

Implementation and Development of Vehicle Tracking and Immobilization Technologies



MTI Report 09-04



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IMPLEMENTATION AND DEVELOPMENT OF VEHICLE TRACKING AND IMMOBILIZATION TECHNOLOGIES

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EXECUTIVE SUMMARY

This publication, *Implementation and Development of Vehicle Tracking and Immobilization Technologies*, discusses specific developments in trailer tracking systems and vehicle immobilization systems relevant to the theft of hazardous cargoes for possible terrorism uses. It is based on research conducted through July of 2007, with the help of many who are cited in the positions they were in as of that date. It provides an overview as of that date of past, current, and anticipated government plans for vehicle tracking and immobilization, and related issues posed for state and private implementers.

This report is a sister publication to MTI Report 09-03, *Potential Terrorist Uses of Highway-Borne Hazardous Materials*. That publication was created in response to the Department of Homeland Security's request that the Mineta Transportation Institute's National Transportation Security Center of Excellence (MTI NTSCOE) provide research and insights regarding the security risks created by the highway transportation of hazardous materials.

Since the mid-1980s, limited use has been made of vehicle tracking using satellite communications to mitigate the security and safety risks created by the highway transportation of certain types of hazardous materials. However, vehicle-tracking technology applied to safety and security is increasingly being researched and piloted, and it has been the subject of several government reports and legislative mandates.

There has been governmental implementation. The military services have long transported arms, ammunition, and explosives (AA&E) by air, sea, rail, and highway. The Department of Defense (DOD) Defense Transportation Tracking System (DTTS) which has been in operation for about two decades is the longest-running government system of commercial vehicle tracking for safety or security reasons. It was, at the time of this research, the only implementation required by the government for a specific motor carrier fleet and therefore may yield important lessons. DTTS and the rest of the security measures required represented a kind of "gold standard"—an expensive one, at that—as a point of reference for any authority in considering transportation of high-risk hazardous materials

At the same time, the motor carrier industry has been investing in and implementing vehicle tracking, for a number of reasons, particularly the increase in efficiency achieved through better management of both personnel (drivers) and assets (trucks or, as they are known, tractors; cargo loads; and trailers). Another reason for tracking is the need to reduce theft, particularly of high-value cargo. Finally, vehicle tracking holds the promise of reducing risks created by unsafe driving practices and by terrorist attacks. Insurance companies that are looking at available methods and technologies as well as commercial best practices no doubt will increasingly factor vehicle tracking into their appraisal of each company's overall posture, which will in turn influence insurance rates.

Vehicle-tracking vendors are also offering more services and appear to be increasing in number, strength, and sophistication. At the time of this research, QUALCOMM, for example, was the service provider for DTTS for many years. It and other companies participated in the Federal Motor Carrier Safety Administration (FMCSA) 2003–2004 Field Operational Test,

and seven vendors are involved in a Transportation Security Administration (TSA) vehicle-tracking pilot project. Two of the companies had also teamed up with other vendors to test technologies that can immobilize vehicles. A scan of advertised services conducted in July of 2007 suggested that these technologies offer an increasingly robust set of efficiency, safety, and security benefits.

While vehicle tracking and immobilization technologies can play a significant role in preventing truck-borne hazardous materials from being used as weapons against any target they are not a “silver bullet.” Immobilization, for example, if not used in conjunction with clearly tested procedures, could create safety risks.

However, the experience of DTTS and the FMCSA and TSA pilot projects indicates that when these technologies are combined with other security measures, and when the information they provide is used in conjunction with information supplied outside of the tracking system, they can provide defensive value to any effort to protect assets from attacks using highway-borne hazmat as a weapon.

IMPLEMENTATION AND DEVELOPMENT OF VEHICLE TRACKING AND IMMOBILIZATION TECHNOLOGIES

BACKGROUND

Since the mid-1980s, limited use has been made of vehicle tracking using satellite communications to mitigate the security and safety risks created by the highway transportation of certain types of hazardous materials. However, vehicle-tracking technology applied to safety and security is increasingly being researched and piloted, and it has been the subject of several government reports and legislative mandates.

At the same time, the motor carrier industry has been investing in and implementing vehicle tracking, for a number of reasons, particularly the increase in efficiency achieved through better management of both personnel (drivers) and assets (trucks or, as they are known, tractors; cargo loads; and trailers). Another reason for tracking is the need to reduce theft, particularly of high-value cargo. Finally, vehicle tracking holds the promise of reducing risks created by unsafe driving practices and by terrorist attacks. Insurance companies that are looking at available methods and technologies as well as commercial best practices no doubt will increasingly factor vehicle tracking into their appraisal of each company's overall posture, which will in turn influence insurance rates.

Vehicle-tracking vendors are also offering more services and appear to be increasing in number, strength, and sophistication. QUALCOMM, for example, has been the service provider for the Department of Defense (DOD) Defense Transportation Tracking System (DTTS) for many years. It and other companies participated in the Federal Motor Carrier Safety Administration (FMCSA) 2003–2004 Field Operational Test, and seven vendors are involved in an ongoing Transportation Security Administration (TSA) vehicle-tracking pilot project. Two of the companies have also teamed up with other vendors to test technologies that can immobilize vehicles. A scan of advertised services suggests that these technologies offer an increasingly robust set of efficiency, safety, and security benefits.

While vehicle tracking and immobilization technologies can play a significant role in preventing truck-borne hazardous materials from being used as weapons against any target, they are not a "silver bullet." Immobilization, for example, if not used in conjunction with clearly tested procedures, could create safety risks. However, the experience of DTTS and the FMCSA and TSA pilot projects indicates that when these technologies are combined with other security measures, and when the information they provide is used in conjunction with information supplied outside of the tracking system, they can provide defensive value to any effort to protect assets from attacks using highway-borne hazmat as a weapon.

This report provides an overview of past, current, and anticipated government plans for vehicle tracking and immobilization, and related issues posed for state and private implementors.

The DOD and DTTS

The military services have long transported arms, ammunition, and explosives (AA&E)² by air, sea, rail, and highway. DTTS, which has been in operation for nearly two decades, is the longest-running government system of commercial vehicle tracking for safety or security reasons. It is also the only implementation required by the government for a specific motor carrier fleet and therefore may yield important lessons. DTTS and the rest of the security measures required represent a kind of “gold standard”—an expensive one, at that—as a point of reference for any authority in considering transportation of high-risk hazardous materials.

Outline of the DTS Program

Name: *Defense Transportation Tracking System (DDTS)*

Origin: *1984 and 1985 accidents (torpedoes and 500-pound bombs)*

Cargo: *Mandatory for arms, ammunition, and explosives (AA&E) for DOD (small arms to Stingers to highly classified material)*

Scope:

- *Operating for two decades*
- *51 carriers; 2,876 trucks, approximately 60,000 shipments per year*
- *16 main carriers that have the bulk of the business, with roughly 1,600 trucks*
- *Command center in Norfolk, VA*

Works together with high security measures:

- *To counter insiders: SECRET clearances for many*
- *To counter access to terminal: CCTV, cages, locks and seals, signatures required at all transfer points*

For higher-threat shipments or all shipments under high threat:

- *Security escort vehicles*
- *Two SECRET cleared drivers*
- *Category I and II shipments held only in DOD-approved facilities*
- *Shipment-specific approval*

AA&E materials are grouped into the following four risk categories, described in DOD transportation regulations:³

- **Category I Arms:** missiles and rockets such as Stinger and Redeye, and ammunition and explosives for them.
- **Category II Arms:** light automatic weapons up to .50 caliber and 40-mm Mk-19 machine guns, along with silencers, mufflers, and noise-suppression devices; ammunition and explosives, including grenades, high explosives, antitank and personnel mines, C4, and dynamite and TNT used in demolition; warheads for sensitive missiles; and rockets weighing less than 40 pounds each.
- **Category III Arms:** launch tubes and other equipment for surface-to-air missiles such as Stinger and Redeye; ammunition and explosives, including grenade launchers, flame throwers, and certain sights.

- Category IV arms: shoulder-fired weapons, handguns, and recoilless rifles; ammunition and explosives, including grenades, fuses, and incendiary destroyers; warheads for precision-guided munitions weighing more than 50 pounds.

As of October 1, 2007, 2,876 trucks operated by 51 carriers were registered in DTTS, but about 16 carriers, those with the bulk of the trucks, participate in everyday business. Cost estimates for next year's fleet assume a fleet of 1,591 trucks, which presumably represent the core fleet.⁴ In FY07 there were 65,813 shipments (the average assumed for next year is 60,000). Of these, 569 were Category I shipments (0.9% of the total); 10,226 (15.8%) were Category II shipments; 8,634 (13.3%) were Category III shipments; and 24,327 (37.5%) were Category IV shipments. The remaining 32.5% consisted of 21,057 "other" shipments.⁵

Needless to say, a small number of specialized motor carriers participate in the program. The number of gasoline tankers operating, by contrast, should be far greater. According to MTI's own research, the Chevron terminal in San José alone serves 400 petroleum tankers a day.

DTTS and the broader set of strengthened security measures run by the Surface Deployment and Distribution Command (SDDC)—formerly the Military Traffic Management Command (MTMC)—were created as the result of external events. On August 1, 1984, a tractor-semi-trailer carrying torpedoes overturned on a major highway near Denver, Colorado, causing major disruption exacerbated by an emergency response from local authorities who lacked sufficient knowledge of the truck's load.⁶ Then, on August 4, 1985, another tractor-semi-trailer loaded with ten Mk-84 2,000-pound, general-purpose bombs collided with a car on I-40 near Checotah, Oklahoma. Although the accident did not result in any fatalities, the NTSB description of it is breathtaking:

The automobile fuel tank ruptured and spilled gasoline which quickly ignited. Both vehicles were engulfed in flames. Subsequent explosions from the bombs destroyed the vehicles and left a crater 27 feet deep and 35 feet wide in the roadway. Three hundred and seventy-one residences were damaged. Other buildings, including a school located 734 feet from the accident site, suffered substantial damage. Total damages were estimated at \$5 million. Forty-nine persons reported to a hospital emergency room for treatment of injuries, most after breathing smoke and gases from burning tritonal. No one was fatally injured.⁷

The NTSB went on to recommend that DOD's program for ensuring the safe transportation of munitions should be significantly improved. Specifically, NTSB recommended that:

DOD ... upgrade its munitions transportation safety program and ... provide thermal protection for explosives shipments. The Safety Board also issued recommendations to the Research and Special Programs Administration (RSPA) to require thermal protection for explosives shipments and to increase recommended minimum evacuation distances for explosives shipments involved in fire. The Safety Board reiterated recommendations to the Federal Highway Administration and the RSPA to eliminate ambiguities in the routing requirements for vehicles transporting hazardous materials, to encourage states to establish through routes for shipments

of hazardous materials and to coordinate the compatibility of the designated routes regionally and nationally.

These accidents also prompted the Navy Department to institute a vehicle tracking system, using cellular and, later, satellite communications; to institute a command center and procedures to continually track vehicles carrying AA&E; and to provide accurate information to first responders. DOD then used this same system to track all AA&E shipments carried by various modes, including trucks, and gradually improved its capabilities. It now operates under the control of SDDC.

In addition to participating in DTTS, motor carriers of AA&E must also comply with stringent security standards. A critical review by the Government Accountability Office (GAO) following the 9/11 attacks found the standards inadequate, and they were subsequently raised. DTTS and the security measures work together to provide security for AA&E shipments. DTTS is an integral part of DOD's security approach, not a standalone system.

The minimum, baseline measures that apply to all commodities at the lowest force-protection conditions (FPCONs) are laid out in DOD regulations⁸ and can be categorized according to purpose:

To Verify That Drivers and Other Employees are Trusted

1. All commercial drivers must carry adequate identification that verifies their affiliation with the carrier(s) named on the bill of lading. Drivers must also carry a driver's license, medical qualification card, and employee record card, one of which must contain the driver's photograph.
2. Drivers, escorts, operations and driver/fleet managers, dispatchers, router/load planners, and facility security officers from commercial companies must have DOD SECRET security clearances obtained through the DOD Industrial Security Program.
3. Hazmat/compliance personnel, terminal manager personnel, government sales representatives, computer programmers or technicians supporting transit operations, and any other personnel with prior knowledge of shipments may require SECRET clearances if they receive advance notification of information regarding DOD AA&E Protective Security Service (PSS) or SECRET shipments.

To Ensure the Security of the Terminal and Vehicles When They are Loaded and Unloaded

1. Carriers can use CCTV if it is approved beforehand, the TV is monitored 24/7, and personnel can immediately respond to incidents.
2. Security cages must be fabricated from commercial steel grating panels; walls, doors, floors, and ceiling must provide protection equivalent to the steel grating to preclude forced entry.
3. Signature and tally-record service are required for each person handling the

shipment; each person responsible has to sign the record at each point where the cargo is transferred.

4. Containers or vehicles utilized as AA&E conveyances must be sealed with specialized equipment, and the seals must be inspected regularly.

To Protect Trucks and Loads En Route

All AA&E shipments must have two qualified drivers in the truck and must be under constant surveillance, which consists of the following protocols:

- The vehicle must be attended at all times by a qualified representative of the carrier; the representative must be awake and either inside the vehicle cab or within 25 feet of the vehicle, with a constant, unobstructed view.
- During lengthy stops, the vehicle must be parked at a DOD-approved facility and either monitored by a qualified representative of the carrier or facility with the shipment in full view and within 25 feet or secured in an adequately lighted area surrounded by at least a 6-foot chain link fence and continuously patrolled, or placed in a security cage.
- Stops of more than four hours' duration must occur at a secure holding facility on a military installation.
- The trailer must always be connected with the power unit during shipment, except during loading and servicing, at a carrier-designated point where the driver maintains constant surveillance during disconnection, at an approved state or local secure holding location, or, in emergencies, at a DOD secure holding location.
- The tractor must be equipped with two of the following means of communication: a mobile communications unit, CB radio, or cellular telephone.
- The carrier must be able to trace a shipment in less than one hour.
- The carrier must notify the consignee by telephone if a shipment cannot reach the consignee within 24 hours of the agreed-upon delivery date.
- The carrier must provide dual drivers when the shipping distance exceeds 250 miles.

In addition, for higher-risk Category I and II shipments, certain *additional* measures have to be applied, the most important being the requirement for *two* drivers, one of which must have a SECRET clearance and the other of which must have one in progress, and the mandatory use of DOD-approved secure holding facilities (including a protected cage or a vault) for *any* stop. In addition, security escort vehicles (SEVs) are needed for the highest-risk (Category I) shipments.

At the highest FPCON (Delta), only essential shipments, which must receive prior authorization, are transported. For these shipments, the highest security measures are

required, including SEVs, two SECRET-cleared drivers, and stop-offs only at DOD-approved facilities.

Technical Components of DTTS

Current:

- *Tracks far more frequently than in normal trucking applications, using QUALCOMM satellite units*
- *Uses shipper and driver electronic messaging to compare planned to actual movement*
- *Has manifest data (mostly electronic), so load is known*
- *Evaluates alarms (about 100 in one year; mostly (1) 64 accidents, (2) some communication failures, (3) mechanical breakdowns, and a few instances of suspicious criminal behavior)*
- *Uses panic alarms*
- *Uses geofencing, but only for national security events; pushes frequency to a much higher rate*
- *Uses system in conjunction with driver and law enforcement officer (LEO) communication*

Future:

- *Experimenting with vehicle immobilization technologies (VITs)*

Characteristics of DTTS

The key technical characteristics of the system are described below.

- Electronic messages from the shipper and receiver of any covered shipment on its scheduled pickup and delivery time and point, and from the driver, provide DTTS with the truck's estimated pickup and delivery times. The driver sends different messages to the system, indicating that he is beginning to move, or that he is stopping for a rest, or that he is starting again, or that he has reached his destination. Together, these messages provide a baseline state against which the actual movement of the vehicle can be compared.
- Vehicle tracking through a transmitter located on the truck and a QUALCOMM satellite communications network provide the actual performance of the vehicle, with a normal preset communications frequency. Once the driver picks up the shipment and activates the system, the vehicle begins to emit a signal. If the driver decides to stop, he sends a message to the system, and the signal on the vehicle now indicates that the truck is stationary. When the driver starts to drive again, he sends another message, and the system sees that the vehicle is moving. At every step, the systems software that DTTS uses automatically generates an "exception report" if the vehicle is behaving differently from what the driver has messaged or if there is a loss of signal, which can happen occasionally due to technical problems. Whenever there is an exception, DTTS managers contact the company dispatch center first to determine whether they can get in touch with the driver to verify that there is no threat or dangerous situation. If that is unsuccessful, local and state police are alerted. Each exception report is evaluated before authorities decide that a critical, high-risk event is occurring.
- Each driver has the ability to press a panic alarm, which alerts DTTS that there is

a problem. In one year in which over 60,000 shipments were made, just over 100 alarms were sent. Of these, 64 involved accidents. Other alarms occurred when satellite communications died. Drivers have also issued alarms when they noted suspicious behavior (such as being followed or photographed), if there has been a mechanical breakdown, or, in very rare cases, if someone has fired on them (every occurrence of this has been an act of vandalism or shooting practice done too close to a highway). Again, in every case, company dispatch is contacted to determine the source of the problem before law enforcement is contacted.

- DTTS has the ability to geofence anything, and when it does, the frequency of transmission can be increased substantially. However, geofencing is usually instituted only where there is a national-security event—a large, high-profile event (such as the Super Bowl) or the appearance of a dignitary (such as the president)—and not to construct an assigned route. Carriers are expected to use best practices and efficiency in choosing routes.

Interviews with DOD personnel indicated that acquiring and keeping a set of drivers and other personnel with SECRET clearances was the most difficult and presumably costly operational requirement for motor carriers.

Technologies and Capabilities Not Yet Included

DTTS does not yet include biometric or other more-sophisticated access controls to the trucks. Also, vehicle immobilization technologies (VITs) are not incorporated, although discussions and experiments with VITs have been conducted. The safety risks of a hard shutdown are considered too significant to justify implementation. Softer or more-intelligent shutdowns (or, as they are called, “forcing the vehicle into a limp mode”) are also being considered and might be implemented in the future.

However, recent conversations with DOD indicate that the DTTS Project Management Office (PMO) intends to start implementing a trailer tracking system in April 2008 to take advantage of the growing commercial trends in use of tracking to find lost or stolen high-value cargo. In such systems, a transmitter with “sleep cycles” that uses increased battery power is activated by the dispatch office. It “wakes up” at frequent intervals and notes whether the trailer is untethered, whether it is stopped or moving, and whether the cargo doors are open. If any of these events take place out of the planned sequence of the trip, an exception report is generated, and the trailer will begin transmitting more frequently until the exception is resolved.

DTTS itself provides no additional ability to deal with an event involving a coerced driver or an insider hijacking if the preventive security measures do not work, and it thus relies on those measures to protect against hijackings, which are very robust.

The total cost of DTTS and the SDDC-mandated security measures could not be attained because they vary by carrier and are built into the rate structure. However, the following anecdotal and illustrative data were provided by DOD officials.⁹

- The startup cost per truck using the QUALCOMM system for DTTS truck-tracking

varies, depending on whether a communications package has already been implemented. The estimated cost of installation is between \$3,000 and \$4,000 per truck, and the operating cost per truck is between \$75 and \$110 a year. Interestingly, DOD pays QUALCOMM for three additional communication feeds to the satellite system (to increase the rate from once an hour for the normal commercial package to the required higher normal rate). Based on an estimated active fleet of 1,591 trucks, the DTTS systemwide annual cost paid directly by DOD is between \$300,000 and \$400,000.

- Assuming 60,000 shipments a year with three trailers per truck, the per-load cost of DTTS trailer tracking is estimated to be between \$180 and \$326 for the first year, then \$37 to \$48 per truck for subsequent years, with the five-year average cost being between \$67 and \$104. This cost includes all maintenance, operations, and a profit margin.
- Carriers charge DOD \$1.00 to \$2.00 for CIS service, between \$1.00 and \$3.20 a mile for SEVs, and between \$1.00 and \$2.50 per mile for an extra driver.

Illustrative DTTS Costs

Truck tracking

- *Start-up costs: \$3,000 to \$4,000 per truck*
- *Annual operating costs: \$75 to \$110 a year*
- *Fleetwide annual DOD costs for 15-minute communication cycle: \$300,000 to \$400,000*

Trailer tracking

- *Average 5-year annual cost: \$67 to \$104 per truck*
- *Assumes 60,000 shipments and 3 trailers per truck*
- *Covers all costs plus profit margin*

Other security measures

- *Constant surveillance: \$1.00 to \$2.00 per mile*
- *Extra driver: \$1.00 to \$2.50 per mile*
- *Escort service: \$1.00 to \$3.20 per mile*

Lessons from DTTS

Several interesting observations can be gained from DOD's experience with DTTS.

First, DTTS was created because of two accidents which, while they did not cause major loss of life (compared to the potential loss they could have caused), created significant economic harm and revealed problems in security and emergency response. Also, subsequent improvements in DTTS were prompted by outside GAO reviews. The GAO reviews found motor-carrier terminal security for very sensitive materials to be inadequate, and DOD has taken measures to ensure carrier terminals meet stringent security standards before being approved by DOD for use.

Second, despite the sensitivity of the cargo carried under DTTS, a government threat analysis determined that no general or specific credible threat of hijacking and misuse of these DOD materials existed.

Third, vehicle tracking is not cheap. Costs for a smaller, discrete fleet that are reimbursed

have little relevance for a large tanker fleet.

Fourth, technology innovation has been gradual. Biometric controls have not yet been implemented, trailer tracking is being implemented, and intelligent VIT is being considered.

Fifth, there is limited use of geofencing, although DTTS is capable of implementing it anywhere. This suggests that DOD's assessment of security risks is low or its confidence in its security measures is high.

Sixth, vehicle tracking is used only in conjunction with stringent security measures and regular and mandatory electronic messages sent from drivers. Also, any exception alert is checked out with the company dispatch center before it is communicated to responders or law enforcement. This is important, because if the agency most experienced in vehicle tracking will not use it as a standalone defensive measure, neither should a state or other federal agencies.

Seventh, DOD relies on the requirement for drivers and certain other employees to have SECRET clearances and other internal measures to guard against insider attacks or drivers who have been coerced, not vehicle tracking itself.

Finally, DOD officials indicated that while TSA is aware of DOD experience, they may not make full utilization of DOD's experience in DTTS. According to one official, "We've been doing this for 20 years and it seems TSA wants to learn the same lessons over again." Any implementing authority might want to actively engage DOD as well as TSA, to determine lessons learned.

