trailer:

1. The satellite-based mobile communications terminal detects via the 7-way connector interface that there is an UTT terminal connected to the tractor.
2. The satellite-based mobile communications terminal sends a connect message to the NOC.
3. The NOC forwards the event to the trailer-tracking host application, alerting the dispatcher of the trailer connection event.
4. The dispatcher verifies that the trailer is connected to the assigned tractor.

Monitoring Trailer Doors

Upon completing the trailer loading, the trailer door is closed:

1. The door sensor automatically engages when the doors are closed.

Monitoring Trailer(s) En Route

When ready to depart for the destination, the driver sends a “departing macro” to the dispatcher via the satellite-based mobile communications system.

Two mechanisms exist for monitoring the trailer while it is en route:

1. Trailer positioning (default position interval is one position per day):
    a. If the trailer is pulled by a tractor not equipped with a satellite-based mobile communications terminal or the satellite-based mobile communications terminal is not functioning, the dispatcher monitors the trailer’s location using the UTT system via the trailer-tracking host application.
    b. The dispatcher modifies the trailer terminal’s positioning frequency to be more frequent than the default, once per hour or once every 6 hours, while en route.
        i. The dispatcher enters the setup configuration for a specific trailer to select the positioning frequency parameter.
        ii. The trailer-tracking host application creates a message and sends it to the trailer terminal via the NOC and terrestrial network.

2. Tractor positioning:
    a. If a tractor is equipped with a functioning satellite-based communications terminal pulling the trailer, the dispatcher monitors the trailer's location using the satellite-based mobile communications system via the host application.
    b. The default positioning frequency is once per hour. If the dispatcher requires more frequent positioning, the MIPR parameter is modified on the tractor terminal.

Detecting and Disconnecting Trailer(s)

The driver arrives at the destination and disconnects the trailer at the designated location:

1. The satellite-based mobile communications terminal detects that the UTT terminal is no longer connected and sends a disconnection message to the NOC.
2. The NOC forwards the event to the trailer-tracking host application, alerting the dispatcher of the trailer disconnections.
3. The dispatcher verifies that the trailer is disconnected in an authorized drop location.

Geo-fencing Disconnected Trailer(s)

When the dispatcher receives an alert that a non-empty trailer has been dropped at an authorized location, the dispatcher creates a geo-fence surrounding this disconnected trailer:

1. The dispatcher uses the trailer-tracking host application to create or edit a geo-fence.
2. The dispatcher selects the center point for the geo-fence (self-centered, landmark, or latitude/longitude), the east/west and north/south lengths, the geo-fence start/stop time, the enable geo-fence flag, the geo-fence wake-up interval, and the type of geo-fence (exit/enter).
3. The UTT system host application generates a message with the updated information and sends it to the trailer terminal via the NOC terrestrial network to the trailer terminal.
4. An "electronic fence" is set around the trailer, which is monitored by the trailer terminal, based on its configuration.
5. Using the UTT system host, the dispatcher has the option to view the geo-fence on a map.

4.5.6 Alerts

The following security alerts were featured in this scenario:

- Untethered trailer leaves or enters a geo-fenced area
- Trailer disconnection with a "not empty" load
- Trailer door opening event with a "not empty" load

Untethered Trailer Geo-fence Alert

1. The driver disconnects the trailer in the consignee's yard and sets a valid geo-fence.
2. The trailer terminal wakes up based on the customer configurable setting every hour in order to determine if a geo-fence violation has occurred.
3. If the trailer has left the geo-fenced area, the trailer terminal sends a geo-fence violation alert to the dispatcher.

Disconnection with a "Not Empty" Load Alert

The driver disconnects the trailer in the consignee's yard with a load that is awaiting offload:

1. The tractor terminal sends a disconnection message.
2. The UTT system host application receives a disconnection message and generates an alert to the dispatcher.
3. The dispatcher uses the UTT system host to determine if the cargo status is "not empty" on the applicable trailer.

Door Opening Event with a "Not Empty" Load

The trailer door is opened:

1. The trailer terminal recognizes that the door has been opened.
2. The trailer terminal determines, based on the trailer configuration, if an alert is required.
3. The trailer terminal generates an alert and sends it OTA to the UTT system host application.
4. The UTT system host application forwards this alert to the dispatcher.

4.5.7 Physical Architecture

The physical architecture and message flow is shown in Figure 18.

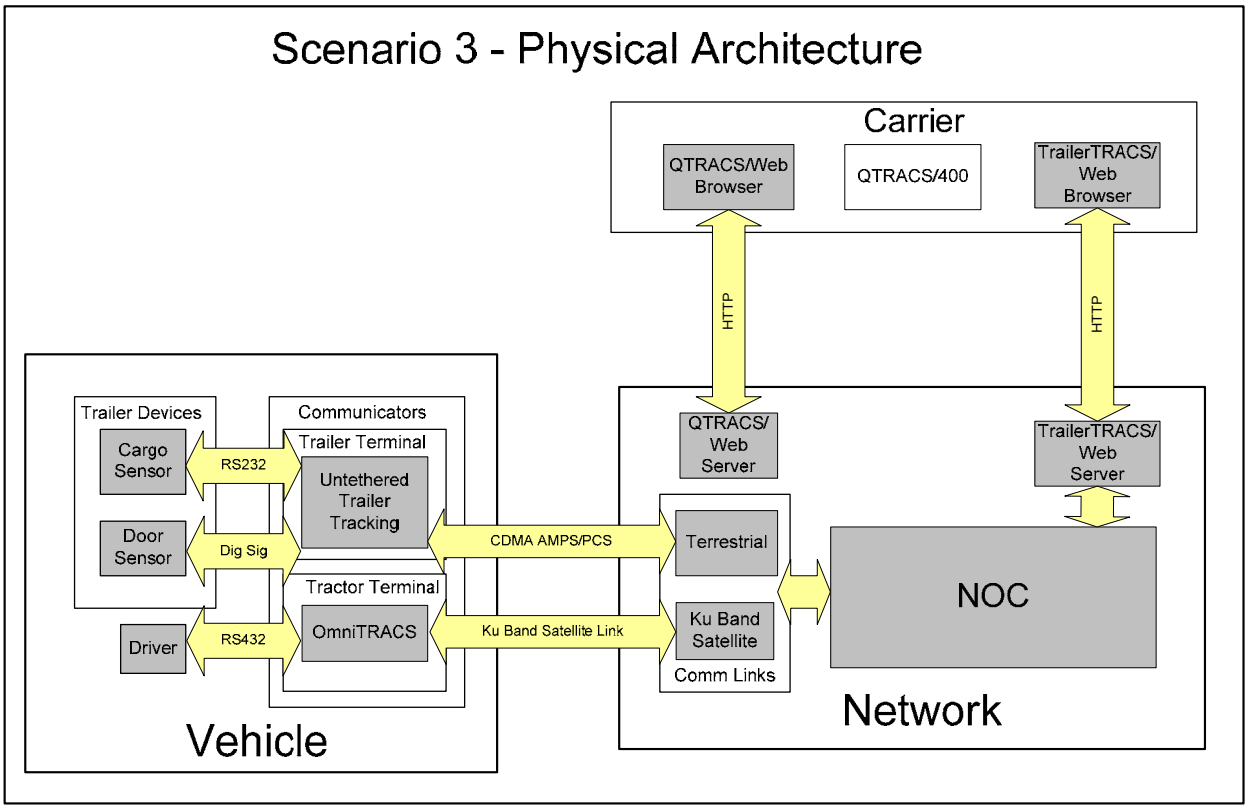

Figure 18: Scenario 3 – Physical Architecture

5 PILOT TEST INFORMATION

5.1 Overview

The two major goals of the UTT system pilot test were to test the UTT system's functional requirements and determine ways that the system could improve safety, security, and efficiency. This section provides information about the pilot test.

5.2 General Test Procedures

Prior to initiating the pilot test, the test participants received training on the UTT system functions and testing procedures. An Implementation Guide was used in addition to various training tools and documentation. The training defined the test participants' roles and responsibilities, which included how to use the trailer-tracking host application to configure the system, investigate and document alerts, and maintain logs.

During the pilot test, automated test data were collected and reviewed weekly to check system performance and usage. For example, the UTT terminal battery was monitored throughout the pilot test to determine its performance against the requirements, which included an assessment of battery life and the low battery indicator.

Telephone interviews and nine on-site visits occurred from October 2004 through January 2005. These site visits and interviews with pilot test participants were conducted to verify and collect functional data and other information concerning UTT system usage. The initial telephone interviews and on-site participant interviews documented the following elements:

- User experiences
- Perceptions of technologies that included appropriateness, efficacy, satisfaction, and willingness to invest
- Possible integration with processes and procedures to enhance safety, security, and operational efficiency
- Suggestions and recommendations

Interviews were conducted with participant management personnel, dispatchers, maintenance personnel, and clerical/office employees. The questions were asked in a Likert-scale format, and the scale included levels of agreement and disagreement with statements for a broad-based compilation of interview results. The interview guide is located in Appendix F.

5.3 Data Collection Methods

The following data collection sources were used for information about the UTT system:

- **Automated System Logs.** A tool collected the UTT system data from the host application database on a weekly basis from each of the three participants. The data was compiled and archived. See Appendix D for a sample of the collected data and description of the data.

- **Staged Tests.** Limited on-site stage testing was conducted on a monthly basis.
- **Manual Logs.** In each scenario, the dispatchers maintained a manual data collection log in bound serialized books as they performed their daily dispatch activities. At least one dispatcher at each participant's location completed information in the logs about trailers with and without the UTT system. See Appendix E for a sample of a daily manual log.
- **On-Site Interviews.** On-site interviews were conducted to obtain qualitative data about the UTT system. See Appendix F for a sample of the on-site test participant guide used to collect qualitative data.

5.4 System-Generated Status and Location Reports during Daily Operations

During the 3-month field testing, system-generated incidences were collected relating to changes in cargo status, door status, connection status, and trailer positions, depending on the scenario.

Appendix C presents a sample of the automated data format from the data logs of all the incidences recorded during the pilot test. The data set contained 13,470 data points representing discrete trailer events and status updates for all trailers involved in the pilot test. The data logs from the daily operations provided information about:

- Cargo and Door Sensors
- Location and Mapping of Trailers Functionality
- Risk Area Geo-fencing
- Battery Life Performance

5.4.1 Cargo and Door Sensors

The automated event logs were reviewed to determine the numbers of door and cargo events and if the door and cargo sensor incidences provided information about "no sensor" indications in the daily field test operations. Table 7 presents the total number of door and cargo status events documented in the automated logs in each scenario.

Table 7: Number of Door and Cargo Status Events from Automated Data Logs

	Scenario 1		Scenario 2				Scenario 3			
	Cargo Empty	**Cargo Not Empty**	**Cargo Empty**	**Cargo Not Empty**	**Door Open**	**Door Closed**	**Cargo Empty**	**Cargo Not Empty**	**Door Open**	**Door Closed**
Number of Events	1,993	1,830	1,945	2,734	2,033	2,666	2,261	2,569	1,025	3,834

For the cargo sensor and door sensor test, a "no sensor" status indicated when the cargo or door sensor failed to report a status for a specific event. For scenarios 2 and 3, the alert test configuration was set to provide a message notification to a carrier only when a "door open" event corresponded with a cargo status of "not empty." If the number of alerts for the "not

empty" cargo status events did not equal the number of "door open" alerts, it was assumed that the cargo and/or door sensors failed to report a status. The results of the numbers of door and cargo status events and information on the numbers of "no sensor" indications are summarized in Table 8.

Table 8: Summary of the Door and Cargo Sensors Status Events from Automated Data Logs

Function	Scenario 1			Scenario 2			Scenario 3		
	# of Status Events	# of Events with "No Sensor" Indications	% of Events without "No Sensor" Indications	Total # of Status Events	# of Events with "No Sensor" Indications	% of Events without "No Sensor" Indications	Total # of Status Events	# of Events with "No Sensor" Indications	% of Events without "No Sensor" Indications
Door Sensor	NA	NA	NA	4,699	0	100	4,948	19	99.6
Cargo Sensor	3,823	0	100	4,699	20	99.6	4,948	48	99.0
Alerts	NA	NA	NA	452	6	98.7	505	13	97.4

5.4.2 Location and Mapping of Trailers Functionality

The system-generated data of the UTT system provided position reports of both tethered and untethered trailers. The UTT system was configured to provide a position report with every event. Table 9 presents the number of trailer location reports when trailers were both tethered and untethered by scenario.

