Untethered Trailer Tracking and Control System Operational Requirements Document

U.S. Department of Transportation

Federal Motor Carrier Safety Administration

August 2005

Foreword

The U.S. Department of Transportation (USDOT), Federal Motor Carrier Safety Administration (FMCSA) funded this pilot test to (1) develop generic voluntary requirements for an untethered trailer tracking system using as a model QUALCOMM's proprietary T2 Untethered Trailer Tracking system that includes specific capabilities and (2) field test a system that meets these requirements.

This report outlines the requirements for this untethered trailer tracking system, provides a detailed break down of the individual technologies used, and explains how they will be field tested to provide evidence that the technologies meet the designated requirements.

The results from this project can be used by motor carriers as system guidelines for voluntary adoption of untethered trailer tracking systems within their trucking fleets.

This is a final report developed under FMCSA's deployment of untethered trailer tracking system program. It does not supersede an earlier report on the subject. Note that certain confidential and proprietary information that pertains to QUALCOMM's proprietary technology has been removed.

Notice

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16. Abstract

 The U.S. Department of Transportation (USDOT), Federal Motor Carrier Safety Administration (FMCSA) funded this pilot test to (1) develop generic voluntary requirements for an untethered trailer tracking system using as a model a proprietary system that includes specific capabilities, and (2) field test a system that meets these requirements.

This document outlines the requirements for this untethered trailer tracking system, provides a detailed break down of the individual technologies used, and outlines how, using a total of seventy five (75) trailers outfitted with QUALCOMM's T2 Untethered Trailer Tracking units and door and cargo sensors, these requirements could be met under three different operational scenarios (Truck load/Dry Van, High Value, Explosives/Hazmat) using field tests.

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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.

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1 Introduction

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 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 (HAZMAT FOT) 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 project to: (1) develop generic voluntary requirements for an untethered trailer tracking system using as a model a proprietary system that includes specific capabilities, and (2) field test a system that meets these requirements.

The requirements section of this document briefly describes the development of requirements for the UTT system tested in the pilot and then lists the functional requirements and constraints in detail.

2 Requirements

Table 2-1 provides an overview of the top-level requirements that serve as a basis for developing the detailed requirements specified in this document.

Table 2-1: Top-level Requirements Overview

1	Real-time trailer identification: Provide trailer number, status, and location
2	Accurate time of connection and disconnection activities: Provide time and position of a trailer hook and drop
3	Location and mapping of trailers: Provide a map showing a trailer's location
4	Geo-fencing to identify a risk area to monitor: Provide geo-fencing for keeping a trailer in and out of a risk area
5	Unscheduled movement notification: Provide a notification of a trailer that moved outside of its geo-fence
6	Remote sensing of a loaded or empty trailer: Provide an indication of a loaded or empty trailer
7	Door sensors: Provide an indication of open or closed doors
8	Alerts: Provide alerts for geo-fencing and cargo and door events

Three scenarios were developed to test the requirements in regard to safety, security, and trailer utilization:

- Scenario 1:   Truckload/Dry Van

  o Scenario 1 will include trailer tracking of the Truckload/Dry Van portion of the trucking industry. Loads are general dry freight, such as electronics, clothing, and potatoes. The loads will vary throughout the season, and will be delivered throughout the 48 states.

- Scenario 2:   Truckload/High Value

  o Scenario 2 will include trailer tracking of the Truckload/HighValue portion of the trucking industry. Loads are general high-value dry freight, such as retail items, electronics, and food. The loads will vary throughout the season, and will be delivered throughout the 48 states.

- Scenario 3:   HAZMAT/Explosives

  o Scenario 3 will include trailer tracking of the HAZMAT/Explosives portion of the trucking industry. Loads are Class 1.1 – 1.6 explosives. The loads will vary throughout the season, and will be delivered throughout the 48 states. The transport of some U.S. military loads requires mandated satellite mobile communications systems on the tractors in this scenario.

Table 2-2 depicts the mapping of the requirements to the three pilot test scenarios:

Table 2-2: Requirements to Scenarios Mapping

Function		Scenario		
		1	2	3
1	Near real-time trailer identification	X	X	X
2	Accurate time of connection and disconnection activities	X	X	X
3	Location and mapping of trailers	X	X	X
4	Geo-fencing to identify a risk area			X
5	Unscheduled movement notification		X	X
6	Remote sensing of a loaded or empty trailer	X	X	X
7	Door sensors		X	X
8	Alerts		X	X

2.1 Functional Requirements

The following sections contain a definition and the UTT system functional requirements.

