THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**RADIO FREQUENCY IDENTIFICATION**
APPLICATION:	**TRACKING HAZARDOUS WASTE SHIPMENTS ACROSS INTERNATIONAL BORDERS**
TECHNOLOGY NAME:	**PANASEC MOBILE PERSONNEL AND ASSET VISIBILITY SYSTEM**
COMPANY:	**AVANTE International Technology, Inc.**
ADDRESS:	**70 Washington Road PHONE: 609-799-8896 x 121** **Princeton Junction, NJ 08550 FAX: 609-799-9308**
WEB SITE:	**www.avantetech.com**
E-MAIL:	**bjakubovic@aitechnology.com**

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 AVANTE International Inc.'s PanaSec Mobile Personnel and Asset Visibility System (PAVS).

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, BorderWriting (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 HAZMAT 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 tight-packed or loose-packed orientation.

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. Prior to embarking on each round trip (RT), an external reader was situated on a stand at 90° with respect to the road with the stand placed four feet from the side of the front bumper. RFID tag reads were made at distances of 5, 15, 30, 50, and 70 feet from the front bumper of the stationary truck by moving the external reader straight forward from the initial placement of the reader. For the two U.S. RTs, the truck left the NMBA loading dock, passed an RFID reader location in the driveway of the NMBA, and 15- and 25-mile-per-hour (mph) read locations were performed 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 reader 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 turn around 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 PAVS to discriminate between the AVANTE 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 PAVS 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 HAZMAT 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 all available at www.epa.gov/etv/centers/center1.html.

TECHNOLOGY DESCRIPTION

AVANTE's PAVS system included the RFID tags (attached to HAZMAT waste containers) and readers (roadside external or an in-truck reader referred to as the Relayer that resided in the cab of the truck and uplinked data to a central server in near real-time). The uplinked configuration is a HAZMAT transportation tracking system and solution that incorporates patented RFID technologies coupled with global positioning system (GPS)-general packet radio service -cell phone communication to assist HAZMAT transportation security. The AVANTE data center server stores all transit and condition data to provide real-time tracking of the HAZMAT via web-based software.

Each container of HAZMAT is individually tagged with an active ZONER^{TM} tag. The identity of each container is linked to the active tag identification. During verification testing, PAVS used two different methods for RFID tag reading and communication: (1) external readers and (2) an uplinked system. The external readers are placed at fixed locations and only collected RFID data when the truck is driven past the readers whereas the uplinked system with the reader, or Relayer, located in the cab of the truck, collects RFID data and uplinks it to a central server approximately every minute.

VERIFICATION RESULTS

Accuracy and precision. The table below summarizes the accuracy and precision of the PAVS.

Truck Route	External Reader (Identified Tags/Total Tags)±SD	Uplinked Data (Identified Tags/Total Tags)±SD
RT1-US	94% (248/264) ± 6%	(1)
RT2-US	93% (211/228) ± 10%	67% (233/348) ± 32%
RT3-MX	86% (166/192) ± 25%	89% (1,594/1,786) ± 15%
RT4-MX	(1)	95% (804-850) ± 7%

(1) Read location not applicable for this RT

The external readers generated container identification accuracies that were above 90% and had SDs of 10% or less for RTs 1 and 2. RT 3 resulted in a lower overall accuracy and a higher SD. However, there were two read locations as part of RT 3 that resulted in less than 35% accurate results, thus impacting the overall accuracy for that RT. All of the other read locations for that RT had greater than 83% accuracy.

The uplinked configuration for RTs 2, 3, and 4 generated accuracies of 67%, 89%, and 95%, respectively. Data were only collected for the first 40 minutes for RT 2. The frequency of missed reads increased throughout that time period. The results from RTs 3 and 4 show that data were collected more than 80% of the time. Apparently, the time periods during which data were not collected were due to inadequate cell phone coverage, preventing the transmittal and storage of the tag identification and GPS tracking data.

Interference with other RFID signals. Three out of the five collision test data sets resulted in 100% accuracy, one had 92% accuracy, and one had 75% accuracy. While difficult to determine conclusively with this small data set, these results were similar to the non-collision test results in that some non-collision test read locations resulted in accuracy percentages of 75%, 92%, and 100%. These similarities, while not a quantitative evaluation, suggest that the presence of the collision tags did not negatively affect the accuracy results.

Influence of confounding factors. The influence of container type was quantitatively considered as a possible factor in PAVS performance. A paired t-test was performed on the container identification accuracies as a function of container type and no significant differences were determined between the container types. In addition, there was no indication that environmental conditions during the testing significantly impacted any of the results. However, one tag was wetted by water splashed from a container during a RT. This tag was missed at a higher rate compared to other tags. High winds caused sandstorm conditions during the testing which caused difficulty in reading the memory cards used for data collection on the external readers. Instead of using the memory card, the data were downloaded using an ethernet port.

Operational factors. Three RTs were performed using the external reader and uplinked configurations of the PAVS system. The external readers were used during the first two RTs that were performed within the U.S. and the first RT into MX. Prior to RT 3, AVANTE performed a firmware update to their software to ensure the uplinked system worked properly. That update did not accommodate simultaneous operation with the external reader configuration. The uplinked system was used for all four RTs, but had higher levels of data completeness during RTs 3 and 4. No uplinked data were collected during RT 1 and data from 63% of RT 2 were not collected due to gaps in cell phone coverage required for data transmission.

AVANTE staff set up the external readers and assisted with the application of the RFID tags to the HAZMAT waste containers. The ease of use of the Mobile PAVS was notable as setup could be quickly accomplished by powering the system through the dashboard 12-volt power outlet and positioning of two small antennae inside the truck's cab.

The PAVS technology had a decreased level of data completeness for the uplinking system due to blocks of missing data during the verification test. The reason for these missing blocks were not fully known for RTs 1 and 2, and for RTs 3 and 4, the gaps in data collection were due to lack of cell phone coverage. During RTs 1and 2, the loss of cell phone coverage took place in the U.S., during RT 3 the loss of cell phone coverage took place on both sides of the border near the MX POE on the way back in to the U.S., and during RT 4, the loss of coverage took place in MX on the way to the turnaround point. During RTs 1 and 2, the transmission of tag identification data did not restart when the truck re-entered an area with adequate cell phone coverage. Prior to RT 3, AVANTE was able to make a change to the PAVS firmware that allowed for this to take place during RTs 3 and 4. This update did not accommodate simultaneous operation with the external reader configuration so the external readers were not used for RT 4. In addition, following RT 1, AVANTE staff had to repair a faulty GPS receiver within the Relayer. Please see the full ETV report for Avante's explanation of performance and technology modifications they have taken to address the gaps in data collection.

The uplinked configuration of the AVANTE PAVS can be purchased as a service at a current price of $1/day/vehicle which includes the Relayer, one driver's identification badge with Panic Button, and two RFID tags for cargo or wall mount. The price is based on a two-year contract, with a $200 security deposit refundable at lease termination. The price includes the utilities described above (i.e., route deviation, driver location alerts, panic button functionality, text message alerts, etc.). Additional RFID tags are available for purchase at $25 - $32 depending on quantity.

original signed by Lisa McCauley 9/24/09
Lisa McCauley Date
Operations Manager
Chemical, Environmental, and Materials Operations
National Security Global Business
Battelle

original signed by Sally Gutierrez 9/29/09
Sally Gutierrez Date
Director
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency