THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**RADIO FREQUENCY IDENTIFICATION**	
APPLICATION:	**TRACKING HAZARDOUS WASTE SHIPMENTS ACROSS INTERNATIONAL BORDERS**	
TECHNOLOGY NAME:	**MULTITRACK™ LAYERED TRACKING SYSTEM**	
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The U.S. Environmental Protection Agency (EPA) has established the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies. Information and ETV documents are available at www.epa.gov/etv.

ETV works in partnership with recognized standards and testing organizations, with stakeholder groups (consisting of buyers, vendor organizations, and permitters), and with individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field and laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Advanced Monitoring Systems (AMS) Center, one of six verification centers under ETV, is operated by Battelle in cooperation with EPA's National Risk Management Research Laboratory. The AMS Center evaluated the performance of a system for tracking hazardous material (HAZMAT) waste shipments across international borders using radio frequency identification (RFID). This verification statement provides a summary of the test results for Private Pallet Security System's (P2S2) MultiTrack™ Layered Tracking System (MultiTrack).

VERIFICATION TEST DESCRIPTION

This verification test was conducted from March 24-26, 2009 at the New Mexico Border Authority (NMBA) Santa Teresa facility and other field locations throughout the El Paso/Ciudad Juárez area. Battelle coordinated

this verification test with support from the NMBA, New Mexico Department of Public Safety (NMDPS), Texas Transportation Institute, U.S. EPA Region 6 El Paso Border Office, U.S. EPA Office of Enforcement and Compliance Assurance, Border Writing (a New Mexico company that coordinated participation of the local collaborators prior to the ETV test), and Servicio de Transporte Internacional y Local (STIL). This test simulated shipments of hazardous waste contained in polyethylene (poly) drums, metal drums, and corrugated boxes through routine land transportation routes and across international ports of entry in the El Paso/Ciudad Juárez trade area. RFID tags were attached to four of each container type for a total of 12 containers which were loaded onto a standard 53-foot semi-truck and trailer at the NMBA facility's U.S. loading dock. Throughout testing, the 12 containers were arranged in the trailer in either a tightly-packed or loosely-packed configuration.

Originally, this ETV test was planned with the expectation that all of the trucking routes would include border crossings. However, due to concern of local authorities related to the violence in Ciudad Juarez during the test, there were some difficulties in obtaining permission to cross the border into Mexico, so two of the trucking routes did not cross into Mexico and two routes included crossing the border into Mexico. For the two U.S. RTs, the truck left the NMBA loading dock, passed a RFID read location in the driveway of the NMBA and 15 and 25 miles per hour (mph) read locations in the driveway of the NMDPS truck inspection facility. Subsequently, the truck was driven to a casino parking lot where the truck passed an additional RFID read location before returning to the NMBA loading dock. As part of the two Mexico RTs, the truck followed a similar route except that instead of including the casino, it travelled through the Mexico Port of Entry and onto a turnaround point in Mexico before returning to the U.S. The RFID tag reads were recorded electronically throughout each truck route.

A collision test was performed during each RT to evaluate the ability of the MultiTrack to discriminate between the P2S2 RFID tags and other commercially available active RFID tags. Battelle supplied four commercially available tags for collision testing (Wavetrend® TG801) at a frequency of 433 MHz, the same frequency at which the MultiTrack system operated. The collision tags were affixed to a wooden block and placed in the truck before it travelled by the second 15 mph read location.

The key evaluation parameters included:

- Accuracy – proper identification of the tagged containers at various locations, at various truck speeds, on corrugated boxes or steel and poly 55-gallon drums, and in tightly packed and loosely packed configurations. Specifically, proper identification is defined as the retrieval of all information available about the tagged item according to the vendor's standard procedures.
- Precision – standard deviation (SD) of percent accuracy RFID tag read results.
- Interference of other RFID signals (collision test) – ability to discriminate the tags on the hazardous waste containers from other commercially available RFID tags.
- Influence of confounding factors – container type, packing configuration and placement of tags/containers, environmental conditions, and internal trailer conditions.
- Operational factors – such as ease of use, technology cost, user-friendliness of vendor software, troubleshooting, and downtime.