Table 9: Number of Trailer Location Reports (Tethered and Untethered)

Event	Scenario 1			Scenario 2			Scenario 3		
	Total # of Events	Mean # of Events per Trailer per Month	Mean # of Days Between Events per Trailer	Total # of Events	Mean # of Events per Trailer per Month	Mean # of Days Between Events per Trailer	Total # of Events	Mean # of Events per Trailer per Month	Mean # of Days Between Events per Trailer
Trailer Location	3,823	45.1	0.7	4,699	55.0	0.6	4,948	62.9	0.5

For all three scenarios, the test configuration was set at a maximum position reporting interval of 24 hours where the 24-hour cycle was configured to begin from the previous event or status report. It was assumed that exceeding a 24 hours and 30 minutes time interval would indicate a window of lost visibility, which could be the result of a lack in communications coverage[5], loss

[5] If a UTT trailer was in transit or dropped in an area without cellular coverage, the unit would store and then forward all detected events once the unit came back into cellular coverage.

of power to the UTT system, damage to the UTT system, or a needed system configuration adjustment. First, the percentage of trailer location reports for both tethered and untethered trailers that fell within or near the test-configured maximum reporting interval of 24 hours and 30 minutes was determined. These results are summarized in Table 10.

Table 10: Summary of Tethered and Untethered Trailer Location Reporting within 24 Hours and 30 Minutes or Less where a Location Report was Configured to be Sent Every 24 Hours

Event	Scenario 1			Scenario 2			Scenario 3		
	# of Location Reports	# of Reports Received w/in 24 Hours and 30 Minutes or Less	% of Reports Received w/in 24 Hours and 30 Minutes or Less	# of Location Reports	# of Reports Received w/in 24 Hours and 30 Minutes or Less	% of Reports Received w/in 24 Hours and 30 Minutes or Less	# of Location Reports	# of Reports Received w/in 24 Hours and 30 Minutes or Less	% of Reports Received w/in 24 Hours and 30 Minutes or Less
Trailer Location	3,823	3,782	99.0%	4,699	4,655	99.1	4,948	4,930	99.6

Second, the position reports for only untethered trailers were reviewed when a trailer was disconnected from a tractor, as discerned in the data. The number of untethered occurrences was estimated to represent approximately 94 percent of all untethered trailer events during the field test. These results are summarized in Table 11.

Table 11: Summary of Untethered-Only Trailer Location Reporting within 24 Hours and 30 Minutes or Less where a Location Report was Configured to be Sent Every 24 Hours

Event	Scenario 1			Scenario 2			Scenario 3		
	# of Location Reports	# of Reports Received w/in 24 Hours and 30 Minutes or Less	% of Reports Received w/in 24 Hours and 30 Minutes or Less	# of Location Reports	# of Reports Received w/in 24 Hours and 30 Minutes or Less	% of Reports Received w/in 24 Hours and 30 Minutes or Less	# of Location Reports	# of Reports Received w/in 24 Hours and 30 Minutes or Less	% of Reports Received w/in 24 Hours and 30 Minutes or Less
Location	2,034	2,007	98.7	2,860	2,845	99.5%	3,053	3,038	99.5

For all three scenarios, 121 location reports for tethered and untethered trailers were received after 24 hours and 30 minutes, and 81 reports were received after 25 hours. For Scenarios 1, 2, and 3, the number of reports that exceeded 25 hours was 25, 14, and 42, respectively. Twelve location reports from different trailers were not received within 3 days. In general, reporting intervals exceeding 3 days occurred during the first 2 weeks of the carrier test period. This change in reporting intervals coincided with the brief period of time following the initiation of the field test when technical issues, such as faulty wiring of the fuse kits, broken cables on the

tractors, loose wiring on the door sensor, and configuration issues regarding the battery pack were resolved.

For all three scenarios, 57 location reports for untethered trailers were received after 24 hours and 30 minutes. For the 37 reports that were received after 25 hours, all of the trailers were found in less than 2 days during the 2 weeks following the initiation of the test.

Trailer Movements Within United States and Into/Out of Mexico and Canada

Throughout the pilot test, 13,470 position reports were generated. Approximately 63 percent of these position reports showed no trailer movement from the previous report. By scenario, the percentages of position reports showing no trailer movement from the previous reports were 55, 58, and 73 percent for Scenarios 1, 2 and 3.

When the trailers were moving en-route, the average observed haul lengths were defined as trip miles loaded to next loaded cargo status for the three scenarios. The haul lengths were reported as 564 miles (standard deviation [s.d.] 431 miles), 789 miles (s.d. 327 miles), and 928 miles (s.d. 401 miles). Trailer movement locations are illustrated in Figures 19, 20, and 21.