DTTS: Key Observations

- *Little or no risk of attack is assessed.*
- *System was created after an accident, improved in response to criticism.*
- *Expensive DOD security measures are applied to a reimbursed small fleet and may not applicable to a large tanker fleet.*
- *Geofencing and route restrictions are seldom used.*
- *Technology innovation has been gradual.*
- *DTTS operates as part of a set of strong security measures.*
- *DTTS data are not the only type of information used to evaluate alarms and respond to true emergencies.*
- *It is unclear whether TSA has taken full advantage of DOD experience.*

Federal Motor Carrier Safety Administration Pilots

Particularly since the 9/11 terrorist attacks on New York and Washington, there has been considerable interest in creating a vehicle tracking system for certain hazardous materials railroad and highway carriers. To its credit, FMCSA seems to have taken the lead in studying the feasibility and benefits of applying vehicle tracking and associated technologies to increase security and safety for hazardous materials highway shipments and efficiency for motor carrier fleets in general. FMCSA conducted four related but separate tests of vehicle

tracking and related technologies that can improve security, safety, and efficiency. These pilots were:

1. The Hazardous Materials Safety and Security Field Operational Test (FOT)

Initiated by DOT in 2002, this comprehensive evaluation was designed to quantify the costs and benefits of an operational concept that applied technology and improved enforcement procedures to highway hazardous materials transportation and included a six-month field test of various technologies, including vehicle and load (trailer) tracking using satellite and other wireless systems; driver verification using password logins, fingerprint biometrics, and smart cards; geofencing; cargo tampering alerts, using electronic seals; and panic buttons and remote vehicle disabling. Because this study included an analysis of terrorist attacks and threats, touched in some way on all of the technologies that could increase security for gasoline tankers, and is the only report specifically mentioned in the legislation mandating the TSA pilot project, it is discussed extensively in this report.¹⁰

2. Untethered Trailer Tracking (UTT) and Control System Pilot Test

Even as the FOT evaluation began, FMCSA received a congressional earmark on October 7, 2002, to develop and field test a UTT system for high-value or high-security-risk loads, such as explosives. Congress determined that the requirements to be tested include real-time trailer identification, location, geofencing, unscheduled movement notification, door sensors, and alarms.¹¹ The three-month pilot test conducted between October 2004 and January 2005 involved several vendors and carriers and used three different scenarios (each involving 25 trailers). One of them involved standard dry van deliveries, another involved high-value retail clothing and electronics, and the third involved regional truckload deliveries of explosives. A final report was issued in December 2005.¹²

The report indicates that the UTT system functioned with relatively few technical problems, utilizing different combinations of data transmitted by satellite to the carrier on whether or not a trailer door was opened, whether or not it was loaded with cargo, and its location in relation to a geofenced perimeter, all aimed at notifying the carrier when there was an unauthorized movement or opening of the trailer. It concluded that UTT offered security benefits through the increased real-time knowledge about the movement and condition of untethered trailers carrying hazardous materials that could be stolen, tampered with, or delivered illicitly to a target. It also cautioned that technology must be applied together with other security measures and not as standalone systems.

The report also concluded that UTT provided economic gains through reduction in the theft of cargo—particularly high-value cargo—and, perhaps even more important, significant efficiency gains by reducing the time spent locating misplaced trailers or trailers not ready for loading.

Because it is apparently difficult to untether a fully loaded tanker trailer safely, MTI will not examine further the implications of this study during this phase of its work. UTT systems may well, however, be examined in greater depth if MTI considers other high-risk hazmat that can be stolen by untethering a trailer.

3. Expanded Satellite-Based Mobile Communications Tracking System Pilot Test

On November 25, 2003, Congress earmarked \$2 million of FMCSA's FY04 appropriations¹³ to test an effective, wireless, satellite-based communications tracking system to monitor hazardous materials and high-value cargo in areas where satellite coverage is unreliable or nonexistent. The areas tested were in Alaska and Hawaii. Three technologies were tested: UTT, panic buttons, and an expanded satellite-based mobile communications tracking (ESCT) system. The tests involved four carriers with a total of 62 tractors and 58 trailers in Alaska, and one carrier and five trucks in Hawaii. Critical areas were defined where technology-based tracking was not available, and a test was then conducted to demonstrate functionality of ESCT and the other technologies in these areas. The test showed both improved coverage and that the three technologies increased security, safety, and efficiency. According to FMCSA, the primary value of this project was an improvement in communications for tracking hazardous materials in Alaska. A final report was issued in June 2007.¹⁴

MTI's analysis of attacks involving gasoline tankers suggests that they are most likely to be used to create casualties in areas where population densities are high, and when they are acquired and used close to those population areas. Moreover, some states presumably have few areas where satellite coverage gaps are as large as they are in Alaska. We therefore note that an ESCT may be needed as an adjunct but have not focused on it in this report.

4. Vehicle Disabling Technology Study

On November 19, 2004, Congress again earmarked \$250,000 out of FMCSA's programs and directed that the testing done during the FOT continue with a specific focus on vehicle disabling and shutdown technologies.¹⁵ A primary goal of the project is to develop best practices for using these technologies, gathered through information from vendors, stakeholders, and field demonstrations. Another primary component will be development of a concept of operations covering state law-enforcement interaction with carriers that utilize vehicle disabling technologies.

Because vehicle disabling initiated locally and remotely is such an important potential strategy to mitigate risks, and because the technology is specifically mentioned in the congressional guidance for the TSA pilot project, MTI has treated it in considerable detail in this report. (At the time of publication, MTI used extensive interviews with FMCSA staff and briefing charts. FMCSA has just issued a full report, providing this information in detail.¹⁶)

FMCSA and the Field Operations Test

What became known as the FOT of a vehicle and trailer tracking system was conducted in 2003–2004.¹⁷ The test was focused on four segments of the hazardous materials industry: (1) bulk petroleum (particularly gasoline), (2) bulk chemicals, (3) less-than-truckload (LTL) shipments of various commodities, and (4) explosives. The attack scenarios included theft, interception/diversion (e.g., hijacking), and legal exploitation (the purchase and subsequent misuse of a vehicle). FMCSA tested a total of 25 vehicles for each scenario and tried out a combination of commercial off-the-shelf (COTS) technologies to determine

their effectiveness in stopping an attack. It estimated the benefits in this priority order: security, operational efficiency, and safety. It then estimated the cost of implementation and estimated the overall benefit-cost ratio to determine whether industry deployment might take place without government intervention or support. The study was carefully done and independently evaluated.

As a critical part of this effort, FMCSA also commissioned Battelle to evaluate hazardous materials to determine which posed the greatest risks from a security and safety standpoint. This evaluation, which is classified as Sensitive Security Information, has been analyzed by MTI staff, and those analyses have helped to inform and shape the attack scenarios presented in MTI Report 09-03, *Potential Terrorist Uses of Highway-Borne Hazardous Materials*, in the chapter titled “Analysis of the Threat and Potential Attacks.”

Some of the most important findings from the unclassified executive summary of the Battelle report, which may be of particular significance to any state or other authority are discussed below.

Technology Performance. With the exception of biometric login and E-seals—which must be redesigned to be more user-friendly for the ordinary driver—all technologies performed well. Most notable among these were:

- Wireless, satellite-based communications with GPS tracking
- Driver panic buttons
- On-command and automatic vehicle disabling (the latter created through an onboard computer that could be configured to prompt a vehicle shutdown if the vehicle was tampered with)
- Trailer tracking (to prevent a trailer from being disconnected from the tractor and stolen)
- Geofencing of certain locations to cause an automatic alert (and potential disabling) of vehicles approaching too closely

FMCSA reports that some of these features, such as vehicle disabling, have been improved significantly since the test to make them safer and more reliable, while experience with others, such as panic buttons, has increased.

Security Benefits. While the technology performed well, the test revealed that when all security threats were considered, “technology, alone, at best could address approximately one third of the potential hazmat-based vulnerabilities.” The greatest benefits were attained when a panic alert system, remote disabling, and satellite tracking were combined. The cost-benefit calculation of this combination for bulk fuel vehicles equipped with wireless communication was significant (2.6:1), but only when “worst-case attack consequences” were considered. These events are specified in the SSI-protected report; however, FMCSA staff indicated that gasoline tanker accidents were not included in these scenarios. It may be that except when high-consequence materials are involved, safety and efficiency benefits will have to be paramount in any decision to implement a vehicle tracking system as cost beneficial—such as for gasoline tankers—with important security benefits following.

FMCSA found that partial implementation does not yield directly proportional security benefits:

It should be noted that partial deployment might not necessarily result in a directly proportional security benefit. In other words, 50% deployment may not yield 50% of the achievable security benefits. This may occur because while the technology-equipped fleet may not be attacked, a non-equipped fleet would possibly be targeted instead. The deterrent effect of the technologies, if partly deployed, could simply shift terrorist targeting from one fleet to another, with no net change in overall security. Under this assumption then, full deployment is required to achieve the security results.¹⁸

Safety Benefits. The test showed that the ability to monitor driver performance and to intervene when an unsafe pattern is detected, along with the potential of increasing emergency response, increased safety significantly. In addition, FMCSA estimated a total annual industry-wide savings of \$5 million a year for the hazardous materials covered by its pilot study.¹⁹

Efficiency Benefits. The test showed that productivity gains could be achieved if a wireless/GPS (i.e., satellite-based) system were used. The ability to track the time spent by drivers on the road, to find untethered trailers easily, and to save labor and fuel costs produced such significant benefits that the investment required to equip the fleet could be recouped in one year or less across the various implementation scenarios. Approximately \$1 billion per year of net benefits would be gained thereafter across the industry. Driver productivity would increase 11% for bulk fuel carriers, and average savings would be \$5,000 per year per truck for bulk carriers.

Public Sector Reporting Center Concept. The test included consideration of a consolidated public sector reporting center (PSRC). It found that if procedural issues are not carefully resolved, such a center could be counterproductive. MTI's own independent evaluation of what is needed to maintain and enhance, and not degrade, emergency response coincides with the following conclusion:

As a proof of concept, the PSRC demonstrates the ability to fuse and disseminate critical HAZMAT information in a timely manner to enhance enforcement response to security events. In expanding the PSRC concept to a full deployment scenario, significant institutional/procedural issues will have to be addressed. Among the more important of these are the administration of information and the notification process, i.e., ensuring that shipment information, alert notification levels (triggers) and key persons to be notified are current and complete. If not, the effectiveness of the system may be significantly eroded by alerts being directed to personnel and agencies that may not be involved in responding to given events or that appropriate persons/agencies may not be alerted when actually warranted, or that information provided is lacking or inaccurate. In either case, confidence in the PSRC and the ability to readily use alert and shipment background information provided via the PSRC is at stake. Addressing this will require coordination, continuity and uniformity of process among shippers/consignees, HAZMAT motor carriers, and the enforcement/emergency response communities.²⁰

FMCSA completed its test, evaluated overall benefits and costs, and concluded that despite the benefits of implementing new technologies—particularly of wireless and GPS tracking—

to individual firms and the industry, “market forces are unlikely to support strong adoption of the technologies, at least in the foreseeable future,” suggesting that government financial support or regulation is needed if a vehicle tracking system is to be implemented.

2003–2004 FMCSA Field Operational Test

- *COTS technology, including panic buttons, vehicle disabling, and satellite-based tracking, works well, with few exceptions.*
- *Technological solutions show promise but, alone, “at best, could only address approximately one-third of the potential HAZMAT-based vulnerabilities.” However, improved security measures that include technology could significantly reduce vulnerabilities.*
- *Security requirements necessitate equipping 100% of the targeted fleet.*
- *Safety benefits are significant.*
- *Efficiency benefits are significant, suggesting a \$1 billion net return on investment annually.*
- *A public sector reporting center requires all procedural and operational issues to be worked out carefully. Otherwise, security and safety benefits can be lost.*
- *Cost of implementation may necessitate government support or regulation.*

FMCSA’s Follow-On Work on Vehicle Immobilization Technologies

The FMCSA report covered all aspects of vehicle tracking and was instrumental in shaping government and TSA thinking. FMCSA went on to perform an in-depth review and demonstration of VITs, with Oak Ridge National Laboratories as the prime contractor. A public report is forthcoming. MTI received an advance copy of the FMCSA briefing charts and also interviewed FMCSA staff on November 26, 2007.

Vehicle immobilization is a crucial technological innovation. The ability to safely and swiftly disable a truck carrying hazardous materials can offer significant security benefits in at least three basic scenarios:

1. A truck can be equipped so that it cannot be started without evidence that the driver is authorized, e.g., by the driver using a swipe or magnetic card, a PIN, or a biometric device.
2. A driver who observes a vehicle that has been stolen or hijacked can activate the VIT capability within sight of the vehicle by pushing a panic button on a key fob. The same method could be used by a company employee or police officer who is monitoring or following the truck, if they were given the coded key fob for that vehicle.
3. If the vehicle tracking signal is lost or the signal indicates that the truck is moving away from an assigned route or approaching a geofenced area, a company or public center can be notified and can decide, after some verification, that the vehicle should be immobilized. This can be done remotely.

The immobilization command can be accomplished in one of two ways. First, it can activate

a “hard” shutdown, causing an immediate loss of power. However, in the wrong traffic and road environment, a hard shutdown could have significant safety ramifications. Second, more-sophisticated but proven technology can be used to gradually impair the engine’s performance so that the vehicle is slowly brought to a halt.

FMCSA conducted workshops, web teleconferences, and meetings with stakeholders in spring 2007, and actual demonstration tests were performed at Laurens Proving Ground in South Carolina. The objective was to document best practices on the use of VITs in commercial vehicle operations, to develop a concept of operations on how VITs should be used by law enforcement, and to focus on driver authentication as a first line of defense. The initial briefing and a preliminary final briefing were given in advance to MTI. FMCSA has since issued its final public report on November 2007.²¹

FMCSA started with five functional requirements (FRs), which it “binned” into the three basic scenarios mentioned above.

In the first functional requirement (FR1), FMCSA examined technologies that can disable a vehicle if an unauthorized driver attempts to operate it. FMCSA and industry view this as a first line of defense, and the use of driver authentication technologies is considered key. Such technologies can include login devices (similar to the login required to start a computer), proximity and swipe cards, and biometric readers. Login techniques, proximity cards, and wide cards were found easy to use and relatively inexpensive. Biometric techniques tended to be invasive and more expensive. All of these technologies can be combined with fail-safe activation, in which failure to input the correct sequence or code could automatically kill the engine or keep it from starting.

The benefits of such technologies are obvious for the industry: They can prevent simple theft which, for high-value cargo, can cause significant loss. Also, they can prevent hijacking by certain insiders with limited knowledge, or by intruders. However, each countermeasure only raises the bar of operational planning.

In FR3, FMCSA examined remote shutdown that could be activated by a driver using a panic button. This feature worked well. It could prevent or stop simple theft or poorly planned hijackings—ones in which the hijacker, unaware of this disabling technology, leaves the driver free to disable the vehicle, especially if he can covertly enter a distress code. In addition, and although not specifically addressed by FMCSA, the same capability could be provided to any official who can approach the vehicle—as long as he or she could recover the key fob from the driver—and it is certainly less dangerous than shooting out the tires or firing into the engine block.

In FR2, FR4, and FR5, FMCSA examined a remote shutdown of the vehicle in the following three situations:

- In FR2, the loss of signal—which could presumably be caused by an intentional disabling of the satellite tracking system—generates an automatic shutdown. However, while some vendors are offering this capability, there is little interest in procuring it yet.
- In FR4, the company dispatcher, upon receiving some indication of a problem—a

call from the driver, an observation from another party, the vehicle traveling off route, or violation of a geofence restriction—immobilizes the vehicle.

- In FR5, law enforcement is alerted that there is a potential security problem, such as a hijacking, and asks for immobilization to be ordered by a company dispatch operation or a PSRC. The demonstration showed that for legal and liability reasons, law enforcement strongly prefers to provide information to the dispatch center about the vehicle so that a shutdown can be executed and is extremely reluctant to initiate or order the shutdown itself.

A key part of FMCSA's final product is a set of best practices²² for government and industry to consider:

- Degrading a truck's performance is safer than a complete shutdown. Safety is further enhanced if the system is able to sense the roadway environment of the truck—whether it is on a curve, the slope of the road at the moment, and whether it is in traffic. Generally, slow degradation is considered to effectively achieve the security objective and minimize inadvertent creation of safety issues. However, companies and vendors expressed differing views on “hard” shut-downs, some wanting to avoid them at all costs and others indicating they would use them quickly and on command.
- It is important to provide disabling techniques that can protect the driver and allow him or her to activate an alarm in a way that is both effective and not detectable by a hijacker.
- It is always best to have “eyes on” the vehicle that is to be disabled. If a hijacked or suspicious vehicle is identified far enough away from the target, law enforcement aerial or ground surveillance can help determine when and how to activate the command and immobilize the vehicle safely. Conversely, low-earth-orbit surveillance may be able to determine that the signal is inadvertent and avoid wasting valuable security resources. FMCSA has recommended that in conjunction with such surveillance, flashing tail lights or some technique that clearly identifies the vehicle should be instituted to make it easier to acquire visually. If time allows, some kind of visual contact with the vehicle is needed to ensure that alerts are genuine and that the response is safe.
- It is important for the entire system to have high security to eliminate the possibility of spoofing and also to reduce the possibility of false alarms and inadvertent deactivations. High security requires redundancy in both communications and backup power.
- It is important to ensure that public, vendor, or carrier centers that can initiate disabling commands are clear on which alarms gain the most attention so that false alarms can be reduced, the speed of response to true positive alarms can be increased, and accurate information can be provided to law enforcement and first responders.

FMCSA and Oak Ridge National Laboratory officials also revealed the following

insights:²³

- The rate of commercial, voluntary deployment of driver-authentication and vehicle-tracking technologies is much higher than was anticipated. This is due to (a) the economic benefits of avoided theft of high-value shipments; (b) the increased efficiency that vehicle tracking can bring for fleet management in general; (c) the increased safety afforded drivers; and (d) insurance-company practices that examine each trucking company's posture regarding best practices and, in general, relatively low costs. The rate of commercial adaptation of vehicle immobilization, on the other hand, is moving less swiftly, and this may, in fact, require governmental encouragement, guidance, or mandate.
- It is also possible that government-mandated systems could actually slow down the rate of commercial deployment if shippers and insurers begin to look to a government system as the de facto "best practice." (Carriers participating in DOD's DTTS are considered a unique, smaller, and specialized market.)
- No aspect of the technologies—including satellite communications, technical standards and protocols to interface with existing systems, panic alerts and buttons, and even remote vehicle immobilization—poses an insurmountable challenge. Many of these technologies are at or close to COTS status.
- Cost is driven primarily by whether or not a communications system has already been put in place. If it has been, the added cost of initial installation can be as low as \$500 per truck, with additional per-truck costs as low as \$5.²⁴ However, costs increase dramatically with the rate of communications reporting. The standard commercial rate is once every hour; the DOD rate is much higher. In a defensive situation involving geofencing of certain key targets (see below), the rate might have to be even higher in order to organize a response before critical damage is done.
- Cost is also a function of the kind of hazmat motor carrier segment being tracked. Some high-consequence hazmat shippers—both large and small—are security conscious already and have invested heavily in security procedures and technology. In some industries, however, such as combustible gases (propane) and flammable liquids (gasoline), investments may be small. On the other hand, these industries are consolidating, and larger firms may well be able to foot the bill, while the number of smaller firms decreases each year. Although it is not economically desirable, this certainly poses security advantages.
- Regarding the claim that tracking trucks or tractors rather than loads or trailers is the wrong approach, FMCSA indicated that it is highly unusual, and often unsafe, for some hazmat loads to be disconnected from tractors. Specifically, disconnecting a full tank trailer from the tractor would likely cause the front mounts to collapse. The photograph below, taken in November of 2007, vividly illustrates the point: The tank trailer overturned when this maneuver was attempted.
- Although it is possible that terrorists could simply engineer their way around tracked trucks by connecting loads to untracked trucks, in practical terms, this may be difficult, if not impossible, to do, particularly for flammable liquids.

Nevertheless, a disconnect alert—such as was tested in the FOT—could be a good adjunct system, and it would be powered by the unit on the truck.



Figure 1 Overturned Tank Trailer—November 2007

Geofencing, Vehicle Tracking, and Vehicle-Immobilization Technologies

Because it is almost certain that relatively few targets will be considered critical enough to be protected, the combination of geofencing, vehicle tracking, and vehicle immobilization is important to consider as a risk-mitigation strategy.

Technically, such a solution is possible; tracking, geofencing, and immobilization have all been tested. Geofencing, defined in concentric rings from a target, also allows for a graduated response to a vehicle that can pose a threat. The further out from the target the vehicle is, the more time the company or PSRC has to determine if an exception alert is a false alarm or, if it is a true alarm, to shut the vehicle down safely.

However, there are important related operational and cost issues:

- The rate of communication has to be high and reliable; the commercial rate of once an hour will not suffice. A higher communication rate increases the cost per carrier. Also, the most reliable method of ensuring frequent communication appears to be equipping each truck cab with a transmitter that can alternate between ground and satellite receivers as needed. This is also expensive. The bottom line is that more-frequent tracking, combined with the need to equip all trucks in a fleet, increases costs.

- An alarm, and possibly even deactivation, is required in the event of loss of signal. Since cutting a cable can make a hijacked vehicle “blind” to the control center, vehicles must become disabled or at least send an alert if signal is lost. This results in yet more costs and operational issues.

Vehicle Immobilization Technology (VIT)

- *Public report has been issued; MTI was briefed in advance.*
- *VIT works in three scenarios:*
 - *Start is attempted by an unauthorized driver*
 - *Driver sees hijacked vehicle and uses panic alarm*
 - *Tracking center issues shutdown after evaluating:*
 - *Loss of signal*
 - *Call from company dispatch, contacted by driver or observer*
 - *Movement outside of planned route or into geofenced area.*
- *Two types of remote shutdowns:*
 - *Hard kill of engine (hard shutdown)*
 - *Speed is reduced, then engine is shut down (soft shutdown).*
- *No significant technical hurdles*
 - *Vehicle tracking and driver authentication are progressing rapidly*
 - *Panic alarms are reliable*
 - *Trailer tracking is progressing to achieve efficiency and avoid high-value theft (not needed for tankers)*
 - *Much progress has been made in VIT but implementation is slow*
 - *No vendor is offering VIT for loss of signal.*
- *Cost is driven by whether communication system already exists and also by rate of communication.*
- *Best practices*
 - *Soft shutdown is safer: intelligent systems consider speed, road, traffic*
 - *Keep “eyes on vehicle”:* *helped by distinguishing it with flashing red lights*
 - *Protect the driver with soft shutdowns and secret alarms*
 - *100% tracking requires redundancy in communications and power*
 - *High security is needed to prevent spoofing*
 - *Practice procedures to distinguish false from true alarms.*

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- The geographic area in which the tracking infrastructure exists has to be relatively devoid of the type of traffic being monitored. For liquid flammables, that means complete rerouting away from the target, so that vehicles that are “off route” are automatically noticed. For example, if there are gas stations near the target, how would the legal movements of gasoline trucks be differentiated from illegitimate movements in time to react? Geofencing essentially requires a complete prohibition of a particular hazmat from being anywhere near the target.
 - The safety issues involved in implementing automatic, unmonitored vehicle disabling as a last resort are significant. It is one thing to disable a vehicle while law enforcement monitors it; it is another to do it blindly—although this is still better than allowing a suspicious shipment to come close to a target.

The TSA Pilot Project

TSA has initiated a hazmat truck security pilot program, which Congress mandated and provided \$11.5 million for in DHS's FY07 appropriations legislation. The pilot is designed to test a vehicle tracking system that can operate in all 50 states; provides alerts against theft, hijacking, and other security threats; and, perhaps most important, uses a central tracking center, which would be managed by TSA and would be designed primarily to ensure a national response to a national-security incident.