2.1.1 Near Real-time Trailer Identification

Definition

Trailer identification is established via position reports sent from the UTT system terminal on the trailer. The UTT system terminal monitors the Global Positioning System (GPS) for its location, checks other on-board sensors, and sends this information over the air (OTA). The information presented to the user includes the trailer identification number (ID) and trailer type, as well as the user Standard Carrier Alpha Code (SCAC). The user can view the host software to find the latest trailer location and status on a map. Trailer locations are displayed relative to predefined landmarks or street or highway intersections. The trailer status refers primarily to three key pieces of information: whether the trailer has cargo or is empty, whether the door is open or closed, and whether the trailer is connected or disconnected to a tractor. If the latest scheduled report is not sufficiently current, the user can request an update from the UTT system 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.

Performance constraints and requirements

2.1.1.1   The UTT system allows a user to request and obtain the current trailer status information from the terminal, which includes at minimum the trailer position, cargo status, door status, and status of any other sensors, if installed.

2.1.1.2   The UTT terminal shall wake up to listen for status requests at user-configurable intervals, which will include at minimum: never; once per 30 minutes; and once per 1, 2, 6, 8, and 12 hours.

2.1.1.3   The UTT terminal shall default to wake up and listen for requests for status once per 6 hours.

2.1.2 Time of Trailer Connection and Disconnection

<u>Definition</u>

The time of trailer connection and disconnection refers to the time that a trailer is physically connected or disconnected from a tractor. For example, a trailer is typically disconnected from the tractor when the tractor-trailer arrives at a destination where the trailer may be unloaded while the tractor departs to pick up and move another trailer. For this pilot test, the ID number of a tractor connected to or being disconnected from a trailer will be visible only when the trailer is interfacing with a tractor equipped with the QUALCOMM OmniTRACS satellite mobile communications tracking system on the tractor.

<u>Performance constraints and requirements</u>

2.1.2.1   The UTT system shall detect and record time of trailer connections and disconnections.

2.1.2.2   The connection and disconnection times recorded by the UTT system shall be accurate within 15 minutes of the actual connection and disconnection times.

2.1.2.3   The UTT system connection and disconnection events shall be sent immediately upon validation by default.

2.1.3 Trailer Location and Mapping

<u>Definition</u>

Trailer positions are established via GPS or other locating technology. The UTT system terminal is configurable to wake up to check for positions at user-defined intervals. Once the position has been established, the coordinates are reported to the user visually at the carrier site through a map interface. Although latitude and longitude are provided, the user would normally see the trailer's position on a map with reference to highways, streets, intersections, or user-defined landmarks.

UTT system communication coverage for the United States is expected to be greater than 90% of the geographical area of the 48 contiguous states. Although complete coverage in Canada and Mexico may be beneficial, it is not listed as a requirement due to a dependency on third-party telecommunication providers.

<u>Performance constraints and requirements</u>

2.1.3.1   UTT system position reporting intervals shall be user-configurable OTA.

2.1.3.2   UTT system position reporting intervals shall be configurable at a minimum to: never; 15 minutes; 1, 6, 8, 12, 24 hours; and then once per day until the 30th day. (Reporting intervals that are more frequent than 15 minutes may be utilized in certain instances, such as trying to locate a stolen trailer.)

2.1.3.3   UTT system position reporting intervals of less than 60 minutes shall be configurable by the system administrators only, unless system administrators have given a user the capability to change the position reporting interval to less than 60 minutes. (The purpose of this requirement is to prevent excessive messaging and battery drain, especially for users who may not clearly understand the constraints of the system.)

2.1.3.4   The UTT system shall provide a daily interval for position reports by default.

2.1.3.5   The UTT system shall provide the configurable capability to suppress scheduled position reports when power is detected on Pin 7 of the SAE J560 connector. (The SAE J560 is the standard connector used to connect the electrical system of a trailer to a tractor, and power on Pin 7 may indicate that a tractor is attached to the trailer. If there is a mobile communications system on a tractor tethered to a trailer, position reports may be more cost effectively sent from the tractor system versus the UTT system. When the tractor mobile communications system is non-operational or more frequent trailer positioning updates are required, the UTT system can be effectively utilized to provide this information.)

2.1.3.6   The UTT system shall support a mapping module including street-level maps for the United States, Canada, and Mexico.

2.1.3.7   The UTT system shall provide visibility to active geo-fences, cargo event locations, door event locations, connection and disconnection locations, and historical positions on maps. (For the UTT system tested in the pilot test, geo-fences will be visible on maps as polygons or circles overlaid on the map, and geo-fence violations will be visible as icons appearing in a line item for a trailer.)

2.1.3.8   The UTT system shall allow users to view one or more selected trailers with proximity from pre-defined landmarks on a map display. (For the UTT system tested in the pilot test, there is no maximum limit to the number of trailers that may be displayed on maps, although in an area densely populated with trailers, viewing can be difficult. A pop-up list of 'hidden' trailers provides visibility to the trailers that may be overlapped on the display.)

2.1.3.9   The UTT system shall provide the ability for users to view the position history of a trailer on a map display for a user selected period of time or a default setting to the prior week.

Landmarks

2.1.3.10 The UTT system software shall support the creation, modification, and deletion of custom landmarks by authorized users.

2.1.3.11 The UTT system software shall support the display of trailer positions with proximity to the nearest custom landmark, if configured as such under user's preferences. This allows the user to display all position reports in terms of the trailer's proximity to a landmark.

2.1.3.12 The UTT system software shall support the query for trailers near a specified landmark within a specified distance, which allows the user to query for any trailer within a certain distance from a landmark.

2.1.4 Geo-fencing

<u>Definition</u>

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 an 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. Once the geo-fence is set and configured to provide an alert, the terminal will send a notification to the user if the trailer crosses the geo-fence boundary. The geo-fence will send an alert when a trailer exits or enters the boundary through an email or pager notification. Geo-fences may also be removed or inactivated for trailers or groups of trailers at any time.

The UTT system will provide 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 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.

A geo-fence might be used to ensure that a trailer remained in a general area, such as the Los Angeles basin. In this example, the user would create a geo-fence around Los Angeles and then assign that geo-fence to a trailer or group of trailers. If a trailer was taken from the Los Angeles area, an alert would be generated and the user notified. This type of geo-fence might permanently remain in effect if this trailer or group of trailers were meant to stay in that area indefinitely. A geo-fence could also be created around a particular destination, such as a receiving warehouse. When the trailer entered this geo-fence, an alert would be generated so that the user would know that the trailer was delivered within a certain timeframe.

Using the UTT system, a user can set a self-centered geo-fence, which provides a quick way to set a geo-fence without forcing the user to locate the area on the map. A self-centered geo-fence uses the position of the trailer at the time of receiving the "set self-centered geo-fence" command to create the geo-fence boundary. The user does not have to create the geo-fence on a map or choose settings for that geo-fence. As with any geo-fence, an alert will notify the user if the trailer breaks the geo-fence boundary while the geo-fence is active.

<u>Performance constraints and requirements</u>

2.1.4.1 All UTT system generated geo-fences shall have configurable start and end dates.

2.1.4.2 The UTT system shall support a single geo-fence per trailer, which may be reset OTA.

2.1.4.3 The UTT system terminal shall monitor the geo-fence at configurable intervals of 15 minutes; 1, 6, 8, 12, or 24 hours.

2.1.4.4 The UTT system geo-fence monitoring interval shall default to once per hour.

2.1.4.5 The UTT system geo-fence alert shall be configurable to be sent immediately upon validation, saved and sent with the next planned status message, or disabled.

2.1.4.6 The UTT system geo-fences shall be configurable to generate an alert on exit, entry, or both.

2.1.4.7 The UTT system software shall support the assignment and deletion of geo-fences to individual trailers.

2.1.4.8 The UTT system software shall support the display of geo-fence summary data containing the trailer ID/SCAC; last known position; geo-fence status; last geo-fence alert message with location, door, cargo, and connect events; timestamps; and alert acknowledgement status.

2.1.4.9 All UTT system geo-fence sizes shall be configurable.

2.1.4.10 The UTT system shall support a self-centered geo-fence that is centered at the terminal location at time of receipt of the geo-fence command.

2.1.4.11 The UTT system self-centered geo-fence default size shall be a square of 0.5 miles x 0.5 miles. (Note: 0.5 x 0.5 miles has been a useful setting in practice, but this setting and all other self-centered geo-fence default settings may be configurable by users. The UTT system in the pilot test allows the setting of a geo-fence as follows: East/West length from 500 to 40,000,000 meters and North/South Length from 500 to 20,000,000 meters.)

2.1.4.12 The self-centered geo-fence default configuration shall be activated upon receipt by the UTT system terminal.

2.1.4.13 The UTT system self-centered geo-fence default configuration shall remain active until deactivated by the user.

2.1.4.14 The UTT system self-centered geo-fence default configuration shall be to send an alert when a trailer exits the geo-fence boundary.

2.1.4.15 The UTT system self-centered geo-fence default configuration shall be to send alerts immediately, as opposed to saving alerts and sending them along with the next scheduled status message.

2.1.4.16 The UTT system self-centered geo-fence default configuration settings shall be editable by system administrators.

2.1.5 Trailer Cargo Sensing

Definition

As a part of the UTT system, an ultrasonic 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, and a status message may be sent depending on user-chosen settings. For example, an erroneous detection could occur if a person walks into the trailer at the moment the sensor is taking a reading of cargo status. In this case, assuming the person exits the trailer, a second check would show the true

unloaded state of the trailer. Validation of cargo events decreases the probability of erroneous state detections.

<u>Performance constraints and requirements</u>

2.1.5.1   The cargo sensor shall be configurable to monitor at four or more different frequencies, including once every 10, 30, 60, or 120 minutes.

2.1.5.2   The cargo sensor shall be monitored at least once every 30 minutes by default.

2.1.5.3   The cargo event message shall be configurable to be sent immediately upon validation, saved and sent with the next planned status message, or disabled.

2.1.5.4   The cargo event message shall be sent immediately upon validation by default.

2.1.5.5   The cargo sensor validation shall be configurable as follows: If a cargo state change is detected, the cargo sensor shall wait an interval of X minutes prior to rechecking, and shall recheck Y times, where X may be 5, 10, 30, or 120 minutes and Y may be 0, 1, 2, or 3.

2.1.5.6   The cargo sensor default validation setting shall be to recheck one time (Y=1) after five minutes (X=5).

2.1.5.7   The cargo event message shall include trailer position, if available. If the position is not available, the message shall provide the last known position with a timestamp or "position unknown".

2.1.5.8   The cargo event status message shall include the last known cargo state (loaded or not loaded) and time of the last known cargo state.

2.1.5.9   All of the above configurable parameters of the cargo sensor shall be OTA configurable by the user.

2.1.6 Trailer Door Sensing

<u>Definition</u>

As a part of the UTT system, the trailer door sensor monitors for an open or closed door 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 will be monitored, and a door opening alert will only be sent when the trailer is loaded.

<u>Performance constraints and requirements</u>

2.1.6.1   The door sensor shall be configurable to trigger an event if the door goes from closed to open and remains open for a configurable amount of time, where the time may be 5, 10, or 30 seconds; or 1, 2, 3, 4, 5, 10, 30, or 60 minutes.

2.1.6.2　The door sensor shall be configurable to trigger an event if the door goes from open to closed and remains closed for a configurable amount of time, where the time may be 30 seconds; 1, 10, 20, 30, or 60 minutes.

2.1.6.3　The default configuration shall be not to send door closed events.

2.1.6.4　The default configuration shall be to send an alert for door open events when the cargo sensor senses a loaded trailer.

2.1.6.5　Door events shall be configurable to be sent immediately upon validation, saved and sent with the next planned status message, or disabled.

2.1.6.6　Door event messages shall be sent immediately upon validation by default.

2.1.6.7　The door event message shall include position, if available.

2.1.6.8　The UTT system terminal shall automatically detect when a door sensor is installed.

2.1.6.9　All of the above configurable parameters of the door sensor shall be OTA configurable by the user.

2.1.7　Alerts

Definition

Alerts are generated by the UTT system host software and presented to the viewer through an alert icon that is displayed near the trailer ID. Alerts are based on a combination of user-preferred settings and events which are generated from the mobile terminal. Alerts are used to notify the user of events, such as geo-fence violations. Alerts can be configured to be forwarded to email or pager addresses.

Performance constraints and requirements

2.1.7.1　UTT system alerts shall meet the requirements for the cargo sensor, trailer door sensor, and geo-fence as specified in each respective section above.

2.1.7.2　UTT system alerts shall be configurable to be sent to a minimum of one email/pager address. (There is no requirement for a maximum number of addresses to which an alert may be forwarded.)

2.1.7.3　The UTT system software shall allow a user to acknowledge alert messages and then the UTT system shall log the corresponding user ID.

2.1.7.4　The UTT system software shall provide an optional alert for a trailer that has failed to send a scheduled status report for a period of X days, where X is configurable at any time. (It is advantageous to have the time period X be configurable in hours when the trailer is laden or in active use versus days when it is not in active use. Then, a user could choose to be notified if a status report was as little as one hour late.)

2.1.7.5　The UTT system software shall provide an optional alert for a trailer that has moved independently of its assigned tractor.

2.1.7.6　The UTT system software shall provide an optional alert for a trailer that has been disconnected outside of a specified distance from any one of a list of user-specified drop points.

2.1.7.7   The UTT system software shall provide an optional alert for a tractor that has sent a "load call" without being connected to a trailer. (A load call is a message sent from the tractor to a dispatcher indicating that it has connected to a trailer and is ready to depart.)

2.1.7.8   The UTT system software shall provide an optional alert for a trailer that reports a door open event while the trailer is not empty.

2.1.7.9   The UTT system software shall provide a way for the user to create and save an alert monitoring plan that may be assigned to trailers. (The purpose of this requirement is to help users specify alert settings quickly and easily for any trailer. Without a monitoring plan, the user would have to set each alert option and notification scheme for each trailer, which could be impractical.)

2.1.8 HERO Certification

<u>Definition</u>

A Hazards of Electromagnetic Radiation to Ordnance (HERO) certification for transmitting devices is required by the Department of Defense when ordnance is shipped. Background information on the certification process and tests can be found in MIL-HDBK-237B and MIL-HDBK-240, respectively. MIL-STD-464 specifies the requirements for HERO certification.

Transportation of goods involving ordnance is of particular concern due to the potential safety hazard. Hazards arise from ordnance that may be detonated through electromagnetic energy. HERO certification establishes the maximum levels of electromagnetic radiation that the transmitting device may discharge without risking a potential safety hazard.

<u>Performance constraints and requirements</u>

2.1.8.1   The UTT system terminal and all other mobile system components shall be HERO certified.

2.2 System Interface Requirements

2.2.1 Interface Configurations

<u>Definition</u>

After installation in the trailer, the UTT system terminal must interface with numerous devices in order to meet system operational requirements. For more information on interfaces, see TMC RP 2401, Recommended Practice, Trailer Tracking Interface Standard.

<u>Performance constraints and requirements</u>

2.2.1.1   The following interfaces shall be supported during the pilot test:

- Rechargeable battery pack

     o   The rechargeable battery pack is a required back-up power source that will power the UTT system when the trailer is disconnected from the tractor

power. The UTT system's source of power is from its rechargeable battery whenever the trailer is disconnected from a tractor.

- J560

  o The J560 connector is the standard connector used on the electrical cable that bridges the tractor and trailer. If so configured, the UTT may interface with this connector in order to determine connect/disconnect events. It may also communicate with the tractor mobile communications system via the J560. For the purposes of this pilot test, the J560 will be used by the UTT system to communicate with the tractor satellite-based mobile communications system and to access tractor electrical power.

- Door sensor

  o The door sensor is installed next to the trailer doors to monitor door opening and closing events.

- Cargo sensor

  o The cargo sensor is installed inside of the trailer to monitor if the trailer is loaded or unloaded.

- Antennas

  o The UTT system for this pilot test includes two separate antennas, one for communications and one for location determinations through GPS. They are installed near the top or on top of the trailer in a position with a clear view to the sky.

- Host interface

  o The UTT system host interface presents information to the user and allows the user to request configuration changes or information updates.

2.2.1.2 The UTT system software shall provide a documented interface for users who use alternative software.

2.2.1.3 The UTT system user interface shall provide full access to all UTT system features.

2.3 Data Requirements

The following section describes where the data flows will be captured and the frequency of data transfers for analysis during the pilot test.

2.3.1 Test Information Stored

2.3.1.1   In general, the UTT system shall retain all user data online for a period of time configurable by authorized users from a minimum of 14 days to a maximum of 6 months. (UTT system users may create their own systems to capture and store information indefinitely.)

2.3.1.2   For the pilot test, all data shall be saved for the duration of the test and analysis period.

2.3.2 Test Data Collection Rates

Definition

The data collection rate specifies the frequency of recording the pilot test information.

Performance constraints and requirements

2.3.2.1   For the pilot test, data shall be collected from every message.

2.3.3 Test Data Storage Means and Format

Definition

Data storage means and format defines the method by which pilot test data is stored for analysis.

Performance constraints and requirements

2.3.3.1   Pilot test data shall be stored in Microsoft Excel spreadsheets.

2.3.3.2   Pilot test data shall be secured in a 64-bit encrypted, password protected zip file, and written to a CD.

2.3.4 Test Data Retrieval

Definition

Pilot test data retrieval specifies the requirements for capturing data produced during the test. In general, trailer and tractor information is sent over the air from mobile terminals, processed in a network management computer, and then sent to individual user accounts. For this test, the applications receiving this data are web applications hosted by the UTT system provider. Relevant test data will be retrieved from these databases and then processed and saved in spreadsheet format.

Performance constraints and requirements

Pilot test data shall be processed into a common format.

Pilot test data shall be categorized by user, vehicle, transaction type, and event type.

Pilot test data shall be imported into an Excel spreadsheet weekly.