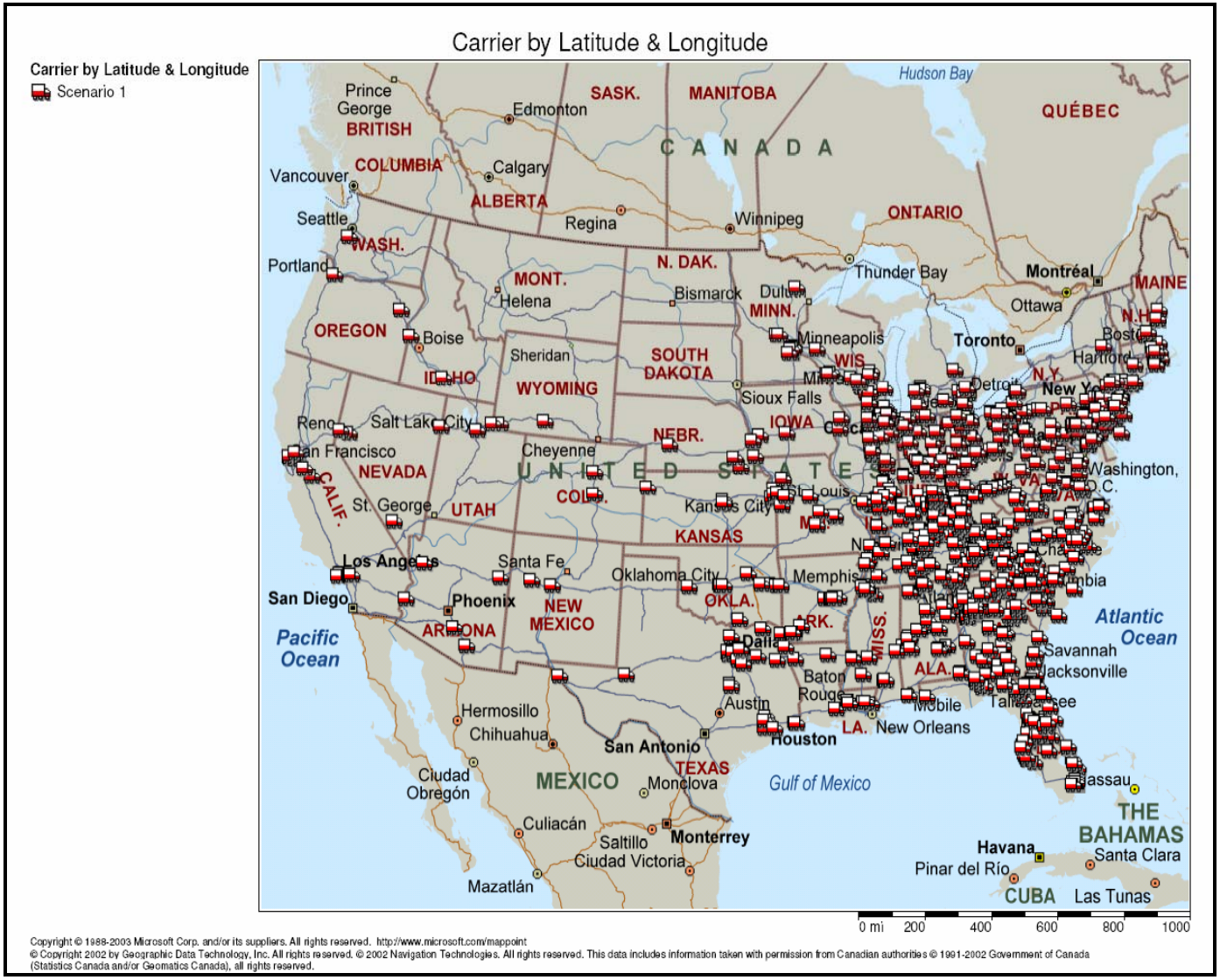

Figure 19: Trailer Positions for Scenario 1

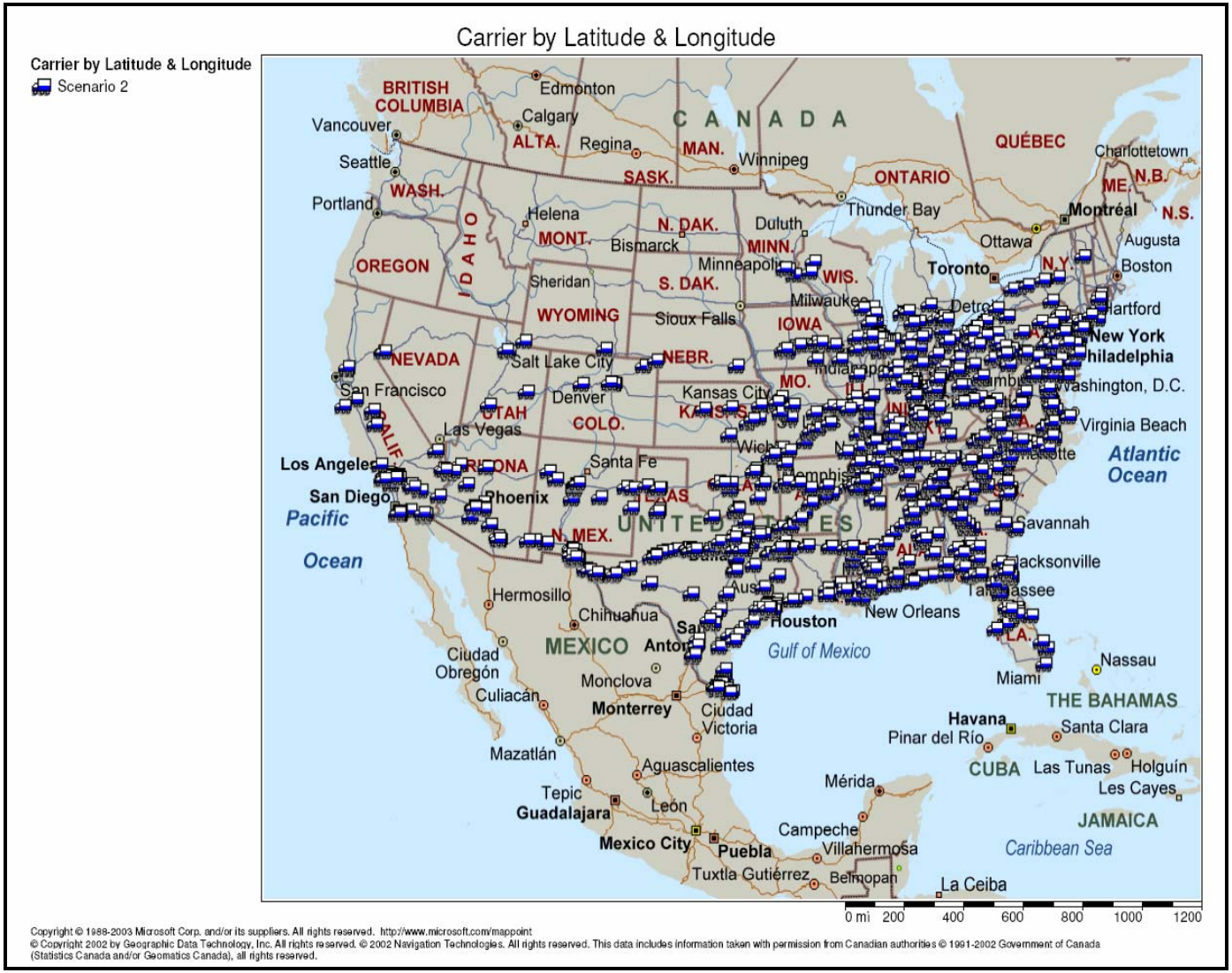

Figure 20: Trailer Positions for Scenario 2

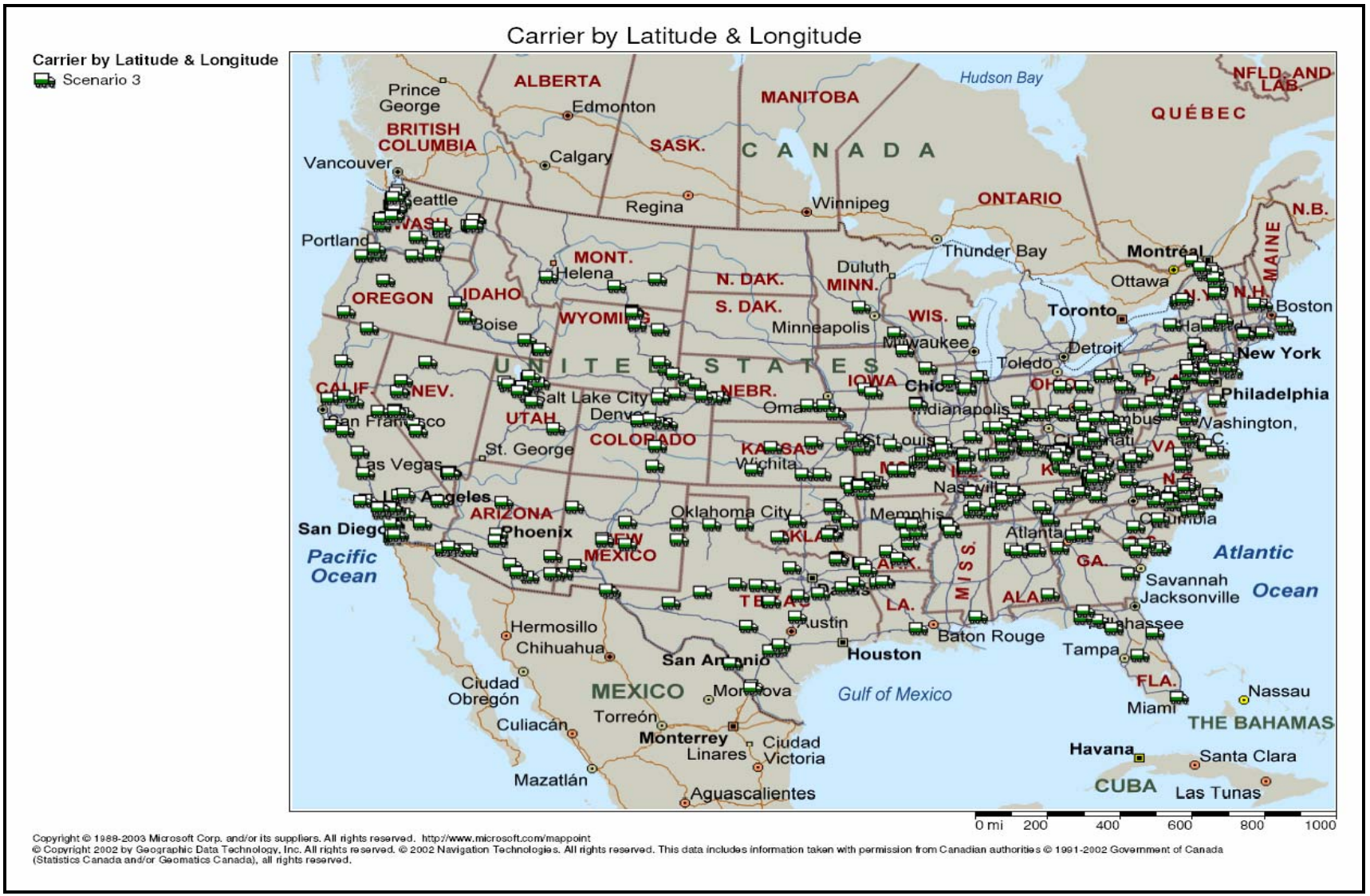

Figure 21: Trailer Positions for Scenario 3

The trailer position reports showed movement into and out of Mexico and Canada, as presented in Table 12.

Table 12: Number of Trailer Position Reports in Mexico and Canada by Scenario

Scenario	Number of Trailer Position Reports	
	Mexico	Canada
1	1	0
2	285	0
3	9	84

In Scenario 3, seven individual trailers made seven separate trips to and from Canada near the Canadian border. Each trip was approximately 50 to 80 miles between participant locations in New York State and customer sites in Quebec. During these trips, 84 position reports were generated.

Trailer movements into Mexico and near the Mexican border were limited for Scenarios 1 and 3, with one and nine trailer position reports, respectively. Scenario 2 did show a number of movements into Mexico – 53 separate trips from drop lots in Texas to 47 separate locations in Mexico (all locations in northern Mexico near the U.S.-Mexican border). Of the 285 trailer position reports in Mexico, performance reporting intervals were approximately the same as observed within the United States. Two reports showed reporting intervals greater than 2 days, and less than 4 days.

Anecdotally, Scenario 2 participants believed that partner carriers were using their trailers in Mexico in an unauthorized manner, although they could not prove it. During the test, the Scenario 2 participants successfully used the UTT system to identify a trailer that was used to move other unauthorized goods within northern Mexico for 2 days prior to picking up the proper load.

5.4.3 Risk Area Geo-fencing

Risk area geo-fencing was used most frequently by participants in Scenarios 1 and 3. Geo-fences were created around a trailer at the carrier's terminal, customer site, or other location when it was disconnected and expected to remain untethered at one location for more than 24 hours. In Scenario 1, a trailer with an advertisement for hiring new drivers was placed alongside the freeway and geo-fenced. For over one month, no unauthorized geo-fence breaks occurred.

In Scenario 3, seven trailers with UTT systems were stored at a DOD facility and geo-fenced. Scenario 3 involved a carrier of munitions and other sensitive loads for the DOD. At the beginning of the pilot test, DOD revised the Hazards of Electromagnetic Radiation to Ordnance (HERO) standards for UTT devices. Due to an advisory released by DOD regarding the use of UTT devices, the Scenario 3 participant was unable to fully utilize these trailers with UTT systems to haul DOD munitions shipments; therefore, the trailers were geofenced at the bases. No unauthorized geo-fence breaks occurred on the DOD facility.

5.4.4 Battery Life Performance

When the trailers were untethered, the UTT system's battery was the sole power source for the sensors, positioning functionality, and transmitting telemetry. When the trailer was tethered to a tractor, the battery was recharged from the tractor's power supply via the 7-pin connector interface on the connecting wiring harness.

During daily operations, a "charge battery" alert was generated four times on four separate trailers: two each in Scenarios 1 and 3. Due to the short time frame of the pilot test, these alerts were infrequent. Three alert notifications were generated at the end of the pilot test data collection period. In Scenario 1, the UTT systems generating the "charge battery" alerts were configured for 2-hour wake-up intervals, and the batteries lost their charges in 32 and 56 days. In Scenario 3, which included door status checks, the UTT systems were configured to wake-up every 6 hours, and their batteries lost their charges in 71 and 90 days. The more frequent wake-up intervals drained the battery at least two to three times as fast as the less frequent wake-up intervals.

In addition, a bench test was conducted to determine the expected life of the battery charge while the trailer is untethered and configured to report positions at high frequency rates (2-minute intervals). This test showed that the battery charge would last approximately 12.5 hours, starting with a fully charged battery.

5.5 On-Site Staged Tests

5.5.1 On-Site Staged Testing Process

During the pilot test, nine on-site staged tests were conducted to collect more information about the UTT system. The steps listed below were followed for the on-site staged testing process.

1. Located a properly equipped tractor and trailer for testing at participant facility.
2. Configured testing parameters and forwarded them to the trailer, such as setting the positioning interval at 2 minutes, selecting the geo-fence, entering email addresses to receive alert notifications, and inputting time settings for door and cargo sensors. (To facilitate the staged testing, the test configurations were set at a shorter duration than those set for the field test.)
3. Monitored testing progress for alert notifications, functional events, and trailer positioning via a Web-based user interface on a laptop computer.
4. Tested UTT system functionalities.

The staged technology events and alert notifications were displayed to participating dispatchers on the web-based user interface screen and sent to the participant's designated email addresses to simulate the events and alert notifications that could normally occur during daily operations. Alert notifications were forwarded to the carrier participants' and test team members' email addresses, which displayed the test trailer ID and the time of the event. The following conditions were set for the staged testing:

- Trailer positioning was set for every 2 minutes.

- Cargo sensors were configured to check the cargo status every 5 to 20 minutes.
  - To simulate a loaded or empty trailer, a piece of paper or cardboard was placed in front of the cargo sensor to create a “cargo loaded” event and removed for a “not empty” event when necessary. The cardboard obstruction was used as an alternative for sensing cargo directly in front of the sensor due to the time constraints of actually loading and unloading cargo.
- Door open events were configured to generate an alert notification immediately upon the trailer door being opened with cargo present in the trailer.
- Trailer connections and disconnections were configured to generate near real-time alert notifications after the tethering and untethering of the trailer.
  - During this process, the connections indicating the trailer serial number and the tractor ID or mobile terminal number were checked in the UTT system web-based user interface. Also, a trailer was disconnected from a tractor to check that the serial number did not change whether the trailer was tethered or untethered.
- Geo-fence violations were configured to be triggered in near-real time upon the violation of an inclusion zone or inside of an exclusion zone.
  - The driver was directed to pull a trailer from the geo-fenced terminal area.
  - When the driver left the geo-fenced area, an exit geo-fence alert notification was immediately generated and displayed on the web-based user application.
  - As the trailer traveled down the road, its position was monitored at 2-minute position updates.
  - When the trailer was moved outside the geo-fenced area, the driver disconnected the 7-pin connection between the tractor and trailer to simulate a trailer drop in an “unknown location” (a location not designated by the carrier as a valid drop location). The disconnection generated an alert notification via the web-based user interface and designated email addresses.

Figure 22 shows an example of the alert screen that would display events and alerts to a dispatcher. Each alert is displayed and assigned to a particular trailer. By clicking on the event, the dispatcher can see the details of a specific security event including the location of an alert.

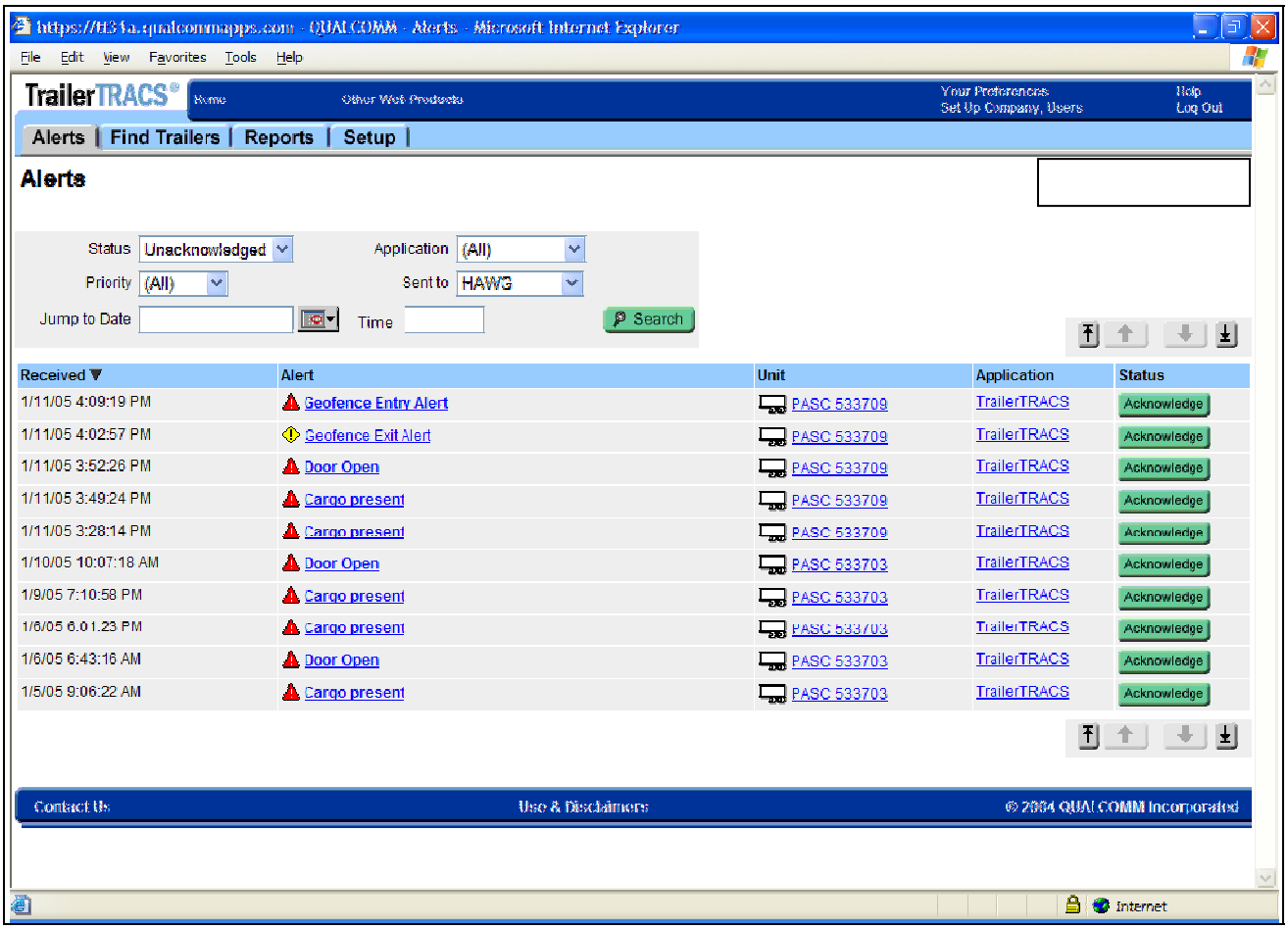

Figure 22: TrailerTRACS User Alert Screen

5.5.2 Staged Testing Results

The staged tests procedures and results are described below for the previously listed functions.