According to briefings given by TSA on October 14, 2007, and November 15, 2007, in Seattle and Washington, D.C., respectively, the system focuses on high-consequence hazmats such as TIH and PIH materials, truckload explosives, and certain substances controlled by the Centers for Disease Control and Prevention (CDC). It is also designed to be used primarily in high-threat situations. Field tests involving 10 carriers, seven vendors, and 128 trucks and regional public safety centers in New York, North Carolina, and Washington, D.C., will be concluded in December 2007; interim and final reports will be issued in spring 2008; and follow-on work will continue for three years (see details below). TSA has repeatedly emphasized its preference for voluntary implementation and that voluntary implementation was intended by Congress.

The primary policy aim of the TSA pilot project is to develop a truck-tracking center (TTC) that will allow TSA to prevent attacks involving high-consequence hazmat that could cause mass casualties—essentially, to prevent another 9/11-type attack in which weaponized, high-consequence hazmat would be carried by truck. As TSA's own briefing slides indicate, "The HAZMAT Truck Tracking Pilot is a congressionally mandated pilot project to design and build a centralized truck tracking center capability" in which "the desired outcome is to provide TSA with a tested and established truck tracking center capability that will allow TSA to 'continually' track truck locations and hazmat load types in all 50 states and to receive exception based events."

Highlights of Section 1554, “Motor Carrier Security-Sensitive Materials Tracking” of the 9/11 Legislation

- *Not later than six months after enactment, the Secretary of DHS—consistent with TSA’s current truck-security pilot—“shall develop a program to facilitate the tracking of motor carrier shipments of security-sensitive materials and to equip vehicles used in such shipments and technology” that provides:*
 - (a) Frequent or continuous communications*
 - (b) Vehicle position location and tracking capabilities*
 - (c) A feature that allows a driver of such vehicles to broadcast an emergency distress signal.*
- *The Secretary is further mandated to (a) consult with the DOT Secretary to coordinate the program with any ongoing or planned efforts for motor carrier or security-sensitive materials at DOT; (b) take into consideration the FMSCA FOT report; (c) evaluate any new information and technologies not included in that test; and (d) consider the range of contact intervals, the use of automated disabling features, and the cost, benefits, and practicality of such an effort.*
- *The bill authorized \$7 million for FY08, FY09, and FY010, allowing \$3 million each year to be used for equipment.*
- *The law requires a report within one year to the appropriate committees and requires the Secretary of DHS to seek additional authority before mandating such a system.*

It is important to read carefully the law regarding the scope and implementation of the pilot:

- The system must include the following high-consequence hazmat: Poison Inhalation Hazards (PIH) materials, TIH materials, truckload explosives, and certain commodities designated by CDC. The Secretary of DHS can add other materials to this list by rulemaking.
- The system is to provide (a) tracking of vehicles that is “frequent and continuous” and therefore requires satellite or a combination of satellite and terrestrial systems, (b) precise positioning of each vehicle, and (c) the ability of the driver to issue a panic alert (“an emergency distress signal”). TSA must study past and ongoing work (and specifically FMCSA’s work). TSA must also consider the advantages and costs of two key technological advances, *but it does not mandate their implementation*: (1) increased “contact intervals” or reporting rates (such as those that would be required to work with a geofencing solution), and (2) “automatic disabling features,” e.g., VIT.
- The law mandates only that the DHS Secretary “develop” a given system that includes certain commodities and certain technologies; the Secretary must also make use of certain past and ongoing studies and coordinate with the Secretary of Transportation; the addition of new commodities and certain new features, particularly those using VIT, must be considered. Finally, the DHS Secretary must return to Congress to seek authorization before issuing a rule that would mandate the use of the system. It is therefore fair to say that Congress wants DHS to prepare such a system for implementation, that it has set minimum requirements

for that system, *and that it has neither declared that any implementation will be voluntary nor declared that there will be mandatory implementation*. It has only mandated that DHS consult with Congress and seek authority *before* it mandates implementation of the system.

These facts are important because TSA has made statements (and has interpreted the law) for the industry in certain ways that allow MTI to offer some observations about the future direction of this pilot project.

A Focus on High-Consequence Hazmat in High-Threat Situations. TSA has emphasized that the focus of the pilot project is high-consequence hazardous materials (defined by the law as “security sensitive” materials and by TSA’s action lists as Tier 1 highway security-sensitive hazardous materials [HSSM Tier 1]) such as TIH and PIH materials, truckload explosives, and certain CDC-controlled materials. At no time was it suggested that commodities assessed as having the potential to produce fewer maximum casualties be included. In fact, the emphasis in the study of “consequences” was primarily on casualties.

Voluntary Implementation as an Insurance Policy. While the law neither mandates implementation nor mandates that implementation be voluntary, at both briefings TSA stated that Congress had mandated voluntary implementation. More important, however, is the way TSA is positioning the pilot study and portraying the advantages of implementation to industry. Clearly, TSA has positioned it as a medium-term (three-year) rather than a short-term (one-year) project, one that seeks additional motor carrier participation and in which industry participation brings not only commercial efficiency benefits for many motor carriers—although not for all, particularly for those with very small fleets—but more important, provides insurance against sudden, emergency actions by the government in the event of an attack that involves hazmat, or should a threat assessment suggest that such attacks are imminent. TSA briefers made the point that it would be far better for Congress to mandate the implementation of a system that is tried and tested and has a high rate of voluntary participation by industry than to mandate implementation of a system that has not been properly tested. The bottom line is that TSA suggested to the industry that it should help prepare and embrace a system that works and can be implemented profitably before one that might not work as well, and is thrust upon it.

Partial Implementation. TSA briefers also suggested that partial implementation had significant security benefits and used the Federal Air Marshal (FAM) program as an example. The theory proffered was that just as aircraft hijackers did not know which flights FAMs were on and therefore had to assume they were on every flight, truck hijackers would have to assume all vehicles in certain fleets had vehicle-tracking and panic-button capability, even if only part of the fleet were actually equipped.

There are serious problems with this rationale. First, it is far easier to restrict knowledge of which flights FAMS are on than to restrict knowledge of which vehicles are equipped with vehicle tracking. The number of staff who need to know about FAM access is infinitely smaller than the number who would need to know which trucks are equipped and which are not. Second, control of FAM-related information is more centralized. Third, the operational security measures that are applied to provide deterrent value for flights without FAMS are far less complex and expensive than those that would have to be applied to the many

people running, driving, and equipping entire commodity fleets. Finally, unless vehicle-tracking antennas are completely obscured, it is likely that the equipment itself will be observable. No equipment that is so observable is used in the FAM program.

During the formal briefing, the MTI staff asked the TSA briefer to clarify his earlier statement, and much of what was suggested was retracted, although TSA still maintained that some security value is provided by partial implementation.

The operational security needed to prevent hijackers from eliminating all the security value of the system by hijacking a truck that isn't equipped is not feasible. Therefore, security benefits can be assumed to exist only when there is 100% fleet implementation, which requires mandatory, not voluntary, implementation.

Past and Future Schedule and Budget. TSA's work on vehicle tracking is considered to have started with operational concept studies funded by congressional mandate in its FY03–FY06 appropriations legislation. These studies constituted Phase I. Phase II was associated with Section 1554 of the 9/11 act and commenced in October 2005. Using seven vendors and ten carriers, it began operating in June 2006 and became fully operational in September 2007. Phase II concluded its operational tests in December 2007. A final technical report was issued May 15, 2008.

Future phases will involve additional volunteers and tests that are not yet outlined. TSA has secured a \$7 annual budget from Congress, of which \$3 million is to be used, in part, to purchase equipment to outfit a portion of a fleet that a motor-carrier volunteers for inclusion in the pilot. (For example, if ten trucks were volunteered, TSA would pay to equip five of them.) This represents an opportunity to participate in the continued demonstration of the pilot project.

Public Benefits and Costs. Security benefits were cast almost completely in terms of avoiding attacks on trucks carrying high-consequence materials. The benefits are assumed to be the value of lives saved and property and economic savings ranging from \$1.6 billion for a small event to \$40.4 billion for a large one. The assumption was that if there is even a 7% chance of a small attack being avoided for three years, the system pays for itself.

Industry Benefits and Costs. For the *high-consequence hazmat-industry fleets* considered, installation costs varied considerably, depending on whether or not the carrier already had a tracking system in place; the installation costs for those that had systems were minimal, and the costs for those that did not have them would be significant. Installation time varied from one person working full time for three weeks to one person working full time for four weeks. The monthly operating cost was \$136 per truck; however, the estimated monthly per-truck efficiency gain was \$206. This created an efficiency-cost ratio of 1.5:1, enabling the system to pay for itself through increased efficiency within 18 months, although motor carriers with very small fleets are unlikely to realize this increased efficiency. However, mandating an increased communication frequency, from once every hour (the apparent industry standard) to, for example, the higher rate used by DTTS would significantly increase the operating cost. Experience with DTTS supports this observation.

Attack Scenarios. It is not clear that TSA has stressed the system with difficult attack scenarios. The scenario described in the briefing was a simple hijacking attempt in which

the vehicle was taken and the driver was removed (safely) from the cab. The driver was then free to alert the system through use of a panic button. In the briefings, TSA did not treat scenarios that involved insiders or attackers with or without insider information who coerced drivers.

Utilization of Existing Systems. The pilot system would allow current vehicle tracking systems to interface with the central system at a vendor cost of \$15,000 to \$20,000 for each interface, using XML protocol and standards approved by the Institute of Electrical and Electronic Engineers (IEEE). One of the pilot project's three main components is a "universal communications interface" that works with existing systems. According to MTI's review, this appears to be an accurate claim.

Operation of the Truck Tracking Center. How the TSA manages the TTC and how it would respond to an alert are important. Coordination between the TTC watch officer and TSA intelligence would be affected if an exception report was received; the TTC would then contact the company dispatch center to see if there might be an explanation for the exception report. If the exception could not be explained and was considered a high-risk event, local law enforcement would be engaged. Each component would see the same core, common data needed, but proprietary and other sensitive information would be shown only to the company involved and government employees, respectively. If the hazmat shipment was confirmed to be high risk, a local and federal security response could be taken to halt and examine the vehicle in question or, presumably, other similar vehicles.

TSA emphasized two features of TTC operations: (1) a risk-based analysis that would include data from all sources—including data on the load and the position of the vehicle, intelligence information, etc.—to determine the risk level of the shipment, and (2) the ability to reach out quickly to the company and others to see if a reported high-risk exception could be explained, so that precious resources would not be wasted responding to false alarms. The TTC utilizes a "risk-based approach" to highlight high-risk events and minimize false alarms and considers verification of risk factors with carriers to be an important operational element in improving system capabilities. Like DTTS, TSA's system involves verification of exception reports with carriers before an alarm is issued that activates state and local law enforcement and emergency responders.

Geofencing and Vehicle Disabling. Although the pilot did not include vehicle immobilization technology (VIT), this is clearly a next step that is contemplated as an efficient way of stopping a coordinated "9/11 attack on the ground." It would combine the use of geofencing—which was being considered during Phase II of TSA's pilot study—and VIT, which is not. Geofencing for high-consequence hazmat focuses on high-threat urban areas (HTUAs)—specifically, 48 such areas, including the national capitol region. Some of these were presumably involved in actual tests of geofencing. VIT will presumably be included in later phases, and it is to be hoped that the work on this technology performed by FMCSA (as well as any performed by DOD) will be incorporated.

System Performance and Other Issues. While the pilot system tracked vehicles well, certain technical "glitches" need to be resolved, as well as some larger issues, including the following:

- *System performance and improperly resolved alerts.* Of the 39 (relatively simple) test events staged with six carriers, only 30 were properly identified and responded to. That represents a failure rate of around 25%. In addition, TSA indicated that response-time and system-security issues also needed to be resolved.
- *Lack of manifest information.* While DTTS requires an electronic upload of manifest information from the shipper, the TSA pilot system did not. Having details on the cargo being transported provided instantly to the TTC and other authorities is critical for risk analysis and timely response.
- *Difficulty in providing first responders.* Two table-top exercises performed with simulated or live truck-tracking data illustrated that there are problems in providing first responders. First, insufficient first-responder “bandwidth” is available. Second, there is a need for “alignment with current procedures.” Third, more manifest information is needed, along with improved methods for stopping a vehicle that has been verified as posing a high risk. This raises a concern about whether TSA will be able to give first responders the information priority they need over its own need to determine whether an entire fleet should be grounded.
- *Lukewarm carrier reception.* Finally, the carriers’ reaction to TSA’s vehicle-tracking technologies has been lukewarm thus far. This probably explains why TSA has gone to great lengths to avoid any indication of mandatory implementation and why it is offering funds for motor carriers of high-risk hazmat to join in the pilot project.

The future progress of the TSA pilot project needs to be tracked. However, it is to understand that the project is specifically focused on high-consequence materials and that the targets to be protected are those that promise very high body counts. Many lessons can be learned by observing and perhaps participating in this program. Whether or not these are lessons that carriers have already learned by participation in DTTS remains to be seen. In any event, the implementation of VITs, particularly in combination with geofencing, needs to be encouraged and examined carefully.

Outline of TSA Pilot Project

- *Phase I: Conceptual studies mandated in FY03–FY06 appropriations bills*
- *Phase II: Pilot study endorsed and funded in 9/11 bill for FY08–FY10*
- *Participants: 10 carriers with 128 trucks, 7 vendors, 3 public safety centers*
- *Focus*
 - *High-consequence hazmat in high-threat situations*
 - *Mass casualties*
 - *Operation of TTC covering all states*
 - *Use of tracking systems and panic alerts (VIT not included)*
- *Characterization*
 - *Voluntary implementation as insurance against mandated government implementation*
 - *Use of existing systems through common protocols*
 - *Partial implementation has value (questionable)*
- *Schedule and budget*
 - *March 30, 2008: Draft technical report*
 - *May 15, 2008: Final technical report*
 - *Next phase will last three years*
 - *\$7 million for each year; of which \$3 million is for equipment (some will be used to equip participant fleets)*

KEY ISSUES IN IMPLEMENTING VEHICLE TRACKING

Several key issues need to be considered before implementing a vehicle tracking system for gasoline tankers or, eventually, for other commodities and other vehicles. Most of these are not related to the technical details of communications and message formats, since most of the equipment and interfaces used are commercially available and relatively well tested. For example, satellite-based GPS systems are recommended in the federal pilot studies, a recommendation consistent with our finding of problems encountered with alternatives that rely on radio or cell-phone ground transmitters. (Thus far, ground-based systems have been used successfully only on small fleets of vehicles, such as those maintained by the Federal Emergency Management Agency (FEMA), in certain geographic areas.) Although satellite coverage is limited in certain remote areas, this should not be an impediment if the target is large groups of people in crowded urban settings—for example, the satellite-based On-Star response system is widely used in passenger cars. Coverage limitations may diminish the system's value as an anti-hijacking or anti-theft mechanism, however, so the capacity of urban satellite systems to accept additional hundreds or thousands of GPS transmitters would have to be studied to prevent failures due to overcrowding of the frequencies. Similarly, emergency response to system signals would overwhelm the capacity of a 911 call center designed as a local government resource.

The driver panic button tested well in the FMSCA pilot, as did vehicle disabling. Work has since progressed, bringing to the fore even more “intelligent” and safer ways of remotely disabling vehicles (taking into account, for example, the speed of the vehicle and its vertical inclination when disabling is needed).

Finally, first opinions suggest that the IEEE, XLM, and web formats for data should make it relatively easy for organizations with systems and those without to interface well.

A myriad of technical issues will have to be considered as a tracking system is designed, and any constraints they impose will have to be taken into account. However, these do not appear to be the major issues any state or other authority must consider.

The more important issues will relate to technical requirements, legal authority, operational control, and costs. Also, specific operational questions must be addressed to ensure that current emergency response capabilities are enhanced—and not diminished—by system implementation.

The following general systems engineering issues will need to be addressed if and when a decision is made to implement a vehicle tracking system:

- *Requirements and trade-offs of the system design.* What is the hierarchy of requirements and where are the tradeoffs that most likely will have to be made? For example, will system designers have to prioritize the flow of information, deciding, for example, whether the need to find out where all other vehicles are is more important than the need to get information about an actual incident to emergency responders?
- *Systems engineering and future growth.* Does the system have the capacity to expand for future uses? Can it be designed for expansion? Is there a robust

systems engineering approach at the top level for the current and future iteration of vehicle tracking?

- *Federal versus state legal authority.* Federal preemption is more established in the transportation of hazardous materials than in most other areas. There will be even more preemption if the federal government implements a TSA-managed or -overseen vehicle tracking system for high-consequence materials. And while most of the gasoline tanker deliveries are intrastate, some cross state borders. To be effective, the system will have to apply to any vehicle operating in or coming into a state, which could mean banning the use of tankers not equipped for tracking at state borders unless the federal government was to mandate a requirement or other states were to join in the system. Obviously, this poses a major implementation barrier.
- *Operational issues.* Among the questions that will have to be answered are: (1) Who controls the information and who has authority to disable or shut down vehicles? The driver, the company dispatch center, local police, a central control center, or all of them? (2) If information to be conveyed is either law enforcement or security sensitive (which should be the case in the event of an attack), how does the right information get to the right people at the right time? (3) If proprietary company information is involved, how can it be secured?
- *Legal liability.* Legal liability will have to be defined for at least three circumstances: (1) an accident caused by an inadvertent or unnecessary activation of vehicle disabling; (2) an accident or an attack in which the system was not activated and could have been; and (3) an attack or accident in which the system was activated but did not work properly or did not prevent the accident. These are complex issues.
- *Mandatory/voluntary implementation and cost-sharing.* Whether the system is mandatory or not and how to shoulder its costs are key issues, and they are linked. Voluntary implementation, supported by financial incentives or state or local support, could secure the cooperation of large companies that have an inherent economic interest in the operational efficiencies and accident-reduction benefits a vehicle tracking system would bring. However, the cost-benefit ratio may be different for many smaller motor carriers, and they may not be capable of or willing to make the investments. In addition, any implementing authority would have to consider whether a system designed to meet a perceived security need that does not incorporate all motor carriers is inherently flawed, since attackers could easily determine which company's tankers are not equipped for tracking, thereby defeating the purpose of the system.

Mandatory implementation would require one or some combination of the following methods to provide financial support: (1) federal and/or state payments financed through general taxes; (2) license or other user fees or special taxes levied on some combination of manufacturers, entities, or consumers in the supply chain; or (3) the generation of production efficiencies that might follow a mandatory requirement set by a state. Needless to say, there is no easy solution that will appear equitable to all parties.

Regardless of whether the system is voluntary or mandatory and how costs are covered, it is important that the full costs of the system be considered. These would include not only the costs of ground-based equipment, but also the cost of creating and staffing operational centers, future expansions and upgrades of equipment, and any retrofitting required. These need to be carefully estimated.

General System Development Issues

- *Requirements and tradeoffs: What are they, and which tradeoffs will have to be made?*
- *Future growth: Is systems engineering capacity built in for future growth?*
- *State and federal authority: How can a system that requires 100% subscription work where there are out-of-state tankers and the federal government can preempt the state?*
- *Who will control the system and the flow of information?*
- *Who is responsible if something goes wrong?*
- *Will the system be mandatory or voluntary, and what is the best way to allocate full costs?*

Specific Issues Pertaining to Emergency Response

It is clear that if a vehicle tracking system is needed, it cannot diminish—and indeed should enhance—the emergency response systems and resources used in gasoline tanker highway accidents involving an explosion and/or fire. And if the system is extended to other commodities, it should enhance other resources as well. Therefore, it is important to determine those characteristics of a tracking system that could increase response times and decrease the effectiveness of current emergency response capabilities and that must be avoided. The preliminary recommendations that follow indicate just how challenging a task this will be.

Although tankers are placarded and regulated and are limited to specific routes by local communities for traffic management purposes, there are state limitations on such restrictions, and in general, tankers are fairly ubiquitous. This is understandable given the need to supply gasoline for motor vehicles.

Currently, the response to the discharge of petroleum materials resulting from traffic accidents, human error during delivery, or vandalism is based on the local fire department handling abatement and private contractors paid for by the truck's owners handling clean-up. For large spills, the federal Environmental Protection Agency's (EPA's) Technical Assistance Team (TAT) oversees the clean-up to ensure protection of the environment and complete elimination of all environmental hazards. Local governments have limited hazmat response capability, and only the largest cities have dedicated hazmat teams with specialist- or technician-level personnel. In fact, local-government public safety personnel in many states are likely stretched thin trying to answer the calls for service generated by the growing population.

Therefore, either a state authority would have to respond to all calls, or a new state-based response team would have to be created. If a statewide service were created, its costs could be reduced by positioning the teams near the most critical population targets, which presumably comprise or are near the most heavily trafficked freeways and state highways. A state law limiting the use of state highways by gasoline tankers except for direct deliveries to gas stations and private gas tanks (police and fire facilities, trucking-company garages,

and similar non-retail outlets) might minimize the cost impacts.

Preliminary Recommendations for a Vehicle Tracking System

Without considering other system tradeoffs, the following recommendations focus on what an optimum vehicle tracking system should include to maintain or increase response time and effectiveness.

Recommendation 1: Create System Use Protocols

Prior to activation, states needs to develop protocols to:

- Distinguish between service calls generated by routine events and those requiring a specialized team. For example, a routine traffic accident should still be handled by the responsible jurisdiction, but a driver distress call or waypoint signal alarm would be responded to by a specialized team
- Determine the scope of the system by considering commodities being transported, vehicle routing, and proximity to critical targets.
- Base infrastructure decisions on a solid plan, and establish emergency-asset response times accordingly. For example, flat roadbed in remote areas might require a relatively slow response time, while other stretches of roadway near refineries or other sensitive facilities, or through highly congested urban areas might require a 3- to 5-minute response time. Such a rapid response would require the prepositioning of special teams for high-risk commodities and locations and would depend on the capabilities of local first responders for lower-risk commodities and locations.
- Review response plans to determine whether and how hazmat-transporting vehicles have been factored into disaster planning.
- Work with administering agencies, regional emergency-planning organizations, and local emergency-planning committees across the state to ensure that the vehicles, commodities, and attack scenarios identified as being of greatest concern are considered in all future regional transportation threat-analysis documents.

Recommendation 2: Create System Integration Protocols

It is necessary to agree on who responds to what. At the present time, state laws may provide for a response to hazardous-materials-related events by the closest police (on the public roads) or fire department (on private property) first responders. A new vehicle tracking system would require a statewide agreement among all first-responder agencies on how responses to different events would be handled. The local government would probably retain responsibility for routine traffic accidents and events involving petroleum tankers, while a new organization would probably be responsible for responding to events detected by the new surveillance system. To avoid duplicating expensive resources, such as fire department-based hazmat response teams or police department-based explosive-

ordnance disposal units, the new system might establish a fee-for-service relationship between existing first responders and any state-based licensing system for specialized responses.

Recommendation 3: Train and Equip Chemical-Terrorism Response Teams

As noted earlier, a response capability has to be in place. Teams should focus, but not exclusively, on petroleum products, their derivatives, and the fires associated with their accidental or intentional discharge. Federal and state law also requires that personal protective equipment (PPE) be issued to such teams. Each type of PPE has its own testing, quality control, training, and medical surveillance requirements for each officer using it.