Pilot test data shall be organized within the spreadsheet in pivot tables to provide summary data views.

2.4 Hardware and Software Requirements

The following sections contain the requirements for the UTT system mobile hardware and software needed for the UTT system user to interface with the system.

2.4.1 Hardware Requirements

<u>Definition</u>

For the pilot test, the UTT system consists of the following hardware:

- Terminal – The terminal contains the processors and firmware required for operation.
- Antennas – The UTT system for this pilot test includes two separate antennas, one for communications and one for location determinations through GPS installed near the top or on top of the trailer in a position with a clear view to the sky.
- Cables – Cables connect the UTT system terminal to any installed sensors, tractor power, and the rechargeable battery
- Rechargeable battery – The rechargeable battery is a required back-up power source that will provide power to the UTT system when the trailer is disconnected from the tractor.

- Cargo sensor – The cargo sensor is installed inside of the trailer to monitor if the trailer is loaded or unloaded.

- Door sensor – The door sensor is installed next to the trailer doors to monitor door opening and closing events.

- Terminal/cargo sensor/battery combined mount – The terminal/cargo sensor/battery combined mount is installed in the trailer and holds the three components of the UTT system.
- Field service tool – The field service tool is a software package that operates on a handheld computer. It is used to communicate with the UTT system for configuration and diagnostic purposes to verify proper operation.

- Other inputs – It may be desirable to have available inputs to interface with other sensors on the UTT system in addition to cargo and door sensors for detection of motion, intrusion, radiation, etc. The UTT system includes two additional available inputs for such integration.

<u>Performance constraints and requirements</u>

Physical Dimension Constraints

2.4.1.1 Any hardware component placed on the trailer roof shall not exceed 1 inch in height. (The purpose of this requirement is to protect hardware, such as antennas and solar collector plates from being hit and damaged. For example, some carriers drive trucks beneath a fixed beam to scrape snow and ice from the roof of the trailer, which may damage hardware on the trailer roof.)

Environmental Specifications

2.4.1.2 Hardware shall meet or exceed the mechanical and environmental requirements listed in Table 2-3.

Table 2-3: Environmental Specifications

Condition	Requirements
Temperature – Operational	Terminal: -30°C to +60°C, Antenna: -40°C to +70°C
Temperature – Non-Operational	Terminal: -40°C to +85°C, Antenna: -50°C to +85°C
Vibration – Operational	2.4 gRMS from 10 -1000Hz
Vibration – Non-operational	5.2 gRMS from 10 -1000Hz
Humidity – Operational & Non-operational	0-98%RH @ 38°C without condensation
Immersion and Splash (Water, Chemicals, and Oils)	Terminal: Immersion Tests, per SAE J1455 Revised OCT 10a, section 4.3.3.2. (This test is recommended, but not required if the terminal is to be mounted inside the wall of a dry van in a protected location.) Terminal: Splash Tests, chemical exposure per SAE J1455, limited to engine oils and additives, washer solvent, gasoline, diesel fuel, alcohol, anti-freeze water mixture, soap and detergents, steam, battery acid, water, snow, and salt water. (This test is recommended, but not required if the terminal is to be mounted inside the wall of a dry van in a protected location.) Antenna: Exposure per SAE J1455, Section 4.4
Fungus	Per MIL-STD-810E, Procedure 508.3
Altitude – Operational	0 – 15,000 ft
Altitude – Non-operational	0 – 15,000 ft
Shock – Maximum Level	20G @ 11msec
Electrical	9-16V
Thermal Cycle	8 and 24 hours per SAE J1455
Thermal Shock	Per SAE J1455
Transit Drop (in packaging)	Packaged drop per SAE J1455, Section 4.10.3.2.2
Solar Radiation	**Antenna and cables only**: 43-75 watts/sq.m of 280-400 nm for 300 hr according to John Deere JDQ 53.2

Cables/Connectors

2.4.1.3   All connectors shall be differentiated from each other to prevent incorrect attachment.

Electromagnetic Interface (EMI) Shielding

2.4.1.4   All EMI shielding shall be built into the UTT system terminal and associated hardware; external shielding shall not be required.

Marking

2.4.1.5   The UTT system terminal marking shall clearly identify terminal manufacturer, part number, and serial number, at a minimum.

2.4.1.6   The UTT system terminal shall include a separate label with serial number and barcode that may be attached externally to the trailer at time of install.