Scenario 1

Testing was conducted at the participant's facilities on October 28, 2004; December 2, 2004; and January 13, 2005:

- Cargo Sensor (remote sensing of empty or loaded trailers)
  - Cargo loaded and unloaded functionalities were both tested successfully.
- Connections and Disconnections with Alerts
  - Connections and disconnections were each tested with alert notifications generated and displayed on the alerts web page display as well as to the participant email accounts.

- Trailer ID
  - The trailer ID and tractor ID were successfully displayed on the TrailerTRACS program. A specific truck ID was not tied to a trailer ID; therefore, the mobile communications terminal (MCT) number was substituted instead.
- Location and Mapping of Trailers
  - The test was set with positioning updates at 2 minutes. The trailer was tracked and mapped following the geo-fence exit event.
- Unscheduled Movement Notification (geo-fencing) with Alerts including the function of detecting unauthorized trailer drops
  - A geo-fence was set up around the motor carrier's terminal and the driver pulled away with the trailer. The geo-fence exit alert was received. A drop at an unknown location alert notification was generated following the geo-fence exit event by having a disconnect event occur at a non-land marked location. During one test, the driver returned to the lot several minutes later to cause the geo-fence entry event. During another test, there was no geo-fence break as the tractor broke down with a blown turbo charger right on the edge of the geo-fence perimeter.

Scenario 2

Testing was conducted at the participant's facilities on October 26, 2004; November 30, 2004; and January 11, 2005.

- Door Sensor
  - During the first site visit, the test trailer's door sensor was damaged and continuously indicated an open condition. Another trailer's door sensor also continuously indicated an open door status. One driver stated that that the trailer doors are frequently hit when trucks back up to loading docks. During the remaining site visits, the test trailers had functioning door sensors. In an improved post-test redesign, the door sensors will be recessed into the trailer door.
- Cargo Sensor (remote sensing of empty or loaded trailers)
  - Cargo loaded and unloaded functionalities were both tested successfully. During one site visit, the trailer was loaded with empty chemical barrels, and the cargo sensor correctly relayed the "not empty" message.
- Connections and Disconnections with Alerts
  - Connections and disconnections were tested with alert notifications displayed on the alerts web page display as well as to the participant email accounts. During one site visit, there was no power on the truck's pin 7 of 7-way terminal, which did not allow visibility regarding the connections and disconnections. The driver brought the truck back to the yard for troubleshooting and repair. In disassembling the 7-way terminal, the wire feeding the UTT system had been severed. The damage may have been caused by a previous dent to the front of the trailer in the area between the 7-way connector interface and the UTT terminal. During another site visit, the truck was wired with the fuse kit that enabled this functionality. This truck was set up for

manual connection and disconnection, but not with auto connection. Unsuccessful attempts were made to get the auto connection enabled from the hub. Instead, successful manual connections and disconnections were conducted via the tractor keypad.

- Trailer ID
  - The trailer ID was successfully shown with the corresponding tractor ID on the TrailerTRACS program. The truck was wired with the fuse kit that enabled this functionality.
- Location and Mapping of Trailers
  - The test was set with positioning updates at 2 minutes. The trailer was tracked and mapped following the geo-fence exit event.
- Unscheduled Movement Notification (geo-fencing) with Alerts, including the function of detecting unauthorized trailer drops
  - A geo-fence was set up around the motor carrier's terminal, and the driver pulled away with the trailer. The geo-fence exit and entry alerts were received and displayed as expected. A drop at an unknown location alert notification was generated following the geo-fence exit event with a disconnection event occur at a non-land marked location.

Scenario 3

Testing was conducted at the participant's facilities on November 2, 2004; December 7, 2004; and January 18, 2005.

- Door Sensor
  - In two of the three tests, the test participants did not receive the email alerts due to anti-spam software on their email systems, which deleted the alerts. Following the staged tests, the software problem was remedied by changing the email header. In one test, the "door open" alert was not generated, since the cargo sensor incorrectly relayed an "empty" event due to a testing procedure failure. During the remaining site visits, the test trailer had a functioning door sensor.
- Cargo Sensor (remote sensing of empty or loaded trailers)
  - Cargo loaded and unloaded functionalities were both tested successfully. During one test, the sensor did not indicate the cargo loaded status. This failure may have been caused by the size of the piece of cardboard used in the test. On-site diagnostics verified that the sensor was working properly. The sensor was finally tested with a person standing in front of the sensor, which resulted in the system indicating a cargo loaded status.
- Connections and Disconnections with Alerts
  - Connections and disconnections were each tested with alert notifications generated and displayed on the alerts web page display as well as to the participant email accounts.
- Near Real-Time Trailer ID

  - The trailer ID was successfully shown with the corresponding tractor ID on the TrailerTRACS program.
- Location and Mapping of Trailers
  - The test was set with positioning updates at 2 minutes. The trailer was tracked and mapped as it traveled eastbound following the geo-fence exit event. The trailer turned around several minutes later, returning prior to the geo-fence entry event.
- Unscheduled Movement Notification (geo-fencing) with alerts, including the function of detecting unauthorized trailer drops.
  - During the tests, a geo-fence was set up around the motor carrier's terminal. The driver pulled away from lot with the trailer to cause the geo-fence exit event and returned to the lot several minutes later to cause the geo-fence entry event.

5.5.3 Manual Logs

The three participating motor carriers in the pilot test utilized the UTT system TrailerTRACS web application to identify the location and cargo status of their 25 respective trailers with the UTT system. Simultaneously, the motor carriers also continued to use their normal methods of phone and manual searches for trailers without the UTT system. During the pilot test, the dispatchers or route planners at each motor carrier were asked to complete logs for trailers with and without UTT systems. A sample log with carrier entries is presented in Appendix D along with the instructions to the dispatchers.

Due to the different dispatchers in each scenario, the logs provided varying amounts of information. However, the logs showed that trailers without the UTT system were not found where they were expected to be 41, 11, and 38 percent of the time (percent of manual log entries showing "not where expected" versus all log entries for the particular participant carrier) for Scenarios 1, 2 and 3, respectively.

After using the UTT System, the participants in all three scenarios stated that it allowed for better and easier tracking of loads, drivers, and vehicles. Trailers can be located by querying the UTT system host application for a specific trailer, trailers near a specified location or landmark, trailers with a certain cargo status of "empty" or "not empty," or a listing of all assigned trailers.

6 IMPROVEMENTS TO SECURITY, SAFETY, AND EFFICIENCY

During the pilot test, improvements to security, safety, and efficiency were illustrated. In every pilot test scenario, satellite-based mobile communications systems were on all of the tractors, which provided the location of trailers tethered to tractors at a pre-defined reporting interval of once per hour. However, the tractor-based communications system did not monitor trailer and cargo integrity, report trailer door openings, provide information on untethered trailer locations, or detect unauthorized trailer movements. Thus, the UTT system provided distinct benefits.

In Scenario 1, prior to the pilot test, the interval of time that a trailer was not tethered averaged approximately 2 days in which its status was unknown. In transit, the time averaged 1.2 days where the visibility into cargo status was limited or non-existent. When untethered trailers were not at company locations, the participant would not know trailer locations or status related to cargo.

In Scenario 2, prior to the pilot test, the interval of time that a trailer was not tethered averaged 3.9 days, with an unknown status to the carrier. The average en-route time between locations was 1.6 days where visibility into cargo status was limited or non-existent. The participant also indicated that all of their cargo losses occurred while the trailers were loaded and untethered.

In Scenario 3, prior to the pilot test, the participant stated that it was impossible to monitor unauthorized trailer movements or integrity of the cargo space of untethered trailers. The interval of time that a trailer is untethered could be as long as 7 days with unknown status to the carrier. En-route trips averaged approximately 2 days without cargo status visibility, yet this participant did not experience any cargo loss to theft.

Compared to the baseline conditions, the UTT system provided the locations of untethered trailers at pre-determined shorter intervals during the pilot test. In addition, the UTT system could also provide frequent trailer position reports while tethered to a tractor to provide in-transit visibility. Furthermore, the carriers were able to detect door openings, cargo status, and trailer movement outside an assigned geo-fenced area through alert notifications. The following sections show how security, safety, and efficiency can be improved by using the UTT system.

6.1 Security

Truck trailers pose a security threat, since they provide an easy means to transport dangerous cargos. Within the trucking industry, the key threats to security that the UTT system can address are:

- Theft of cargo or untethered trailers through fraud, deception, stealth, or violence, where the theft of hazardous material could result in catastrophic releases, and stolen trailers could be used to convey illicit WMD.
- Sabotage of trailers or cargo, where shipments, such as food could be contaminated.

- Interception or diversion of tractor-trailers en route, where unauthorized personnel could gain access to trailers, cargo, and important information for illicit purposes.

To reduce the vulnerabilities relating to the lack of visibility of trailers and their cargo, the UTT system pilot test was configured to provide information on trailer positions with cargo and door status indications, trailer movements, and trailer connection and disconnections.

This section identifies the ways that security can be improved using the UTT system, which can reduce theft vulnerabilities based on deterrence and enhanced detection, response, and recovery capabilities.

6.1.1 Ensure Cargo Integrity

Cargo integrity involves the assurance that cargo tampering has not occurred and unauthorized cargo has not been placed in a trailer. A major impact of exploited cargo integrity in trailers is the potential for transporting a weapon or explosive device in a trailer. Currently, motor carriers who do not use UTT systems with door and cargo sensors have limited visibility into the trailer door and cargo status. Unmonitored trailers are security risks, which can potentially be used as a weapon of mass destruction.

During the pilot test, the UTT system sent door opening messages to the motor carriers only when the doors were opened and cargo was in the trailer. The UTT system provided a trailer position and cargo status when a door opening event occurred and the trailer was "not empty." Using the UTT system host application, the participants could view the trailer's location on a map, identify if the trailer was at an unauthorized location, and determine if the door opening event was a potential intrusion into the trailer. The UTT system sent alert notifications to the participant via pager and email when a door event occurred.

6.1.2 Reduce Cargo Pilferage

Cargo pilferage is the theft of cargo in a trailer. During typical operations, fleets have little visibility into how often their trailer doors are opened en route to a destination; therefore, they are unable to detect pilferage occurrences. Unmonitored trailers are a security risk, because cargo, such as hazardous material, could be stolen for use as a weapon.

According to interviews with the pilot test participating motor carriers, 80 to 100 percent of cargo theft occurred while the trailers were loaded. Trailers are particularly vulnerable to theft at truckstops or parking lots where trailers are dropped or disconnected from tractors. Anecdotally, interviewed motor carriers stated that cargo theft often involved the cooperation of someone directly involved in the shipment. Their rationale was that "an insider" either provided thieves with information regarding the content of shipments, or a driver was in collusion with thieves by allowing access to the trailer. One pilot test participant stated that thieves can obtain advance knowledge about the shipment contents and wait for an opportunity en route to steal the entire trailer or its contents when it is left unattended. However, the participants indicated that the costs of theft to their operations were relatively small compared to their revenue.

With the increased visibility provided by the UTT system's cargo and door sensors, motor carriers could detect and respond to theft to reclaim the lost cargo. In addition, incidents of

insider theft by their own personnel could be deterred with the use of the UTT system in conjunction with cargo and door sensors.

Ten members of an independent panel of experts were consulted regarding the use of the UTT system to reduce the vulnerabilities of trailers containing explosives to theft. These experts included seven motor carriers and/or shippers of hazardous materials, two enforcement officials, and an insurance carrier representative expert in security and loss prevention. The experts indicated that the greatest vulnerability of explosives to theft occurred when the trailer was loaded and tethered, followed by trailers loaded and untethered, and lastly, trailers unloaded and untethered.

The compilation of the experts' opinions showed that they believed that the vulnerability of truckload explosives to theft could be reduced the most through the notifications of unauthorized trailer drops and tracking locations of trailers. Next, cargo and door status indications were believed to provide additional incremental improvements in reducing vulnerabilities.

One motor carrier who has been using the UTT system in daily operations reported that the system has reduced theft losses by approximately 50 percent, and believed that the mere presence of the device has a deterrent effect on cargo theft. Although the UTT system can enhance the security of cargo and equipment, the test participants and the experts consulted for this analysis stated that the UTT system capabilities could not exclusively ensure the security of shipments. The participants stated that a well developed and managed security program is also critical that encompasses actions, such as employee screening; employee training and vigilance; enforced policies regarding route adherence, parking and trailer drops; and physical security of facilities. The participants also noted that technology can fail, be disabled, or circumvented.

6.1.3 Reduce Trailer Theft and Detect Unauthorized Trailer Movement/Usage

Unattended trailers may be stolen when a thief or terrorist connects a trailer to a tractor and hauls it away. Potential security impacts of unauthorized trailer movement and theft are pilferage of dangerous cargo, such as hazardous materials for the use as a weapon and loss of unloaded trailers for the transport of a weapon or explosive device. Carriers without UTT systems have limited visibility into the movement of their untethered trailers since they often rely on verbal feedback from customers on the trailer status and location. Trailers may also be falsely obtained and utilized by carrier personnel with legitimate identification.

With increased visibility into when a theft may be occurring, the carrier can use the UTT system to respond and alert authorities to potentially stop the theft and apprehend the thieves.