Recommendation 4: Create Response Protocols

In the event of a terrorist threat or an actual attack that requires the vehicle tracking system to be implemented, particularly for vehicle disabling, the response plan must be harmonized with various state and federal systems, such as the Incident Command System (ICS), the Standardized Emergency Management System (SEMS), and the National Incident Management System (NIMS). Response protocols will have to be integrated into broader terrorism-response plans at the local, operational area, state, and federal levels. The questions that will need to be addressed include the following:

- Managing distress-signal alarms. If a driver distress signal is received, what is the responding law enforcement agency supposed to do? How are false alarms to be anticipated and managed?
- Alarms without driver distress. If a vehicle alarm or exception report is received but there is no driver distress signal, how should the event be examined? When should it be treated as a possible hijacking? When should chemical-response gear be donned?
- Notification and sequence of response. Which agency responds first, and who provides mutual aid? In what order are first responders notified, and how can first responders be guaranteed to get all the information they need?
- Victims and potential victims. How and when are potential victims notified? What are they instructed to do? Shelter in place, evacuate? How are the choices made, based on what information?
- Media interface. Who will handle the emergency media information system? Which reporting authority will issue the alerts? Who is responsible for opening the Emergency Operations Center (EOC)/Joint Information Center (JIC)?
- Controlling agency? Who is the controlling authority? Is the incident a state event, with the regional emergency operations center in the lead, or a local emergency, with the city or county emergency operations center in the lead?

This is just a sample of the key issues that need to be explored in considering the implementation of a vehicle tracking system.

Preliminary Recommendations to Maintain and Enhance Emergency Response

- *Create system use protocols and define the scope of coverage in terms of fleets and infrastructure; review and deconflict all existing emergency response and security plans.*
- *Create system integration protocols, i.e., decide who responds to what and how.*
- *Train and fully equip a chemical-terrorism response team.*
- *Create response protocols to manage the entire range of issues, from false alarms, to treatment of the injured, to fielding press inquiries, and for deciding which, and under what circumstances, is the controlling agency.*

SOURCES OF ADDITIONAL INFORMATION ON VEHICLE TRACKING AND DISABLING SERVICES

This section provides the names of vendors that participated in the FMCSA and TSA pilot projects or studies, as well as the only technology evaluation to date. One of these companies, QUALCOMM (apparently the largest firm in this field) also has provided vehicle tracking service for DOD's DTTS. While we have reviewed the web-based literature of some of these vendors, we have not attempted to evaluate the range, price, or quality of services offered. Such an evaluation would require a market assessment and contacts with each vendor. However, the number, range, and services offered seem to be increasingly robust, and the number of vendors is apparently increasing, primarily in response to the drive toward efficiency, theft reduction, safety, and finally security-risk reduction.

FMCSA's Field Operational Test

In FMCSA's 2003–2004 Field Operations Test, the deployment team that tested the various technologies was led by Battelle and included QUALCOMM, the American Transportation Research Institute (ATRI), the Commercial Vehicle Safety Alliance (CVSA), Savi Technologies, the Biometrics Solutions Group (BSG), TotalSecurity-US, and the Spill Center. An evaluation was performed by Science Applications International Corporation (SAIC). During beta testing, QUALCOMM used a "technology truck" to validate the system design and operational concept of the test. The technologies of various vendors were used to test the following components:

1. Wireless-mobile communication, including wireless satellite or terrestrial communication and tracking (with GPS), and digital phone (without GPS)
2. In-vehicle technologies, including on-board computers (OBC), panic buttons that allow for localized vehicle disabling, and electronic seals
3. Personal identification through biometrics and personal identification numbers (PINs)
4. Mobile data management, including routing and geofencing software and trailer tracking²⁵
5. Remote ("over the air") vehicle disabling

The field test was designed not to evaluate the quality of all vendors, but to evaluate specific functional requirements. Battelle chose QUALCOMM, Savi, Saflink, and the Spill Center to provide technologies for testing. The team also developed a compendium of COTS (commercially available off-the-shelf) technology available in the marketplace that might be applied to hazmat safety and security. This compendium included a review of articles and information provided by interested vendors who responded to news alerts that directed them to a website. The compendium includes contact information, product functionality and descriptions, and market penetration and pricing information for 88 companies that had products to offer.

Products offered by the vendors include the following categories:

- Satellite tracking
- Terrestrial tracking
- Trailer tracking
- Keypad personnel authentication
- Biometric authentication
- Asset management
- Mapping
- Inventory management
- Radio-frequency identification tag
- Electronic cargo seals
- In-vehicle mounted computer
- Integration software
- Others
- Cellular phones or paging service
- Automated collision notification
- Untethered-trailer tracking
- Trailer securement
- Driver authentication
- Cargo securement
- Remote vehicle disabling
- Web-based shipping tracking
- Out-of-route mapping system or alert
- Mechanical cargo seals
- In-vehicle communications
- Consultant services

Another six companies that were not yet offering COTS products were identified but not included in the compendium.²⁶

The number of vendors gives some indication of the market interest, and while FMCSA has not updated this compendium, the FMCSA staff involved in the later vehicle immobilization technology (VIT) demonstration noted that certain technologies, such as vehicle immobilization and trailer tracking, had expanded considerably. DOD officials also indicated that trailer tracking was expanding.

FMCSA's UTT Demonstration

To conduct the demonstration, SAIC and QUALCOMM conducted the test using QUALCOMM's TrailerTRACS system. Other UTT systems mentioned in the report because they had similar technologies include General Electric's VeriWise, GeoLogic Solution's TrailerMax, Terion's Fleetview 3 Trailer Management System, Skybitz's Global Location System, TransCore GlobalWave, Teletouch Communication's Vision Trax, and AirIQ's Refrigerated Trailer Tracking Solutions. Skybitz and Geologic also served on the expert panel and provided technical information throughout the pilot.²⁷

FMCSA's Extended Satellite Coverage Demonstration

QUALCOMM's wireless satellite-based mobile communications system (OmniTracks) and related host software (QTRACS) was tested, also using a QUALCOMM communications center. These QUALCOMM components provided two-way data communication between the driver and the carrier, with a driver interface unit for two-way text communication; 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; tethered trailer tracking; and panic alerts.²⁸

FMCSA's VIT Demonstration

The following vendors participated in FMCSA's test of VITs by testing all of the functional

requirements and by bringing their equipment to the test ground: QUALCOMM and MAGTECH, Satellite Security Systems and Bluebird Bus Company, International Truck and Engine and NAVISTAR, BSM Wireless, and Glue Hugh Enterprises and Archetype. FMCSA staff also indicated that some of these vendors, including QUALCOMM and MAGTECH, are teaming to offer VIT technology in the marketplace, which is significant because of QUALCOMM's large commercial presence²⁹ in the wireless communications area.

TSA's Truck Tracking Pilot

TSA's current hazmat-truck-security pilot has been managed by a project team consisting of General Dynamics Advanced Information Systems (GD), Science Applications International Corporation (SAIC), Northrop Grumman (NG), and DOD's DTTS TieBridge and Wu Consulting. The carriers that participated were CYNACO, Dupre, Honeywell, Martin CNG, Midwest X-Ray, Occidental Energy Transportation, Orica, R&R Trucking, Tri State, and VandeMark. The tracking vendor participants were Cadec, PeopleNet, QUALCOMM, SafeFright, Shaw Trucking, Transcore, and Volvo.³⁰

DOD's DTTS

QUALCOMM provides the satellite truck tracking service for DTTS, and another vendor (ComTech Mobile) has also been selected. Three additional vendors have been selected to provide trailer tracking services beginning in April 2008.³¹

In summary, there seem to be no major barriers to technical development and implementation if a state chooses to implement a tracking system that also includes geofencing and vehicle disabling, although all technologies—and the latter technology in particular—will require careful integration with public authorities, private companies, and their operational procedures, particularly in responding to an alert or exception report.

ENDNOTES

1. This research was originally drafted and completed on July 11, 2007.
2. Transportation of nuclear materials is regulated under a separate system managed by the Department of Energy (DOE).
3. See Table 205-4, "Examples of AA&E Shipment Categories," DOD Transportation Regulation, Chapter 205, last updated 2006.
4. Ibid.
5. These figures came from the DTTS Project Management Office (PMO). The term "other" was not defined.
6. "Overturn of a Tractor Semitrailer Transporting Torpedoes, Denver, Colorado, August 1, 1984," National Transportation Safety Board, adopted October 21, 1985, NTSB Number HZM-85-02, NTIS Number PB85-917015.
7. "Special Investigative Report, Collision Between a Tractor-Semitrailer Transporting Bombs and an Automobile, Resulting in Fire and Explosions, Checotah, Oklahoma, August 4, 1987, National Transportation Safety Board, adopted March 3, 1987, NTSB Number SIR-87/01, NTIS Number PB87-917001, <http://www.nts.gov/pub-lictn/1987/SIR8701.htm>.
8. *Defense Transportation Regulations*, Chapters 202 and 205, both updated 2006, and the SDDC Freight Traffic Rules Publication NO. 1C (MFTRP NO. 1C), Motor Carrier Safety, January 4, 2004.
9. December 18, 2007 teleconference with LTC Essick.
10. A set of final publicly available reports can be found at <http://www.fmcsa.dot.gov/safety-security/hazmat/fot/index.htm>. MTI obtained access to the Sensitive Security Information (SSI)-protected contractor reports analyzing security threats, attacks, and risks under the terms of a Non-Disclosure Agreement with FMCSA.
11. See HR Report 107-722, Department of Transportation and Related Agencies Appropriations Bill, 2003, October 7, 2002. See page 105: "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, geofencing, unscheduled movement notification, door sensors, and alarms."
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13. The November 25, 2003, Conference Report for FY04, House Report No. 108-401, stated on p. 97: "As proposed by the Senate, the conference agreement directs \$2,000,000 from funds provided for the high priority initiative program for an expanded satellite based communications system to monitor and track hazardous materials and high value cargo in uncovered areas of the United States."
14. U.S. Department of Transportation, Federal Motor Carrier Safety Administration, *Expanded Satellite-Based Mobile Communications Tracking System Final Report*, MCSA-RRT-07-0008, June 2007, <http://www.fmcsa.dot.gov/facts-research/research-technology/report/Expanded-Satellite-based-Mobile-Communications-Tracking-System-Final-Report-June2007.pdf>.
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16. See "Vehicle Immobilization Technologies: Best Practices for Industry and Law Enforcement," FMCSA, Report No. FMCSA-RRT-07-021, November 2007, <http://www.fmcsa.dot.gov/facts-research/research-technology/report/VIT-Best-Practices-Law-Enforcement-Nov2007.pdf>.
17. *Hazardous Materials Safety and Security Technology Field Operational Test, Vol. I, Evaluation Final Report Executive Summary*, November 11, 2004.
18. *Ibid.*, 12.
19. *Ibid.*, 14.
20. *Ibid.*, 24.
21. See "Vehicle Immobilization Technologies."
22. *Ibid.*, 73–80.
23. FMCSA staff interview, November 26, 2007.
24. Some of the costs of DTTS are provided in the sidebar on page 8 of this report.
25. See *Hazardous Materials Safety and Security Field Operational Test, Volume I*.
26. For the information on the technology compendium and for information on technologies offered by vendors, see *Hazmat Safety and Security Field Operational Test, Final Report to FMCSA*, August 31, 2004, p. ES-6, and FMCSA report FMCSA-RRT-07-021 particularly its appendices.
27. FMCSA Report No. FMCSA-MCRRT-06-002, 6–8.
28. FMCSA Report No. FMCSA-RRT-07-008, 25–29.

29. See FMCSA briefing slides; other information provided by FMCSA staff in an interview on November 26, 2007.
30. See TSA briefing slides.
31. Information provided by LTC Essick, PMO DTTS, in a telephone interview, December 17, 2007.

ABBREVIATIONS AND ACRONYMS

AA&E	Arms, Ammunition, and Explosives
ATF	Bureau of Alcohol, Tobacco And Firearms
ATRI	American Transportation Research Institute
BSG	Biometrics Solutions Group
CCTV	Closed Circuit Television
CDC	Centers For Disease Control
CIA	Central Intelligence Agency
COTS	Commercial Off-The-Shelf
CVSA	Commercial Vehicle Safety Alliance
DHS	Department of Homeland Security
DOD	Department of Defense
DOT	United States Department Of Transportation
DTTS	Defense Transportation Tracking System
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ESCT	Expanded Satellite-Based Mobile Communications Tracking
FAM	Federal Air Marshal
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FOT	Field Operation Test
FPCON	Force Protection Conditions
FR	Functional Requirement
FTA	Federal Transit Administration
GD	General Dynamics
GPS	Global Positioning System
GAO	Government Accountability Office
Hazmat	Hazardous Materials
HHSM	Highway Security-Sensitive Hazardous Materials
HTUA	High Threat Urban Area
ICS	Incident Command System
IEEE	Institute of Electrical And Electronic Engineers
JIC	Joint Information Center
LEO	Law Enforcement Officer
LTL	Less-Than-Truckload
MTI	Mineta Transportation Institute
MTMC	Military Traffic Management Command
NG	Northrup Grumman
NIMS	National Incident Management System

NTSB	National Transportation Safety Board
NTSCOE	National Transportation Security Center Of Excellence
OBC	On-Board Computers
PIH	Poison Inhalation Hazard
PIN	Personal Identification Number
PPE	Personal Protective Equipment
PMO	Project Management Office
PRSC	Public Sector Reporting Enter Concept
RSPA	Research and Special Programs Administration
SAIC	Science Applications International Corporations
SDDC	Surface Deployment and Distribution Command
SEMS	Standardized Emergency Management System
SEV	Security Escort Vehicle
SSI	Sensitive Security Information
TAT	Technical Assistance Team
TIH	Toxic Inhalation Hazard
TRB	Transportation Research Board
TSA	Transportation Security Administration
TTC	Truck Tracking Center
UTT	Untethered Trailer Tracking
VBIED	Vehicle-Borne Improvised Explosive Device
VIT	Vehicle Immobilization Technology

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BRIAN MICHAEL JENKINS, PRINCIPAL INVESTIGATOR

Brian Michael Jenkins is the director of the National Transportation Security Center of Excellence (NTSCOE) and one of the world's leading authorities on terrorism and sophisticated crime. He works with government agencies, international organizations, and multinational corporations as an analyst, investigator, and crisis-management consultant. From 1989 to 1998, Mr. Jenkins was the Deputy Chairman of Kroll Associates, an international investigative and consulting firm. Before that, he was chairman of the RAND Political Science Department, where, from 1972 to 1989, he also directed RAND research on political violence.

Mr. Jenkins obtained his bachelor of arts degree in fine arts and his master of arts degree in history from the University of California, Los Angeles. He has also studied at the University of Guanajuato in Mexico and the University of San Carlos in Guatemala, where he was a Fulbright Fellow and the recipient of a second fellowship from the Organization of American States.

Commissioned in the infantry at the age of 19, Mr. Jenkins became a paratrooper and, ultimately, a captain in the Green Berets. He is a decorated combat veteran, having served in the Seventh Special Forces Group in the Dominican Republic during the American intervention and later as a member of the Fifth Special Forces Group in Vietnam (1966–1967). He returned to Vietnam on a special assignment in 1968 to serve as a civilian member of the Long Range Planning Task Group; he remained with the group until the end of 1969, receiving the Department of the Army's highest award for his service. Mr. Jenkins returned to Vietnam again in 1971 on another special assignment.

In 1996, President Clinton appointed Mr. Jenkins to the White House Commission on Aviation Safety and Security. From 1999 to 2000, Mr. Jenkins served as an advisor to the National Commission on Terrorism, and in 2000 he was appointed to the U.S. Comptroller General's International Chamber of Commerce and became a member of the board of directors of ICC Commercial Crime Services. Mr. Jenkins was also a member of the Transportation Research Board/National Research Council Panel on Transportation: Science and Technology for Countering Terrorism 2002.

Mr. Jenkins has been the counterterrorism research team leader and a research associate with the Mineta Transportation Institute since 1996. He is the author or co-author of the following MTI reports:

- *Protecting Surface Transportation Systems and Patrons from Terrorist Activities: Case Studies of Best Security Practices and a Chronology of Attacks*, December 1997.
- *Protecting Surface Transportation Systems and Patrons from Terrorist Activities: Continuation of Case Studies of Best Security Practices and Updated Chronology of Attacks*, October 2001.
- *Executive Overview of MTI Terrorism Reports*, October 2001.
- *Saving City Lifelines: Lessons Learned in the 9-11 Terrorist Attacks*, September 2003.
- *Selective Screening of Rail Passengers*, March 2007

Mr. Jenkins is also a senior advisor to the President of the RAND Corporation and a

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BRUCE ROBERT BUTTERWORTH, FIELD RESEARCH DIRECTOR

Bruce Butterworth has had a distinguished government career, working at congressional, senior policy, and operational levels. Between 1975 and 1980, as a professional staff member of the House Government Operations Committee, he ran investigations and hearings on many transportation safety issues, particularly in aviation. He spent 11 years in the Department of Transportation, eight of them in the Office of the Secretary. He managed negotiations on the inclusion of air and maritime services in the GATT (now WTO), chaired U.S. delegations to United Nations Committees, dealt with transport and aviation issues related to border inspections, and was part of the response to the bombing of Pan Am 103.

Mr. Butterworth held two executive posts in aviation security and in both worked closely with Congress as the informal but primary liaison. He was Director of Policy and Planning (1991–1995), establishing strategic long-term and contingency plans and federal rules. As Director of Operations (1995–2000), he was responsible for federal air marshals, hijacking response, and 900 field agents; he worked hard to improve security and the performance of security measures by U.S. airports in this country and by U.S. airlines everywhere. He ran the FAA's aviation command center, successfully managing the resolution of hijackings and security emergencies. He launched a successful program of dangerous-goods regulation and cargo security after the 1995 ValuJet crash, oversaw the conversion of the air marshal program to a full-time program with high standards, was a key player in the response to the ValuJet and TWA 800 accidents, and was a frequent media spokesperson. He has worked closely with Congress, the National Security Council staff, the intelligence community, law enforcement agencies, and authorities of other nations.

He served as an associate director of the United States Holocaust Memorial Museum (2000–January 2003), responsible for security and building operations. He designed and implemented a “best practice” procedure for dealing with mail possibly containing anthrax powder and developed and conducted new, comprehensive emergency planning and exercises. Between January 2003 and September 2007, he was one of two deputy directors in a 1,300-person Engineering Directorate at NASA's Goddard Space Flight Center, managing workforce planning, budgeting, and all aspects of human capital management for complex robotics space missions, substantially reducing overhead and improving workplace safety there. He currently works for TKC Communications Corporation as a strategic planner in DHS's Information Sharing and Analysis Branch and is also active as a research associate with the Mineta Transportation Institute.

With Brian Michael Jenkins he co-authored *Selective Screening of Rail Passengers* (MTI Report 06-07), published by the Mineta Transportation Institute in February 2007. He also co-authored a May 2007 study, *Keeping Bombs Off Planes: Securing Air Cargo, Aviation's Soft Underbelly* with P.J. Crowley, senior fellow and director of Homeland Security at the Center for American Progress.

Mr. Butterworth was awarded a master of science degree from the London School of Economics in 1974 and a bachelor of arts degree from the University of the Pacific in 1972 (magna cum laude). He was a California State Scholar and a Rotary Foundation Fellow. He also received numerous special achievement and performance awards.

FRANCES L. EDWARDS, M.U.P., PH.D., CEM

Frances L. Edwards, Ph.D., CEM, is the director of the Master of Public Administration program and professor of Political Science at San José State University. She is also an MTI research associate and teaches emergency management in the Master of Transportation Management program. In 2009 she was appointed United States chair for the European Union CAST Project for the development of unified training for first responders. Her most recent research has been in global supply chain security, resulting in a chapter co-authored with Dan Goodrich, "Supply Chain Security and the Need for Continuous Assessment," to be published in *Supply Chain Security: International Innovations and Practices for Moving Goods Safely and Efficiently* by Praeger. In 2009 she delivered papers at the Department of Homeland Security Center of Excellence conference on MTI's research agenda, and at the American Society for Public Administration on "Legacy of Hurricane Katrina: The Challenges of International Goodwill." In 2008 she delivered papers at the American Society for Public Administration on the financial impacts of Hurricane Katrina, and at the Stevenson Disaster Institute at Louisiana State University on cross border issues in disaster response. Her paper was published in 2009 in the *Journal of Contingency and Crisis Management*. In June 2007 she was a guest of the Turkish government at the 2nd Istanbul Conference on Democracy and Global Security where she delivered a paper titled "Police in Catastrophic Response: Lessons Learned from Hurricane Katrina." She also presented a paper at the American Society for Public Administration (ASPA) on "Collaborative Leadership in Dynamic Environments of Disasters and Crises: Collaboration at the Local Level;" and she received the Petak Award for the best paper in emergency management delivered at the 2006 conference.

Dr. Edwards was a 2006 Fellow of the Foundation for Defense of Democracies, and spent part of June 2006 in Israel at Tel Aviv University studying Middle Eastern terrorism. She chaired the 2006 NATO STS-CNAD meeting for 20 nations in Portugal, and presented a paper there on the evolution of American emergency management. The book, *NATO and Terrorism: On Scene! Emergency Management after a Major Terror Attack*, co-authored with of Salzburg University professor Friedrich Steinhausler, grew out of the March 2006 NATO workshop. She was guest editor for the 2007, 2008 and 2009 Winter editions of *The Public Manager*, in which she published articles on Hurricane Katrina. Her most recent articles include, "Federal Intervention in Local Emergency Planning: Nightmare on Main Street," in the Spring 2007 issue of *State and Local Government Review*, and "An Ounce of Prevention Is Worth a Pound of Cure: Improving Communication to Reduce Mortality During Bioterrorism Responses," with Margaret L. Brandeau and other colleagues from Stanford University, in *American Journal of Disaster Medicine*, March/April 2008.

Previously, Dr. Edwards was director of the Office of Emergency Services in San José, California for 14 years, including one year as acting assistant chief for the City of San José's fire department. She was director of San Jose's Metropolitan Medical Task Force

(MMTF), a CBRNE terrorism response unit, and head of the four-county “San José Urban Area Security Initiative.” In 2004 she co-chaired the NATO Advanced Research Workshop in Germany where she delivered a paper on research needs to support first responders to CBRNE terrorism. In October 2001 the Wall Street Journal called San José the “best prepared city in the United States” for disasters. She represented emergency management on the five night “Bio-War” series on ABC’s “Nightline with Ted Koppel” in October 1999. She has been a member of the Stanford University Working Group on Chemical and Biological Warfare, the Department of Justice’s Executive Session on Domestic Preparedness at the Kennedy School of Government at Harvard University, the National Academy of Sciences Institute of Medicine MMRS Review Committee, and the California Seismic Safety Commission. Her publications include *Mercury News* op-eds on homeland security; *NATO and Terrorism: Catastrophic Terrorism and First Responders* with Dr. Steinhausler, *Saving City Lifelines* with Brian Jenkins, and chapters in ICMA’s *Emergency Management, Homeland Security Law and Policy, First to Arrive, Handbook of Crisis and Disaster Management*, and *The New Terror*; entries in *WMD Encyclopedia*; and over 25 articles in journals and has presented professional papers at more than 35 conferences.

Dr. Edwards was named “Public Official of the Year 2002” by *Governing* magazine, and one of the “Power 100 of Silicon Valley” by *San José Magazine*. She has a Ph.D. in public administration, a Master of Urban Planning, an M.A. in Political Science (International Relations) and a Certificate in Hazardous Materials Management.

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