2.4.1.7   The UTT system terminal shall include required regulatory markings.

Antennas

2.4.1.8   The UTT system antennas shall be installed on a fiberglass-roofed trailer without drilling or cutting into the fiberglass. (The purpose of this requirement is to avoid cutting of fiberglass roofing material, since holes in fiberglass may lead to water leaking into the trailer. There are no similar conditions for metal roofs.)

Electrical Power Range and Limits

2.4.1.9   The UTT system terminal shall support a direct power feed of 12V nominal (e.g., a vehicle battery).

2.4.1.10 The UTT system terminal shall conform to the electrical test limits of SAE J1455.

2.4.1.11 The UTT system terminal shall conform to SAE J1113-13 Electromagnetic Compatibility Measurement Procedure for Vehicle Components for electromagnetic compatibility and electrostatic discharge.

Circuit Protection

2.4.1.12 The UTT system terminal shall have no internal fuses or circuit breakers that require manual intervention to reset. (External fuses or circuit breakers may be required for safety purposes.)

Rechargeable Battery

2.4.1.13 The UTT system terminal shall support a rechargeable battery with a 1-year shelf life, assuming 25°C, from date of manufacture.

2.4.1.14 The UTT system rechargeable battery shall provide power for at least 30 days if the terminal were configured according to the default terminal power state and messaging schedule as defined in Table 2.3 with the exception of any geo-fence checks (assuming the vehicle battery provides no additional power to the terminal).

2.4.1.15 The UTT system rechargeable battery shall provide power for at least 10 days, over the entire temperature range, if the terminal were configured according to the

default terminal power state and messaging schedule as defined in Table 2.3 including geo-fence checks, assuming 1-hour geo-fence check intervals.

2.4.1.16 The rechargeable battery shall survive for a minimum of 6 months at 40°C after disconnection from a power source without permanent damage to the battery.

2.4.1.17 The UTT system terminal shall provide information to the user OTA of the replacement date of the rechargeable battery.

2.4.1.18 The UTT system terminal shall provide information to the user OTA when the battery requires recharging (approximate 10% threshold).

2.4.1.19 The UTT system rechargeable battery shall be fully rechargeable in 8 hours or less when charging from a typical 12V tractor power supply system.

Power Management

2.4.1.20 The UTT system terminal shall draw power from the following sources if available, in the priority as listed:

1. Vehicle

2. Rechargeable battery

2.4.2 Software Requirements

Definition

Requirements for the software that is visible to the system user are included in this section. The UTT system-provider hosts this software that may be accessed by users through the Internet. Using the software, the user may view information, such as trailer positions and cargo, door, geo-fence, or connection events, or configure settings for the system such as landmarks, trailer groups, and user accounts. Additional software requirements are listed in sections above describing time of trailer connection and disconnection, trailer location and mapping, geo-fencing, alerts, and incorporation of fleet management tools.

Performance constraints and requirements

Messaging

2.4.2.1 The UTT system software shall store in the database and display all incoming messages including trailer connect/disconnect, door open/closed, cargo empty/not empty, battery events, and status reports.

2.4.2.2 The UTT system software shall support the configuration of terminal parameters by authorized users.

2.4.2.3 The UTT system software shall support the ability for an authorized user to request an updated status report from the UTT system terminal.

Accounts

2.4.2.4 The UTT system software shall support the administration of user accounts, including creation, modification, and deletion of accounts.

2.4.2.5 The UTT system software shall allow authorized users from a user account to only access to their user account data.

User Interface

2.4.2.6   The UTT system shall provide access to the data from an Internet browser. (Microsoft Internet Explorer version 6.0 or later is recommended).

2.4.2.7   The UTT system shall support a password-protected secure log-in access to the user's account for authorized users.

2.4.2.8   The UTT system software shall include a monitoring screen for the user to view all trailers, which will display the trailer ID, trailer type, terminal type, SCAC, date/time of last message, door status, connect status, cargo status, and last-known trailer location with proximity to city/town/landmark.

2.4.2.9   The UTT system software shall allow authorized users to modify the labels of the sensors, such as the door sensor and cargo sensor. (The purpose of this requirement is to allow for the configuration of the system at the time of installation. Normally, the installer would connect a sensor to one of the input ports on the terminal and then label that input port with the name of the connected sensor. For the purposes of this pilot test, that name will be either "cargo sensor" or "door sensor". These names are expected to remain for the life of the system, but an authorized user may edit the names at any time.)

2.4.2.10 Using the UTT system software, authorized users shall be able to view and edit trailer details, including trailer ID, SCAC, trailer type, and description.

2.4.2.11 Using the UTT system software, authorized users shall be able to view the event details and event history for a trailer including positions, cargo events, door events, and connect events for a user-selected time period (default to the prior week).