Unscheduled movement notification using trailer-based geo-fencing allowed the test participants to define geo-fences around a trailer. The UTT system was configured to monitor the status of the trailer relative to the set geo-fence at specific intervals. The UTT terminal sent a notification to the participant when it identified that the trailer moved outside of the geo-fence. The geo-fence was viewed on a map using the UTT system host application. This visibility is significant, since unauthorized persons could inappropriately use the trailers, creating increased security risks and reduced trailer utilization for the carrier.

A trailer disconnection and connection can be remotely identified when a trailer with the UTT system is disconnected from and connected to a satellite communications system-equipped tractor. In the initial on-site participant interviews, the test participants mentioned that they noticed a strong relationship between unauthorized disconnections and trailer theft. If a driver disconnects a trailer in an unauthorized location, the potential for trailer theft can increase.

Motor carriers not utilizing a UTT system do not have visibility when a trailer is disconnected from a tractor at an unauthorized location. With the UTT system, motor carriers would gain this visibility by sending alert notifications to the dispatcher via pager and/or email when the system detects that the trailer is disconnected at an unauthorized location.

With increased visibility into when unauthorized disconnections occur, the motor carrier personnel can quickly respond to contact authorities to stop a potential theft and recover a stolen trailer. Also, the motor carrier personnel can detect when a driver performs an unauthorized disconnection or connection and instigate a process to reduce this activity. The UTT system compares the trailer's current location with the set of authorized disconnection locations and sends an alert to the dispatcher if the trailer is not at an authorized location.

6.2 Public Safety

6.2.1 Reduce the Risks of Crashes

This report does not indicate that there are discernible safety benefits in terms of reducing the risks of crashes.

6.3 Efficiency

6.3.1 Improve Trailer Utilization

Motor carriers reported that more trailers are purchased than are truly required, since trailers tend to be temporarily misplaced, or carriers unknowingly wait for trailers assumed to be unloaded, which are actually empty and available. To locate their trailers, most motor carriers explained that they made phone calls to customer locations or performed manual searches in their yards. Both of these methods could be time consuming and possibly inaccurate, and the motor carriers agreed that they would like to improve the ability to use their existing trailers.

Using the UTT system, trailers can be located by querying the UTT system host application for a specific trailer, trailers near a specified location or landmark, trailers with a specific cargo status, or a listing of all assigned trailers. UTT terminals automatically report status information at participant-configured intervals. This information includes trailer location, door status, cargo status, time of status, and the UTT system's battery status. Users can also request a status from the trailer at any time, if they need more timely information. The UTT system "wakes up" at configured intervals to check for requests.

6.3.2 Connect Trailer to Assigned Tractor

During the initial on-site participant interviews, test participants mentioned issues with sending the trailer to the wrong location, typically about 300 miles out of the way, which impacts valuable driver hours of service, fuel, and maintenance charges. Using the UTT system

combined with the satellite mobile communications system on the tractor, a trailer/tractor connection can be automatically captured and transmitted electronically to a carrier to verify that the driver picked up the correct trailer. Providing visibility into tractor-trailer connections can help to optimize the carrier operations.

Direct communication between the UTT terminal and the tractor terminal occurs when this connection feature is enabled and configured on both the trailer and tractor terminals. The UTT terminal can be configured to post its terminal ID (unified address [UA] identification) when it detects power. The tractor terminal identifies the trailer ID when it is connected to a trailer 7-way connector interface. When the tractor detects a connection, it displays the UTT system ID on the driver's display and sends a connection message OTA to the participant. The UTT system host application displays the connection message and sends an alert to the dispatcher. The dispatcher can check that the trailer was connected to the correct tractor by comparing the automated information with the driver's load assignment.

6.3.3 Improve Visibility in Trailer Detention

During deliveries, there are often delays in unloading trailers and failing to properly report when a trailer is empty. The ability to accurately determine that trailers are loaded at a specific location may improve carriers' operational efficiency by collecting trailer detention charges. The process of consistently billing for the known detention of trailers would likely result in decreased incidents of detention and the increased utilization of trailers.

The satellite-based mobile communications system on the tractor records connection and disconnection activities, and sends the status over the satellite system to the UTT system host. The cargo sensor monitors the trailer for an "empty" or "not empty" status. A cargo status change indicates the transition from "empty" to "not empty," or from "not empty" to "empty." This data provides trailer visibility, and information about detention of trailers.

During the pilot test, the UTT system provided a trailer position and cargo status on its daily status update. Using the UTT host application, the participants viewed this location on a map, in addition to the daily reports showing times and dates for connections, disconnections, and cargo status changes. In Scenario 3, the participants used the cargo status and trailer location information to monitor detention time as a customer service tool to alert their customers that trailers were empty and would be going into detention billing.

6.3.4 Improve Route Visibility by Motor Carrier

During typical operations, preferred routes can be provided to drivers; however, due to unexpected events, drivers may change routes. As a result, motor carriers rarely have visibility into the actual routes taken by trucks without tracking systems. Since most motor carriers have limited driver resources, increasing route adherence can improve their efficiency, since longer routes caused by deviations may increase travel costs and delivery times.
For the pilot test, the UTT system was configured to provide more frequent positioning intervals for trailers en-route. The system was particularly beneficial when a non-carrier-owned tractor without a tractor-based mobile communications system transported a trailer, since the UTT system provided route visibility.

6.3.5 Improve Driver Workload and Time Locating Trailers

For economic reasons, motor carriers optimally utilize drivers to reduce unproductive driver work time. It has been a common practice for drivers to look for trailers in the wrong location or for trailers not to be ready for transport when the driver arrives. By reducing the time that drivers wait while cargo is being loaded or unloaded, the carrier could reduce delivery time, fuel consumption, and idle driver time. Also, reducing the trailer to tractor ratio, while meeting customer demands, is a significant benefit of improved trailer fleet management. Enhanced asset utilization includes increased revenue from trailer detention fees, and converting non-revenue miles to revenue-producing miles.

Unproductive personnel activities focused on the time spent by dispatchers involved in searching for available trailers for dispatch purposes. The unproductive personnel activities also included the time a driver spent looking for trailers that had been moved, trailers not being where dispatch thought they were, or in hauling misdirected loads. Through enhanced visibility of trailers and their cargo, trailers can be used more efficiently, and trailer to tractor ratios can be reduced. According to experts and test participants, the UTT system can improve the ability to find trailers and expedite deliveries through knowledge of trailer arrivals, unloading, and loading. The UTT system can improve the management of both assets and personnel time.

7 ACCEPTANCE OF THE UNTETHERED TRAILER TRACKING SYSTEM AND DEPLOYMENT ISSUES

7.1 Test Participant Interview Results

During the pilot test, interviews were conducted to gauge participant opinions about the UTT system at the beginning of the pilot test and as the pilot test progressed. The motor carrier personnel interviewed during the test were:

- **Scenario 1**
  - Route Planner/Truck and Trailer Inventory Manager
  - Dispatcher
- **Scenario 2**
  - Executive Vice President
  - Dispatcher
- **Scenario 3**
  - Executive Vice President
  - Dispatcher

Table 13 presents the resulting average responses from participants to the interview statements using a 5-point Likert scale, with 5 representing the strongest agreement with a statement, and 1 representing the strongest disagreement with a statement.

Initially, the participants had high expectations for the UTT system. Contributing to these expectation levels were previous experience with the vendor, and advance information regarding potential system capabilities, benefits, and use. As shown in the midpoint and final interview results, the UTT system met or exceeded expectations relating to usability, technical performance, and overall participant acceptance. All three carriers expressed a strong interest in equipping their entire trailer fleets with UTT systems.

Table 13: Participant Opinions About the UTT System

Participant Reaction Statements	Start-Up Expectations	Midpoint	Final
The deployed UTT system has made a favorable impression upon yourself and others at your company.	5	5	5
The UTT system has been used significantly and on a regular basis.	4.7	5	5
The UTT system required significant staff resources, including time.	2	1.3	1.3
The initial training provided adequate to prepare personnel to use the UTT system.	4.7	5	5
The dispatchers responded positively to using the UTT system.	5	5	5
The UTT system might prove to be an improvement to your existing operations.	4.7	5	5
The UTT system has been easy to use.	4.7	5	5
The UTT system has been reliable.	5	5	5
The UTT system has allowed for better/easier tracking of loads, drivers, and vehicles.	5	5	5
The UTT system has improved customer service and Estimated Time of Arrivals for pickups and deliveries.	4.5	5	5
The UTT system has provided an increased sense security and safety for company employees.	4.5	5	5

The participant motor carriers also provided the following comments about the UTT system:

- The UTT system has the potential to improve motor carrier productivity and enhance the security of trailers, both moving and stationary.
- One of the most important benefits of the UTT system was in improving the utilization of trailer inventory.
- The UTT system can reduce wasted time and resources spent in manually searching for the location of trailers and identifying trailers available for drivers.
- The UTT system can effectively monitor cargo and trailer integrity by providing alerts of intrusion, diversion, or theft events. The UTT system may aid in cargo theft recoveries, resulting in reductions of insurance premiums and deductibles.

- Through the use of the UTT system, improved visibility of trailer event history and position details can enhance customer service by allowing the carriers to provide timely progress reports on customer cargo location, status, and estimated times of arrival.
- The geo-fencing capabilities provided by the UTT system were helpful in preventing trailer theft or equipment abuse.
- The ability to landmark customer locations was useful to check that drivers are delivering and picking up at the correct spots.
- By receiving door status information for fleet vehicles, additional security resulted from knowing when and where trailer doors were being opened.
- The ability of the cargo sensor to relay information about the change in cargo status was an important way to enforce detention agreements with their customers.

7.2 Deployment Issues and Technical Performance

During the installation and deployment of the UTT systems in the three scenarios, several issues impacted the pilot test.

In Scenario 2, the primary deployment problem was one unit with a defective GPS module that required replacement, which the field service tool successfully identified. Also, this participant's maintenance manager would have preferred a wireless door sensor due to the labor involved in installing the wired sensor.

Scenario 3 involved a carrier of munitions and other sensitive loads for DOD. At the beginning of the pilot test, the DOD revised the HERO standards for UTT devices. Due to an advisory released by DOD regarding the use of UTT devices, the Scenario 3 participant was unable to fully utilize its trailers with UTT systems to haul DOD munitions shipments. Testing the UTT system within sensitive loads hauled for the DOD was not conducted significantly during this pilot test due to the requirement to receive U.S. Army Surface Deployment and Distribution Command (SDDC) approval to put UTT systems in munitions trailers. Near the end of the pilot test, the UTT system was HERO-certified for zero clearance to cargo. This notwithstanding, prior to the certification, the majority of trailers were used for hauling shipments that were not for DOD. The UTT system trailers were domiciled on a DOD facility until the HERO certification process was completed.

According to the test participants, the UTT system performed well in daily motor carrier operational conditions. A technical issue of participant anti-spam software blocking the email alerts occurred during one of the field-testing events. This problem was resolved by modifying the email header. In Scenario 2, two magnetic door sensors were sheared off and disabled. A driver reported that as the trucks back up to the dock, the door-sensing magnet could shear off if the doors hit the dock. In the future, installers plan to consider reducing the height of the sensor or installing the sensor in a more secure location.

7.3 Participant Recommendations for Improvements

The participants had several recommendations for system improvement over the course of the pilot test. In Scenario 1, the users at this motor carrier preferred not to wait 6 hours to determine

the location of untethered trailers. As a result, the systems were reconfigured to 2-hour wake-up intervals. The high level of trailer use and the 2-hour positioning intervals provided significant help in locating trailers.

In Scenario 2, the dispatcher preferred not to exit out of the TrailerTRACS application while exiting the carriers' administration software module. In addition, when viewing a specific trailer and requested position history, the system did not automatically indicate the trailer ID. The dispatcher had to key-in the information again in order to request a position history, often having to back up through screens to get the trailer ID.

In Scenario 3, users indicated that they would like to see all the trailers' positions at the same time in their 24-hour wake-up period. This ability would eliminate many of the steps needed to find accurate positioning. When a participant was in the event history log and pressed the tool bar to refresh, the participant noted that in 7 out of 10 times, the software would display the event history log. For the remaining three times, the participant noted that the system displayed an error message stating that "this cannot be done from this page." Furthermore, the responding carrier saw major benefits from tracking the detention time, and suggested a reporting capability specifically focused on this area.

8 CONCLUSION

As directed by Congress, FMCSA administered a pilot test for the development of a UTT system. The purpose of this pilot test was to test a UTT system that met specific functional requirements and could improve the safety and security of trailers and shipments at each phase of its movement – pick up, delivery, receipt, and storage. The UTT system included:

- Near real-time trailer identification
- Accurate time of connection and disconnection activities
- Location and mapping of trailers
- Geo-fencing to identify a risk area
- Unscheduled movement notification
- Remote sensing of a loaded or empty trailer
- Cargo and door sensors
- Alerts

During the 3-month pilot test, security, safety, and efficiency improvements were recognized through the use of the UTT system by three different carriers.

