System Assessment and Validation for Emergency Responders (SAVER)

Handheld Photoionization Detectors Focus Group Report

April 2013

Homeland Security

Science and Technology

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

Prepared by National Security Technologies LLC

The *Handheld Photoionization Detectors Focus Group Report* was funded under Military Interdepartmental Purchase Request number AGRN6523612MP00240 from the Space and Naval Warfare Systems Center Atlantic on behalf of the U.S. Department of Homeland Security, Science and Technology Directorate.

FOREWORD

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL). The SAVER Program mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency responder equipment; and
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use, and maintain emergency responder equipment.

Information provided by the SAVER Program will be shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state, and local responders.

The SAVER Program is supported by a network of Technical Agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?"

As a SAVER Program Technical Agent, National Security Technologies LLC (NSTec) has been tasked to provide expertise and analysis on key subject areas, including chemical, biological, radiological, nuclear, and explosives (CBRNE) detection; countermeasures; and test and evaluation, among others. In support of this tasking, NSTec will conduct a comparative assessment of handheld photoionization detectors (PIDs) for gas phase chemical detection to provide emergency responders with reference information on currently available technologies. Handheld PIDs fall under AEL reference number 07CD-01-DPPI titled Detector, Photo-Ionization (PID), Point, Volatile Organic Chemical (VOC). As part of the project, assessment recommendations and operational needs were gathered from a focus group and are highlighted in this report.

Visit the SAVER section of the DHS S&T website for more information on the SAVER Program or to view additional reports on handheld PIDs or other technologies.

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1. INTRODUCTION

Handheld photoionization detectors (PIDs) are small, lightweight devices that can rapidly detect volatile organic compounds and other chemicals in parts per million (ppm) and parts per billion (ppb) concentration ranges. Emergency responders often mount handheld PIDs to remotely operated vehicles for plume mapping or collecting data prior to their entry into a spill area. The System Assessment and Validation for Emergency Responders (SAVER) Program plans to conduct a comparative assessment of handheld PIDs for gas phase chemical detection to provide emergency responders with information that will assist with making operational and procurement decisions. The handheld PIDs SAVER assessment will be conducted by emergency response professionals based on the recommendations presented in this report. The project will focus on intrinsically safe, handheld PIDs that can be decontaminated.

In support of the comparative assessment, a focus group met in December 2012 with the primary objectives of recommending evaluation criteria, product selection criteria, products, and scenarios for the assessment. Nine emergency responders from various jurisdictions participated in the focus group. The participants, highlighted in Table 1-1, possessed strong backgrounds using PIDs in a variety of scenarios (e.g., facility monitoring, tactical entry, closed space entry, forensics, chemical cleanup, area monitoring), which facilitated meaningful and productive discussions.

All of the participants acknowledged they did not have an employment or financial relationship that could create a potential conflict of interest with the work to be performed by the SAVER Program. Participants signed a nondisclosure agreement and a conflict of interest statement.

Table 1-1. Focus Group Participants

Participant	Years of Experience	State
Firefighter—HazMat, CBRNE, CT, ICS, WMD	30	CA
Law Enforcement—HazMat, CBRN, WMD	24	CA
Firefighter—HazMat, Medical Decontamination	24	CA
Law Enforcement—ARMOR	24	NV
Law Enforcement—CBRN, CT	18	VA
Firefighter—HazMat	16	VA
Law Enforcement—HSB/ARMOR, CBRNE	15	NV
Law Enforcement—HazMat, CT, CBRN, WMD	13	VA
Incident Commander Advisor—CBRNE	7	DoD

Acronyms:
ARMOR—All Hazards, Regional, Multi-Agency, Operations, and Response
CBRN—Chemical, Biological, Radiological, and Nuclear
CBRNE—Chemical, Biological, Radiological, Nuclear, and Explosives
CT—Counter-Terrorism
DoD—Department of Defense
HazMat—Hazardous Materials
HSB—Homeland Security Bureau
ICS—Incident Command System
WMD—Weapons of Mass Destruction

2. FOCUS GROUP METHODOLOGY

The focus group opened with an overview of the SAVER Program, PIDs technology, and focus group goals and objectives. Once the background material was covered, a facilitator led focus group discussions on four sets of recommendations:

- Evaluation criteria recommendations–General criteria that are important to consider when making acquisition or operational decisions;
- Assessment scenario recommendations–Scenarios in which the products should be assessed to evaluate their performance;
- Product selection criteria recommendations–Criteria that identify specifications, attributes, or characteristics a product should possess to be considered for the assessment; and
- Product recommendations–Products and vendors that are relevant to the emergency responder community and should be candidates for inclusion in the comparative assessment.

Figure 2-1 highlights the process followed to gather these recommendations.

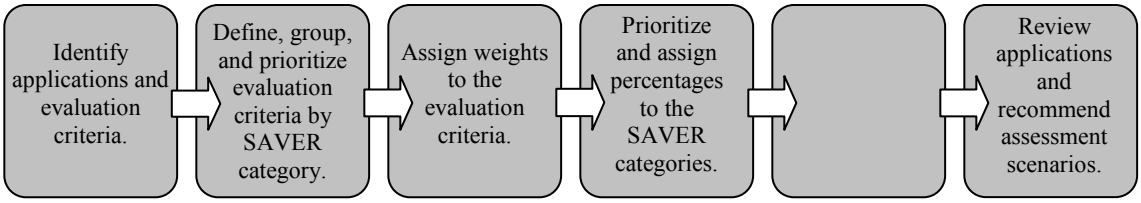

Figure 2-1. Focus Group Process

Focus group participants first identified applications in which handheld PIDs are commonly used. Next, the focus group participants identified and defined evaluation criteria, which were then grouped and prioritized in the SAVER categories: Affordability, Capability, Deployability, Maintainability, and Usability. The SAVER categories are defined as:

- Affordability–Groups criteria related to life-cycle costs of a piece of equipment or system;
- Capability–Groups criteria related to the power, capacity, or features available for a piece of equipment or system to perform or assist the responder in performing one or more relevant tasks;
- Deployability–Groups criteria related to the movement, installation, or implementation of a piece of equipment or system by responders at the site of its intended use;
- Maintainability–Groups criteria related to the maintenance and restoration of a piece of equipment or system to operational condition by responders; and
- Usability–Groups criteria related to the quality of the responders' experience with the operational employment of a piece of equipment or system. This includes the relative ease of use, efficiency, and overall satisfaction of the responders with the equipment or system.