2.4.2.12 Using the UTT system software, authorized users shall be able to view all messages including status reports, events, and positions for a given trailer in a time-sequential order for a user selected time period (default to the prior week).

2.4.2.13 Using the UTT system software, authorized users shall be able to create and delete trailers and their history and to rename trailers (retaining history).

2.5 Lifecycle Requirements

Hardware life expectancy and the ability to accommodate future requirements are covered in the following sections.

2.5.1 Hardware Life Expectancy

2.5.1.1   The UTT system terminal, including internal battery, shall have a 7-year design life from date of manufacture.

2.5.1.2   The UTT system terminal, including internal battery, shall have a 1-year shelf life without receiving external power.

2.5.2 Ability to Accommodate Future Requirements

OTA Upgrade capability

Definition

The OTA upgrade capability allows patches or upgrades to mobile terminal firmware without direct access to the UTT system equipment on the trailer. The OTA upgrade feature is capable of performing "bug fixes," regular maintenance upgrades, and installation of new features.

Performance constraints and requirements

2.5.2.1 OTA upgrades to the UTT system shall be initiated and controlled by the UTT-system provider.

2.5.2.2 The OTA upgrades for the UTT system shall be provided to the terminal within 7 days of the user request if the terminal is able to communicate over the air and is not hibernating.

2.5.2.3 An OTA upgrade for an entire fleet shall be available to the UTT system user.

2.5.2.4 Non-sequential software upgrades for the UTT system shall be available to the UTT system user. (Non-sequential upgrade capability allows a terminal with software version 1.0, for example, to function properly when upgraded to version 3.0 even if it never received version 2.0.)

2.5.2.5 An OTA upgrade transfer shall delay the regular forward or return messaging to a UTT system terminal by no more than 1 hour.

2.5.2.6 An OTA upgrade transfer shall not disrupt or delay regular UTT system processing, such as GPS positioning by more than 1 hour.

2.5.2.7 The OTA upgrade shall not tax the vehicle battery resources if the vehicle battery is at or below the low voltage threshold.

2.5.2.8 The OTA upgrade feature shall manage the applicability and availability of the software upgrades based on the hardware configuration of the UTT system mobile terminal, the software configuration of the mobile terminal, and the user's account software configuration.

2.6 Test Performance Requirements

The following sections list key requirements for minimum UTT system performance that will be required during the test.

2.6.1 Accuracy

Definition

Requirements for the accuracy of position reporting of the UTT system are listed in this section. Position accuracy is a function of GPS receiver performance, configuration

parameters, satellite visibility of the antenna, satellite constellation, and U.S. Government-controlled Selective Availability (SA).

Performance constraints and requirements

2.6.1.1 The location accuracy of the UTT system and UTT system-provider default configuration parameters shall be a position accuracy of 100 meters approximately 95% of the time. (Position accuracy better than 100 meters will often be seen, but cannot be relied upon. These numbers take into consideration the uncontrollable variables that may affect performance. Many variables contribute to errors in position accuracy. For example, position accuracy is a function of GPS receiver performance, configuration parameters, satellite visibility of the antenna, satellite constellation, and selective availability. An industry standard for GPS accuracy has not been defined. Every manufacturer uses its own means of defining, measuring, and calculating position accuracy.)

2.6.2 Repeatability

2.6.2.1 The UTT system shall provide repeatable performance throughout the test period for all functions specified in this document.

2.6.3 Reliability during the Test

Availability of the network operations center, operated by the UTT system provider, has been at least 99.9% from 1999 to 2003 including both planned and unplanned downtime. The UTT system is expected to perform with similar reliability, but its performance is highly dependent on local conditions during the test. UTT system performance may vary by region and is dependent on variables such as cellular coverage and terrain around the mobile terminal.

3 List of Acronyms

Acronym	Definition
DOD	Department of Defense
EMI	Electromagnetic Interface
FMCSA	Federal Motor Carrier Safety Administration
FOT	Field Operational Test
GPS	Global Positioning System
gRMS	Root Mean Square of g-forces, or average force level experienced over randomly distributed frequency of input forces
HAZMAT	Hazardous Materials
HERO	Hazards of Electromagnetic Radiation to Ordnance
ID	Identification
MARAD	Maritime Administration
OTA	Over the Air
PHMSA	Pipeline and Hazardous Materials Safety Administration
SAE	Society of Automotive Engineers
SCAC	Standard Carrier Alpha Codes
USDOT	United States Department of Transportation
UTT	Untethered Trailer Tracking

4 Applicable 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(HERO) 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

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Federal Motor Carrier Safety Administration

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