The UTT system test highlighted various security improvements. A major security improvement was the reduction of theft vulnerability. Vulnerabilities included theft of equipment and cargo, or the use of trailers to convey illicit weapons with intent of direct terrorist attack on persons or property.

According to test participants, the UTT system can effectively monitor cargo and trailer integrity by providing alerts of intrusion, diversion, or theft events. The UTT system may aid in cargo theft recoveries, resulting in the reduction of insurance premiums and deductibles. In assessing the security benefits of the UTT system for hazardous loads of explosives, a panel of experts stated that the UTT system has the ability to reduce inherent shipment vulnerabilities through enhanced visibility of cargo and equipment location and status.

In addition to public sector security and safety benefits, through enhanced visibility of trailers and their cargo status, private sector efficiency can be improved by using the UTT system. Gains in efficiency could be achieved through improved asset management and personnel utilization. Through enhanced visibility of trailers and their cargo, trailers can be used more efficiently, and trailer to tractor ratios can be reduced. According to experts and test participants, the UTT system can improve the ability to find trailers and expedite deliveries through knowledge of trailer arrivals, unloading, and loading. This information can lead to improvements in customer behavior relating to improving the time to turn around trailers for deliveries and preventing the use of trailers as storage. The system can also provide the data to improve the collection of detention charges, even for carriers with good detention programs. It is expected that some of the private sector efficiency benefits are currently being realized by the trucking industry.

APPENDIX A: LIST OF ACRONYMS AND DEFINITIONS

3G	Third Generation Wireless. 3G systems provide access, by means of one or more radio links, to a wide range of telecommunication services supported by fixed telecommunication networks and to other services that are specific to mobile users.
Aux	Auxiliary (used for secondary identification purposes)
Cargo Route Adherence	Geo-fencing cargo tracking process of monitoring load location
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access. Use of any form of spread spectrum by multiple transmitters to send to the same receiver on the same frequency channel at the same time without harmful interference.
Cellular and GPS-Mounted Antenna	Trailer-mounted stealth antenna provided communications through its 800/1900 MHz cellular antenna and received Global Positioning System (GPS) positions through its GPS antenna.
Configuration	The custom arrangement of parameters and values (i.e., cargo check interval set to every 30 minutes) associated with the security and communications technologies being tested during the pilot test.
DOD	Department of Defense
Door Sensor	Trailer-mounted door sensor monitored for a Door Open and/or closed event on the trailer.
Event	Occurrence of cargo status, door status, connect status, geo-fence violation, or trailer position.
Electronic Fence	Geo-fence area boundary
FBI	Federal Bureau of Investigation
FHWA	Federal Highway Administration
Field Service Tool	This tool interfaced with the UTT terminal in the field. The tool provided a field support application hosted on portable data assistants (PDAs) that ran on the Palm operating system.
FMCSA	Federal Motor Carrier Safety Administration
FOT	Field Operational Test
Geo-fence	A defined geographical region used to trigger an event when a user enters the region.
GPS	Global Positioning System
HAZMAT	Hazardous Materials
HERO	Hazards of Electromagnetic Radiation to Ordnance
ID	Identification/Identifier
Ku-band	A portion of the electromagnetic spectrum in the microwave range of

	frequencies ranging from 12 to 18 GHz. Used primarily used for satellite communications, particularly for satellite backhauls from remote locations back to a central location
Landmarks	For geo-fencing purposes, the software supported the creation, modification, and deletion of custom landmarks by authorized users.
Likert Scale	A type of survey question where respondents are asked to rate the level at which they agree or disagree with a given statement; used to measure attitudes, preferences, and subjective reactions.
MARAD	Maritime Administration
MCT	Mobile Communications Terminal
MIPR	Mobile Initiated Position Report
Mobile Unit	OmniTRACS Mobile Unit
NMC	Network Management Center, which processes and manages the messaging traffic between the dispatch center and the fleet
NOC	Network Operations Center
OmniTRACS	A QUALCOMM Inc. developed satellite mobile communications system for near real-time data communications, automatic vehicle tracking and satellite positioning for the transportation industry.
OmniTRACS Mobile Unit	Ku-band Satellite Mobile Unit
OTA	Over the Air
Over-the-Air Message	Wireless message, Ku-band or Terrestrial
Parameters	The custom-configured conditions in a specific scenario, such as “position reporting interval,” set with associated values (1 hour) to test the security and communications technologies as part of the Pilot test.
Pilot Test	As the follow-on task to the original HAZMAT FOT, an untethered trailer tracking and control system was tested to improve the safety and security of trailers and shipments from origin to destination.
PDAs	Portable Data Assistants
PHMSA	Pipeline and Hazardous Materials Safety Administration
QTRACS	Messaging and location tracking software for the transportation industry developed by QUALCOMM Inc. The software allows motor carrier dispatchers to keep track of vehicle location, past location history, forwards data to third parties, and a variety of other features.
QTRACS/Web	Software interface for OmniTRACS that enables users to send and receive messages and display vehicle locations.
Risk Area	Geo-fenced keep-out area, an alert is generated when a vehicle enters this area.
Route Tolerance	Distance vehicle can deviate from geo-fenced route before generating an alert.
RSSI	Received Signal Strength Indication

SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
Satellite Mobile Unit	OmniTRACS Mobile Unit
SCAC	Standard Carrier Alpha Code. This is a unique 2- to 4-letter code used to identify transportation companies, and used to facilitate computerization in the transportation industry.
Scenario	The condition under which individual or a combination of security and communications technologies were tested for the Pilot test.
s.d.	Standard Deviation
SDDC	Surface Deployment and Distribution Command (U.S. Army)
Test Team	Science Applications International Corporation (SAIC) and QUALCOMM
Tractor Mobile Communications Terminal	Tractors received wireless tracking and communications systems via a terminal with an integrated GPS. These tracking and communications systems worked in conjunction with the dispatch systems.
Tractor Power and Satellite Tracking System Interface	The interface included the electrical and mechanical connections between the terminal and the trailer in which it was installed. The interface. This connection enabled the UTT terminal to draw power from the tractor battery when connected, for from the UTT system's rechargeable battery in the trailer.
Trailer Connect	Process of connecting trailer to tractor.
Trailer Disconnect	Process of disconnecting trailer from tractor.
TrailerTRACS/Web	Web-based UTT asset management system developed by QUALCOMM.
TSA	Transportation Security Administration
Ultrasonic Cargo Sensor	Trailer-mounted sensor used to detect the presence of cargo in the trailer.
UA	Unified Address serial number used to identify the hardware.
UTT System	Untethered Trailer Tracking System; trailer-mounted terrestrial CDMA trailer tracking device.
USDOT	United States Department of Transportation
Value	The custom-configured frequency (1 hour) set with an associated condition (position reporting interval) to test the security and communications technologies within scenarios as part of the Pilot test.
WMD	Weapon of Mass Destruction
Wireless Communications System	Ku-band satellite or terrestrial-based wireless communications.
Wireless Satellite Communications	Ku-band communications

APPENDIX B: REFERENCES

- "Tracking the Trailer," by Thomas Strah, *Transport Topics*, I-Tech Supplement, February 21, 2005.
- Hazardous Materials Safety and Security Technology Field Operational Test (FOT) Evaluation Final Report Documents:
  - **Volume I: Executive Summary**, for the Federal Motor Carrier Safety Administration, issued November 11, 2004.
  - **Volume II: Evaluation Final Report Synthesis**, for the Federal Motor Carrier Safety Administration, issued November 11, 2004.
- Untethered Trailer Tracking and Control System Operational Requirements for the Federal Motor Carrier Safety Administration, Document, March 23, 2004.

Supporting Technical Standards Documents

Table B-1 lists the applicable technical standards documents used to support the UTT system project.

Table B-1: Applicable Technical Standards Documents

Document Number/Name	Description
MIL-HDBK-237B	Electromagnetic Compatibility Management Guide for Platforms, Systems, and Equipment
MIL-HDBK-240	Hazards of Electromagnetic Radiation to Ordnance Test Guide
MIL-STD-464	Interface Standard Electromagnetic Environmental Effects Requirements for Systems
SAE J560	Seven Conductor Electrical Connector for Truck-Trailer Jumper Cable
MIL-STD-810E	Environmental Engineering Considerations and Laboratory Tests
TMC RP 2401	Recommended Practice, Trailer Tracking Interface Standard
SAE J1708	Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications
JDQ 53.2	John Deere Standard: Environmental Design & Testing of Electronic & Electrical Components
SAE J1455	Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)
SAE J1113-13	Electromagnetic Compatibility Measurement Procedure for Vehicle Components

APPENDIX C: UNTETHERED TRAILER TRACKING SYSTEM PILOT PROTOTYPE TEST CHECKLIST

The UTT System Pilot Prototype Test Checklist describes the tests performed to verify the functionality as it was defined in the System Design Document – Untethered Trailer Tracking and Control System.

Functionality Tested

- Trailer Location and Status
  - Find empty versus loaded trailers
  - Find a specific trailer or all trailers at a specific customer site
  - Monitor door sensor activity
  - Monitor "unauthorized" usage of trailers by customer tractor assignment
  - Assign tractor to empty/full trailer
  - Send a message to driver with trailer pickup location
  - Verify trailer is authorized for shipping
  - Monitor the load status of the trailer to verify it is consistent with the carrier's manifest
- Drop/Hook Monitoring
  - Verify driver connects to the right trailer (empty or loaded)
  - Verify drops are at an authorized location
  - Monitor for unauthorized drops
- Tracking of Trailer
  - Monitor the route of the trip (tractor position – 15 minutes)
  - Monitor route deviations (host-based route monitoring and mapping)
  - Monitor risk areas (risk area geo-fencing)

The Prototype Test Checklist document beginning on page 84 is divided into three separate scripts, one for each of the scenarios tested. Each script contains the following:

1. The summary section describes the technology tested in the scenario and summarizes the test results.
2. The configuration section describes the configuration and parameter settings used in the UTT and satellite systems.

3. The daily operations section describes the test protocols used to test the functionality in a manner that mimics the carrier's daily operations.

Table C-1: Prototype Test Checklist

Summary of Technology	Pass / Fail	Test Protocol Number
Trailer Location and Status		
Find empty vs. not empty trailers		2
Find a specific trailer or all trailers at a specific customer site		3
Monitor door sensor activity		3, 21, 22
Monitor “unauthorized” usage of trailer by customer		32, 33, 34, 37, 38, 39, 40
Tractor Assignment		
Assign tractor to empty/full trailer		5, 6, 7
Send a message to driver with trailer pickup location		5, 6, 7
Verify trailer is authorized for shipping		8, 9, 10, 11, 12, 14
Monitor the load status of the trailer to verify it is consistent with the carrier’s manifest		11, 12
Disconnect/Connect Monitoring		
Validate the driver connects to the right trailer (empty or not empty)		8, 9, 10
Validate disconnects are at an authorized location		29, 30, 31
Monitor for unauthorized disconnects		20, 23, 24
Tracking of Trailer		
Monitor the route of the trip, (tractor position – 15 minutes)		14, 15, 16, 17, 27, 28
Monitor route deviations (host based route monitoring and mapping)		18, 26
Monitor risk areas (risk area geo-fencing)		19, 25

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Configuration							
1								Date/Time: MCT # : Trailer #: Driver: Dispatcher:
2	Setup trailer with the following configurations:							
3		1035 – Position Reporting Interval (Status Report Interval)	1 per 24 hours (86,400 seconds)		2.2.1.1 2.2.3.1 2.2.3.2 2.2.3.3 2.2.3.4			
4		1052 – Terminal preset wake interval (unpowered: wake-up every)	Every 6 hours (21,600 seconds) (1 hour for testing)		2.2.1.2 2.2.1.3 2.2.2.3 2.2.3.1			
5		1053 – Preset Wake Duration	1 minute					
6		1126 – Stay Wake Time	3 minutes (10,800 seconds)					
7		1121 – Send ID over Power Bus for Connect/ Disconnects	1=Yes Enabled		2.2.2.1 2.2.2.2 2.2.2.3			

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Configuration							
8		1133 – Cargo sensor installed	1=Installed					
9		1108 – Cargo sensor check interval	30 minutes (1,800 seconds)		2.2.6.1 2.2.6.2 2.2.6.9			
10		1109 – The cargo sensor validation interval	5 minutes (300 seconds)		2.2.6.5 2.2.6.6 2.2.6.9			
11		1110 – The cargo sensor validation rechecks	1		2.2.6.5 2.2.6.6 2.2.6.9			
12		1119 – Send cargo empty event	2=Send immediately upon validation		2.2.6.3 2.2.6.4 2.2.6.9			
13		1120 – Send cargo loaded event	2=Send immediately upon validation		2.2.6.3 2.2.6.4 2.2.6.9			
14		1041 – Sensor Label 3 (door sensor)	Door					
15		1129 – Sensor 3 Installed	1=Installed					
16		1111 – Door Validation open time (Verified open after)	5 seconds					
17		1112 - Door Validation closed time (Verified closed after)	1 minute					