QA oversight of verification testing was provided by Battelle and EPA. Battelle and EPA QA staff conducted technical systems audits of the field testing and Battelle QA staff conducted a data quality audit of at least 10% of the test data. This verification statement, the full report on which it is based, and the test/QA plan for this verification test are available at www.epa.gov/etv/centers/center1.html.

TECHNOLOGY DESCRIPTION

The MultiTrack system consisted of RFID tags (attached to HAZMAT waste containers) coupled with P2S2's communication module (referred to as the Sentry). The system components included the RFID tags, an antenna that was attached to the inside of the trailer door, and the Sentry which was connected to the antenna and located in a box mounted to the external of the trailer door. The RFID tags emit a radio frequency that is read continuously by the antenna and stored by the Sentry. This eliminated the need to install or pass any fixed readers along the travel route. Then, approximately every five minutes, and any time an alarm event occurs, the Sentry transmitted the identified RFID tags and the type of the alert or alarm, as well as the global positioning (GPS)

coordinates of the Sentry, to a central P2S2 database via cell phone connection. MultiTrack uses web-based P2S2 software to track the HAZMAT. The P2S2 communication module is customizable with a variety of communication, sensor and power options. Prior to the start of the verification test, P2S2 staff set up the MultiTrack according to their recommended configuration for optimal performance.

VERIFICATION RESULTS

Accuracy and precision. The table below summarizes the accuracy, precision, and data completeness of the MultiTrack system.

Truck Route	Accuracy (Identified Tags/Total Tags) ± SD	Data Completeness
RT1-US	99% (322/324) ± 2%	100%
RT2-US	99% (355/360) ± 3%	100%
RT3-MX	100% (480/480) ± 0%	82%
RT4-MX	100% (324/324) ± 0%	74%

Across the four round trips, there was a possibility of 1,488 container identifications. The MultiTrack system made 1,481 of those identifications correctly, for an overall accuracy of 99.5%.

The two MX round trips included 34-minute periods that the truck was apparently out of the required cell phone coverage area. During this time, the GPS tracking data were stored and transmitted upon regaining adequate phone coverage; however, the feature that would have allowed for the MultiTrack system to store and report the container identification information along with the GPS data was not enabled during the verification test. Therefore, the container identification information was not documented during this timeframe, which is indicated by the data completeness percentages of less than 100% for RTs 3 and 4.

Interference with other RFID signals. The collision test was performed by placing four RFID tags into the trailer along with the containers that were tagged with the P2S2 RFID tags. Three out of the four collision test data sets resulted in 100% accuracy and one had 92% accuracy.

Influence of confounding factors. The influence of container type and environmental conditions such as meteorological and shock conditions was considered as a possible factor in MultiTrack performance. However, accuracies near 100% for container identifications suggest that confounding factors were not an issue during this evaluation.

Operational factors. The verification staff found that the MultiTrack system was easy to use. P2S2 staff set up the in-trailer antenna and the external Sentry communication module and assisted the verification staff in the application of the RFID tags. Once technology setup was complete, there was nothing more that had to be done to operate the MultiTrack system. As implemented during this test, the MultiTrack system required the communication module to be mounted on the outside of the trailer. If implemented this way, it could call attention to the trailer as one that carried valuable goods.

The software that P2S2 uses to handle the data collected by the uplinked data connection is web-based and offers a number of utilities that were used during the verification test. One optional feature that was tested was the ability for the software to provide an alert when the truck crossed an "electronic fence" placed along the planned truck route. This was evaluated by designating the U.S. and MX planned truck route (with destinations) in the system, and setting the alarm to indicate if the truck deviated from the planned route, and when the truck arrived at the destination. The electronic fence was identified as a "geo-fence or route builder" which provided a detailed visual track on the mapping web page. Alarms were sent to the verification staff by text message and email in real-time as the truck entered or exited a geo-fence location. The P2S2 staff operated the software so no hands-on evaluation of its user-friendliness was performed.

P2S2 RFID tags can be purchased at a price of $41 each. P2S2 anticipates that cost of the tags will include the cost of the truck communication unit, the cell phone service and the relational database management for the hauler and disposal site. The cost to gain access to the database is based on a 36 month contract and currently ranges from $135-$150 per month per wireless device (e.g., the one Sentry communication module attached to the back of the trailer which would be compatible with as many RFID tags as necessary).

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