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Configuration							
18		1116 – Door closed event messaging (On close)	0=Ignore (disabled)		2.2.7.2 2.2.7.4 2.2.7.10			
19		1115 – Door open events messaging (On open)	4=Send immediately if cargo is "Not empty"		2.2.7.1 2.2.7.3 2.2.7.5 2.2.7.6 2.2.7.7 2.2.7.10			
20		1130 – Sensor 4 Installed (Aux sensor)	0=Not installed					
21		1124 – Send Status Reports when engine on	1=Yes; for test purposes		2.2.3.5			
23	TTRACS Company Settings System Preferences:							
24		The connect/ disconnect event	Sent immediately upon validation					
25		Trailer position proximity	To the nearest custom landmark					
26		Self-centered geo-fence default size (North/south length)	0.5 miles		2.2.4.9			
27		(East/west length)	0.5 miles					
28		T2 geo-fence monitor interval (Unpowered: check every)	1/hour		2.2.4.3 2.2.4.4			

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Configuration							
29		If trailer enters geo-fence	Send alerts immediately		2.2.4.1 2.2.4.2			
30		If trailer exits geo-fence	Send alerts immediately		2.2.4.5 2.2.4.6			
31	Setup Monitoring Plan:				2.2.8.9			
32		Monitoring plan ID	HZMT					
33		Description	Hazardous Materials					
34		Consider trailers lost after	30					
35	Conditions to Monitor	Cargo loaded	Medium					
36		Cargo unloaded	High					
37		Door open	High					
38		Door closed	None					
39		Aux Open	None					
40		Aux Closed	None					
41		Omni connect	Medium					
42		Omni disconnect	Low					
43		Omni disconnect at unknown disconnect point	High					
44		Non-Omni movement	High					
45		Entered geo-fence	None					

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Configuration							
46		Exited geo-fence	High					
47		Battery needs charge	Medium					
48		Battery needs replacement	Medium					
49	Alert notification	Setup alert notification for high, medium and low priority alerts.	Flash icon on desktop Send e-mail Send to pager		2.2.8.1 2.2.8.2			
50	Setup Trailer Types:							
51		Trailer type	DRV					
52		Description	Dry van					
53		Default monitoring plan	HZMT					
54		Auto-stop monitoring plan	HZMT					
55		Multi unit capable	Y					
56	Setup Trailer Landmarks:							
57		Landmark configuration	Create Landmarks for Shipper, and Consignee locations.		2.2.3.10			
58	Mobile Unit Setup:							
59		MIPR rate	1/ hour					
60		TTRACS	enabled					
61		Time Zone	PDT					
62		Power down timer	5					

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Configuration							
63		Wake-up timer interval	0					
64		Total wake-up power time	5					
65								
66	QTRACS/Web Setup:							
67		FWD macro creation	01 Load Assignment 02 Unauthorized Disconnect Warning					
68		Return macro creation	01 Arrived at Shipper 02 Loaded and Leaving 03 Arrived Stop/Final 04 E-Call 05 Accept Load 06 Fuel Requested					
69		Landmark configuration	Create Landmarks for Shipper location Consignee location Carrier location					
70		Create Route	Alisio Creek					
71		Create Geo-fenced Risk Area	Nuclear Power Plant					

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
0	Test Setup/Start	Driver disconnects trailer, verify cargo simulator is down, makes sure door is closed and sends message "Ready to start test." Drive tractor to carrier location.						
1	Dispatch Login	Dispatcher logs into the TTRACS/Web application in preparation for dispatching drivers to pickup trailers and loads. Dispatcher logs into the QTRACS/Web application in preparation for sending messages to the driver. (optional)	Verify the dispatcher can login to TrailerTRACS/Web. Verify the dispatcher can login to QTRACS/Web.					
2	Request status report	Dispatcher wants updated status on two trailers that appear to be closest to location of interest. Dispatcher selects trailers and does a 'Request Latest Status'.	Verify that a status report is returned for the UTT terminal in the timeframe configured.	Timestamp, Lat/Lon, Trailer Id, SCAC	2.2.1.1 2.2.1.2 2.2.1.3 2.2.6.8 2.2.6.9			

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
3	Find Trailer	Dispatcher clicks on the "Find Trailers" tab to search for desired trailer. a. Specific trailer location b. Trailers based on cargo status (empty/full) c. Trailers near a specific landmark d. All trailers	Verify when dispatcher enters specific trailer ID that the correct trailer detail is displayed. Verify when dispatcher selects Current Trailer Status and enters empty in Cargo list, only empty trailers are listed. Verify when dispatcher selects Trailers Near a Landmark link and enters 10 miles that the correct trailers display. Verify when dispatcher selects Current Trailer Status he sees all trailers in the account.		2.2.3.10 2.2.3.11 2.2.3.12			
4	Driver Login	Driver arrives at truck, starts ignition and sends message to dispatch that he is ready for assignment.	Verify message is received and read. Verify message is from Carrier location.					Freeform message "Ready for Assignment".

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
5	Assign Trailer(s) (optional)	The dispatcher creates a load assignment/pickup macro instructing the driver where to pickup the next trailer and load. The OmniTRACS messaging system (via QT/Web) is used to send the message to the driver.	Verify the dispatcher can create a forward load assignment macro with return receipt and that it gets sent.	Timestamp, Forward macro#, Tractor ID, Lat/Lon, msg length, type (text/binary), user fields				.
6	Accept assignment (optional)	The driver reads the load assignment macro.	Verify the load assignment can be read and that dispatcher gets notification of the receipt.					
7	Accept assignment (optional)	The driver sends a load accepted macro.	Verify the load accepted macro is sent and received at host system.	Timestamp, return macro#, Tractor ID, Lat/Lon, msg length, type (text/binary), user fields				
8	Connecting a Trailer	The driver arrives at trailer pickup location and attaches to the assigned trailer. The OmniTRACS terminal detects via	Verify the driver can see that the correct trailer UA is connected on the MCT display.					

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
		the 7-way an untethered trailer terminal connected to the tractor.						
9	Connecting a Trailer	The OmniTRACS terminal sends a connect message to the NOC. The NOC forwards the event to the TrailerTRACS/ Web application.	Verify the connect message is generated by the Untethered TrailerTRACS device and is displayed in TTRACS/Web	Timestamp, Origin (Vehicle), Lat/Lon, Trailer Id, Event (connect)	2.2.2.1 2.2.2.2			
10	Connecting a Trailer	Dispatcher gets an alert for the connect. Dispatcher validates that the trailer is connected to the assigned tractor. He acknowledges alert and the acknowledgement is logged.	Verify the dispatcher receives a notification (email, page, system tray alert) that there has been a connect to the proper trailer. Verify when the alert is viewed (Descrip-tion=Omni connect) and that the dispatcher name is logged.		2.2.2.1 2.2.2.2			
11	Stage load	Driver covers the cargo sensor to simulate full load.	Verify the dispatcher gets a Cargo Loaded Event following this activity.	Timestamp, Lat/Lon, Trailer Id, Event (Not empty)	2.2.6.1 2.2.6.2 2.2.6.3 2.2.6.4 2.2.6.5 2.2.6.7			

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
12	Stage load	Dispatcher gets an alert for the cargo loaded status. Dispatcher acknowledges alert and the acknowledgement is logged.	Verify dispatcher receives an alert with priority specified. Verify that the alert is acknowledged when read and the dispatcher id is logged.		2.2.8.1 2.2.8.2 2.2.8.3			
13	Monitor Trailer Door Activity	Upon completing the trailer loading, the trailer door is closed. Due to the configuration, Door Closed event is not sent.	Verify that the dispatcher does not get a Door Closed Event following this activity.		2.2.7.4			No Door Closed Event
14	Monitor the Trailer en-route (optional)	The driver departs for the destination. The driver sends a "departing macro" to the dispatcher via the OmniTRACS satellite system (optional).	Verify the driver is able to send a departing macro. Verify the dispatcher receives the departing macro.	Timestamp, return macro#, Tractor ID, Lat/Lon, msg length, type (text/binary), user fields				Truck waits to leave until above events are received.
15	Host Based Route Monitoring (optional)	The carrier initiates a trip by assigning a tractor to a pre-defined route using the QTRACS/Web application.	Verify that on QTRACS/Web the dispatcher is able to start the vehicle on a trip on the assigned route.	Timestamp, Tractor ID, Lat/Lon, Trip ID, Event (Start Trip)	2.2.4.10 2.2.4.11 2.2.4.12 2.2.4.13 2.2.4.14 2.2.4.15 2.2.4.16 2.2.4.17			Start Trip Route: Tolerance: 0.5 On Route ping: 15 Off Route ping: 5 Trip name: Day of week abbreviation and date (i.e., Mon062104)

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
16	Host Based Route Monitoring (optional)	The QTRACS/Web application will commence the monitoring of the tractor's trip by scheduling the "on route" positioning interval (e.g., every 15 minutes).	Verify the system starts 15-minute position ping while the unit is on route.	Timestamp, Tractor ID Lat/Lon, Proximity				Position
17	Host Based Route Monitoring (optional)	The QTRACS/Web application monitors the vehicle for positions and route progress.	Verify the vehicle displays positions on the route map.		2.2.3.6 2.2.4.15			
18	Host Based Route Monitoring (optional)	The QTRACS/Web application monitors for any route deviation and alerts the dispatcher if a deviation occurs. The Driver deviates from his predefined route. The Driver sends Return Macro # 6 "Fuel Requested".	Verify Out of Route Alert is sent to dispatcher via email or pager identifying information related to the violation. Verify pop-up alert is displayed on QTRACS/Web. Verify the ping rate increases to the value identified for out of route.	Timestamp, Origin (Vehicle), Lat/Lon, Geo-fence ID, Event (Off Route)	2.2.4.17			Tractor Out of Route Alert

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
19	Host Based Route Monitoring (optional)	Driver enters keep out risk area that he has been told to avoid.	Verify a Violating Geo-fence Alert is sent to dispatcher via email or pager identifying information related to the violation. Verify pop-up alert is displayed on QTRACS/Web. Verify the ping rate increases to the value identified for entering a risk area.	Timestamp, Origin (Vehicle), Lat/Lon, Geo-fence ID, Event (Violated Geo-fence)	2.2.4.17			Tractor Entered Risk Area Alert
20	Monitoring for unauthorized disconnect	Driver does a disconnect in risk area, which is considered an unauthorized disconnect.	Verify that an Unauthorized Disconnect Alert is sent to dispatcher.	Timestamp, Origin (Vehicle), Lat/Lon, Trailer Id, Event (disconnect)	2.2.8.6			Disconnect Event Disconnect Alert Unauthorized Disconnect Alert
21	Monitoring for unauthorized disconnect	Driver opens the door. The trailer terminal recognized that an open door event has occurred. The trailer terminal determines based on the trailer configuration if an alert is required. The Trailer terminal generates an alert and send sit OTA to	Verify the Open Door Event occurs and is displayed on TTRACS/Web.	Timestamp, Lat/Lon, Trailer Id, Event (Door Open)	2.2.7.1 2.2.7.2 2.2.7.3 2.2.7.4 2.2.7.5 2.2.7.6 2.2.7.8 2.2.7.9 2.2.7.10			Open Door/Cargo not Empty Event

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
		the TrailerTRACS/ Web application.						
22	Monitoring for unauthorized disconnect	Dispatcher receives an alert that a door has been opened on a non-empty trailer.	Verify the Open Door Alert occurs and is displayed on TTRACS/Web.		2.2.8.8			Open Door/Cargo not Empty Alert
23	Monitoring for unauthorized disconnect (optional)	Dispatcher sends message to driver to reconnect and return to route.	Verify message is received and read.	Timestamp, Forward macro#, Tractor ID, Lat/Lon, msg length, type (text/binary), user fields				
24	Monitoring for unauthorized disconnect (optional)	Driver reconnects trailer to tractor.	Verify connect message is received.					Connect Event Connect Alert
25	Host Based Route Monitoring (optional)	Driver exits keep out risk area.	Verify an Exited Geo-fence Alert is sent to dispatcher via email or pager identifying relevant information. Verify pop-up alert is displayed on QTRACS/Web.	Timestamp, Tractor ID, Lat/Lon, Geo-fence ID, Event (Exiting Geo-fence)				Tractor Exit Risk Area Alert

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
26	Host Based Route Monitoring (optional)	Driver returns to predefined route.	Verify a Back in Route Alert is sent to dispatcher via email or pager identifying relevant information. Verify pop-up alert is displayed on QTRACS/Web.	Timestamp, Tractor ID, Lat/Lon, Geo-fence ID, Event (On Route)				Tractor Back in Route
27	Host Based Route Monitoring (optional)	The driver arrives at the consignee. The driver sends an arrived at consignee macro.	Verify driver can send the arrived at stop/final macro. Verify the dispatcher can view the arrived at stop/final macro on host system.	Timestamp, return macro#, Tractor ID, Lat/Lon, msg length, type (text/binary), user fields				Arrived at Stop/Final Macro
28	Host Based Route Monitoring (optional)	The dispatcher initiates a trip end when a tractor arrives at the pre-defined route destination.	Verify the dispatcher is able to identify that the truck has arrived at the proper location and is able to end the trip.	Timestamp, Tractor ID, Lat/Lon, Trip ID, Event (End Trip)				Trip End
29	Trailer arrives at destination	The driver disconnects the trailer at the designated location.	Verify the trailer ID no longer displays on the OmniTRACS terminal display.					

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
30	Trailer arrives at destination	The OmniTRACS terminal detects that the untethered trailer terminal is no longer connected and sends a disconnect message to the NOC. The NOC forwards the event to the TrailerTRACS/Web application, alerting the dispatcher of the trailer disconnect.	Verify the disconnect message is displayed on TrailerTRACS/Web application (Non-empty Trailer Disconnect Alert).	Timestamp, Origin (Vehicle), Lat/Lon, Trailer Id, Event (Disconnect)	2.2.2.1 2.2.2.2 2.2.2.3			Disconnect Event
31	Trailer arrives at destination	The dispatcher receives an alert that a non-empty trailer has been disconnected at an authorized location. The dispatcher validates that the trailer is disconnected in an authorized disconnect location.	Verify the dispatcher gets a disconnect alert. Verify the dispatcher can identify that the Trailer is in an authorized location by identifying the position of the disconnect on the map or confirming the landmark. (Trailer position history with map). Verify the dispatcher can validate the last cargo status is not empty.					Disconnect Alert (at consignee landmark, last cargo status is "Not empty") Authorized Disconnect at Consignee

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
32	Geo-fencing the Disconnected Trailer	The dispatcher can choose to create a geo-fence surrounding this disconnected trailer.	Verify the dispatcher can create a self-centered geo-fence around the trailer with 1 mile east/west and north/south coordinates, and 1 day start and stop time. The wake-up interval should be every 5 minutes and the type of geo-fence is alert on exit.		2.2.4.1 2.2.4.2 2.2.4.3 2.2.4.4 2.2.4.5 2.2.4.6 2.2.4.7 2.2.4.9 2.2.5.1 2.2.5.2 2.2.5.3 2.2.5.4 2.2.5.5 2.2.5.6 2.2.5.7			Create Trailer Geo-fence
33	Geo-fencing the Disconnected Trailer	The TrailerTRACS/ Web application generates a message with the updated information and sends it to the trailer terminal via the NOC, Terrestrial Network to the trailer terminal.	Verify the TTRACS/Web identifies a geo-fence has been sent to the trailer.					
34	Geo-fencing the Disconnected Trailer	An "electronic fence" is set around the trailer, which the trailer terminal will monitor based on its configuration. The dispatcher using TTRACS/ Web has the option to view the geo-fence on the map.	Verify the dispatcher, using TrailerTRACS/Web has the option to view the geo-fence on a map. Check the Positions Details.		2.2.3.7 2.2.4.8			

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
35	Cargo Tracking: E-Call (optional)	The driver sends a message to the carrier indicating that he has disconnected the load at the consignee.	Verify driver can send the e-call macro. Verify the dispatcher can view the e-call macro on host system.	Timestamp, return macro#, Origin (Vehicle), Lat/Lon, message length, type (text/binary), user fields				E-Call Macro #4
36	Cargo Tracking: New Load Assignment (optional)	The dispatcher sends message to driver to return to Shipper location. The driver leaves the consignee and heads back.	Verify message is sent, received and read by driver.	Timestamp, forward macro#, Origin (Vehicle), Lat/Lon, msg length, type (text/binary), user fields				Freeform message: "Return to Shipper".
37	Untethered trailer geo-fence alert	Driver turns off the engine and lets the MCT power down timer elapse. Then he connects the trailer back to the tractor. No connect event is sent from the OmniTRACS system since it is in shutdown.	Verify no tractor positions are received on return trip.					
38	Untethered trailer geo-fence alert	The Trailer terminal will wake-up based on the customer configurable setting (e.g. every hour) to determine if the geo-	Verify the dispatcher receives an Exited Geo-fence Alert notification.	Timestamp, Lat/Lon, Trailer Id, Event (Exiting Geo-	2.2.4.3 2.2.8.5 2.2.8.3			Trailer Exited Geo-fence Alert

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
		fence violation has occurred. Move the trailer outside of the geo-fence. If the trailer has left the geo-fenced area, the trailer terminal will send a Geo-fence Violation Alert to the carrier.	Verify that when alert message is acknowledged the user is logged.	fence)				
39	Untethered trailer geo-fence alert	When trailer exits the geo-fence, the dispatch changes the Status Report interval to 15 minutes and tracks the trailer.	Verify positions for the trailer are received every 15 minutes.	Timestamp, Lat/Lon, Trailer Id, SCAC	2.2.31 2.2.3.2 2.2.3.2 2.2.3.4			Status report interval 15 minutes
40	Trailer monitoring	When tractor returns to Shipper, driver needs to disconnect the trailer, turn on the MCT and let it power up, then do a connect.	Verify that when a connect is received the TrailerTRACS application identifies that the trailer has moved from its last disconnected location.		2.2.8.5			Non-Omni Movement Alert

No.	Scenario Test Description	Methodology	Expected Result	Data Fields	Rqm't	Status	FR	Comments
	Daily Operations							
41	Test End	Driver sends message "Test End" when tasks are complete. Dispatcher sends message "Test End" when tasks are complete. Dispatcher runs Event History report to gather information on trailer.	Verify the Event History report runs properly with correct information. Verify data collection against web-based user interfaces.		2.4.1.1			Request Data collection process is performed. Reset the status report parameter.

APPENDIX D: UNTETHERED TRAILER TRACKING SYSTEM PILOT AUTOMATED DATA CAPTURE FORMAT

A tool was developed to collect UTT system data from the host application database. This tool was run on a weekly basis to collect UTT system data from each of the three participating carriers.

The table beginning on the following page is representative of the data collected automatically from the NOC showing a sample of the collected data and data descriptions. The actual data was provided in pipe-delimited format for parsing by analysis software. In addition, data was reviewed by QUALCOMM personnel to identify inconsistencies and verify customer participation. All data was archived.

Transaction Type	Date	Time	Time Zone	Veh. ID	Comm Unit#	Trailer ID	Cargo	Door	Macro#	Macro Ver.	Event Type	LAT	LONG	Proximity	Msg Length	(B)inary/ (T)ext	Message Body
TRAILER EVENT	12/19/04	00:26:46	GMT		0	XX1810005	EMPTY	CLOSED	0	0	STATUS REPORT	140021	-0312914	Crane IN 47522	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE
TRAILER EVENT	12/20/04	00:26:46	GMT		0	XX1810005	EMPTY	CLOSED	0	0	STATUS REPORT	140021	-0312914	Crane IN 47522	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE
TRAILER EVENT	12/21/04	00:26:46	GMT		0	XX1810005	EMPTY	CLOSED	0	0	STATUS REPORT	140024	-0312914	Crane IN 47522	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE
TRAILER EVENT	12/21/04	18:30:21	GMT		0	XX1810005	NOT EMPTY	OPEN	0	0	CARGO LOADED	139986	-0312782	1 ESE Crane IN 47522	0	B	
TRAILER EVENT	12/21/04	19:25:39	GMT		0	XX1810005	NOT EMPTY	CLOSED	0	0	DOOR SENSOR CLOSED	139986	-0312781	1 ESE Crane IN 47522	0	B	
TRAILER EVENT	12/22/04	19:00:35	GMT		0	XX1810005	NOT EMPTY	CLOSED	0	0	STATUS REPORT	140022	-0312913	Crane IN 47522	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE

Transaction Type	Date	Time	Time Zone	Veh. ID	Comm Unit#	Trailer ID	Cargo	Door	Macro#	Macro Ver.	Event Type	LAT	LONG	Proximity	Msg Length	(B)inary/ (T)ext	Message Body
TRAILER EVENT	12/23/04	19:00:35	GMT		0	XX1810005	NOT EMPTY	CLOSED	0	0	STATUS REPORT	140022	-0312916	Crane IN 47522	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE
TRAILER EVENT	12/24/04	17:42:13	GMT	5885	717484	XX1810005	NOT EMPTY	CLOSED	0	0	OMNI CONNECT (UTT)	140022	-0312927	Crane IN 47522	0	B	
TRAILER EVENT	12/24/04	19:00:35	GMT	5885	717484	XX1810005	NOT EMPTY	CLOSED	0	0	STATUS REPORT	138357	-0312976	2 N Haysville IN 47546	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE
TRAILER EVENT	12/25/04	19:00:35	GMT	5885	717484	XX1810005	NOT EMPTY	CLOSED	0	0	STATUS REPORT	126395	-0287253	3 NNW Ellerbe NC 28338	0	B	GEO-FENCE STATUS: ACTIVE GEO-FENCE TYPE: LANDMARK INSIDE GEO-FENCE: NOT INSIDE

APPENDIX E: UNTETHERED TRAILER TRACKING SYSTEM PILOT SAMPLE MANUAL LOG DATA

During the testing, various data collection sources were used to measure and evaluate the UTT system. Each of the carrier's dispatchers maintained a manual data collection log in bound serialized books for accurate and timely collection of data. They completed the manual logs as they performed their daily dispatch activities. A minimum of one dispatcher at each carrier location was asked to complete the log for their assigned trailers. These were used for trailers with and without the UTT system.

The Manual Log instructions for the dispatchers were as follows:

Instructions:

1. Data entry errors are expected. Never erase entries. Correct errors by putting a single line through an error: ~~Error occurred here.~~
2. Record occurrences when the **expected** result occurred as well as when the **unexpected** result occurred. They are **equally** important.
3. Retain and return **all** notebooks including ones with coffee and food stains.
4. Never remove a page from the notebook even if it has stains on it.

Please write legibly since someone will type your results in for analysis. This includes initials.
If it is impossible to retain a page or notebook, copy the pages so we can see them.

A sample of a filled in daily Manual Log, Figure E-1, is shown on the next page.

				Choose Exactly 1					Choose Exactly 1						
Entry No.	Date Recorded	Time Recorded Begin/End	Trailer Number	Location	Cargo State	Unexpected Geofence break	Unexpected Hook w/haul	Was	As Expected	Near Expected	No Expectation /Don't know	Not as expected	Date of Referenced Report	Time of Referenced Report	Initials/ Name
1	10/04/04	1015/1020	5[illegible]	✓								✓	10/4/04		B Rice
	Actual location/incorrect distance driven if known:														
2	10/04/04	1020/1030	7810095	✓								✓	10/4/04		B Rice
	Actual location/incorrect distance driven if known:														
3	10/04/04	1020/1035	7810121	✓								✓	10/4		B Rice
	Actual location/incorrect distance driven if known:														
4	10/04/04	1320/1322	R17793	✓					✓				10/4		B Rice
	Actual location/incorrect distance driven if known:														
5	10/05/04	1600/1609	R16595	✓								✓	10/05		B Rice
	Actual location/incorrect distance driven if known:														
6	10/13/04	1045/1115	3850002	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														
7	10/13/04	1045/1115	41621	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														
8	10/13/04	1045/1115	7810045	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														
9	10/13/04	1045/1115	3830058	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														
10	10/13/04	1045/1115	7810027	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														
11	10/13/04	1045/1115	R9545	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														
12	10/13/04	1045/1115	7810109	✓								✓	10/13/04		B Rice
	Actual location/incorrect distance driven if known:														

Figure E-1: Example of UTT Manual Participant Log

APPENDIX F: UNTETHERED TRAILER TRACKING SYSTEM PILOT ON-SITE TEST PARTICIPANT INTERVIEW GUIDE

	Disagree 1	2	3	4	Agree 5	N/A
1. The deployed UTT system has made a favorable impression upon yourself and others at your company.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

2. The UTT system has been used significantly and on a regular basis.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

3. The UTT system required significant staff resources including time.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

4. The initial training provided adequate to prepare personnel to use the UTT system.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

5. The dispatchers responded positively to using the UTT system.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

	Disagree 1	2	3	4	Agree 5	N/A
6. The UTT system might prove to be an improvement to your existing operations.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

7. The UTT system has been easy to use.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

8. The UTT system has been reliable.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

9. The UTT system has allowed for better/easier tracking of loads, drivers, and vehicles.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

10. The UTT system has improved customer service and Estimated Time of Arrivals for pick-ups and deliveries.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

11. The UTT system has provided an increased sense security and safety for company employees.	☐	☐	☐	☐	☐	☐

Comments:_____
_____
_____
_____

General Technology Comments

The test team will collect general comments concerning the deployed test technologies at each participant test site:

- Wireless Satellite Communications

- UTT Terminal

- Cargo Sensor

- Door Sensor

- Geo-Fencing

- Connects/Disconnects

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

Report No. FMCSA-MCRRT-06-002

For more information on the Federal Motor Carrier Safety Administration, check out our website at www.fmcsa.dot.gov.