Once the evaluation criteria were prioritized within the SAVER categories, focus group participants assigned a weight for each criterion's level of importance on a 1 to 5 scale, where 5 is of utmost importance and 1 is somewhat important. Table 2-1 highlights the evaluation criteria weighting scale.

Table 2-1. Evaluation Criteria Weighting Scale

Weight	Definition
5	**Utmost importance** *"I would **never** consider purchasing a product that does not meet my expectations of this criterion or does not have this feature."*
4	**Extremely important** *"I would be **hesitant** to purchase a product that does not meet my expectations of this criterion or does not have this feature."*
3	**Very important** *"Meeting my expectations of this criterion or having this feature would **strongly** influence my decision to purchase this product."*
2	**Important** *"Meeting my expectations of this criterion or having this feature would **slightly** influence my decision to purchase this product."*
1	**Somewhat important** *"Other things being equal, meeting my expectations of this criterion or having this feature **may** influence my decision to purchase this product."*

After the evaluation criteria were assigned a weight, the focus group participants recommended whether the criteria should be assessed operationally or according to vendor-provided specifications. Next, considering the evaluation criteria in each category, the focus group participants ranked the SAVER categories in order of importance. Based on the ranking, a percentage was assigned to each category to represent its level of importance.

Next, the focus group participants identified vendors that should be considered for the assessment. Lastly, the focus group participants reviewed the applications identified at the beginning of the focus group session and recommended assessment scenario considerations.

3. EVALUATION CRITERIA RECOMMENDATIONS

The focus group identified 25 evaluation criteria and concluded that Capability was the most important SAVER category, followed by the Usability, Affordability, Deployability, and Maintainability categories, respectively. Table 3-1 presents the category weights, the evaluation criteria, and the evaluation criteria weights.

Table 3-1. Evaluation Criteria

SAVER CATEGORIES				
Capability	**Usability**	**Affordability**	**Deployability**	**Maintainability**
Overall Weight 30%	Overall Weight 25%	Overall Weight 20%	Overall Weight 15%	Overall Weight 10%
Evaluation Criteria				
Performance Weight: 4	**User Interface** Weight: 4	**Initial Costs** Weight: 3	**Operational Environment and Ruggedness** Weight: 5	**Maintenance Tasks** Weight: 3
Multi-Sensor Capability Weight: 4	**Ergonomics** Weight: 4	**Maintenance Costs** Weight: 3	**Start-Up** Weight: 3	**Warranty and Repair** Weight: 3
Alarm Communication Weight: 3	**Alerts and Notifications** Weight: 3	**Consumable Costs** Weight: 3	**Portability** Weight: 3	
Detection Range Weight: 3	**System Diagnostics** Weight: 3			
Chemical Library Weight: 3	**Software** Weight: 2			
Communication Interface Weight: 3	**Accessories** Weight: 2			
Power Source Weight: 2				
Data Logging Weight: 2				
Data Transfer Weight: 2				
Data Storage Weight: 2				

3.1 Capability

Ten Capability criteria were identified and defined by the focus group.

Performance refers to how much time is required for the device to detect a chemical and communicate an alarm as well as how much time is required for recovery if the detector is saturated (also called "clear down"). The focus group noted that the pump speed should be adjustable either by the user or automatically and the pump should automatically shut off if it becomes blocked or encounters fluids.

Multi-sensor capability refers to if the device can be connected to compound- or hazard-specific sensors. The focus group was interested in knowing the number and variety of available sensors, either as part of the standard device or as accessories.

Alarm communication refers to the number and type of available alarm modes (e.g., lights, vibration, display messages, audible sounds), if the alarm modes are configurable, and the availability of a stealth mode in which an alarm is not apparent to other people near or in view of the device. Other considerations include the volume of the alarms, the ability to configure different sounds for different alarm types, and if alarms can be heard or seen when wearing personal protective equipment (PPE).

Detection range refers to whether the device can detect volatile chemical compounds in ppm, ppb, or both concentration ranges. Other considerations include operator selection of the concentration range used for detection, the ability of the device to perform auto-scaling, or both.

Chemical library refers to the number of chemicals in the library, ease of library navigation when selecting a specific chemical, whether mission-specific libraries exist or can be configured, the ability to create user-specific libraries, and the ability to update the libraries.

Communication interface refers to the communication interface of the device (e.g., standard cable connections, cellular links, Bluetooth®, radio), the ability to encrypt communications, and the ability to link the device to a network in the field through accessories or built-in capabilities.

Power source refers to the types and availability of power options, including if batteries are removable and rechargeable, if there is an option to use commercially available batteries (e.g., standard C-cell batteries in a pack), and if batteries are hot swappable. The focus group was interested in knowing the number and type of charging options (e.g., 110 VAC, 12 VDC), options for external power sources, battery life, and recharge time.

Data logging refers to the ability to create files specific to a deployment or measurement, the ability to name and date/time stamp the data files with operator-selected titles, and the ability to add metadata and user input to the files. Other considerations include the ability to set the frequency of data logging, the range of the data logging frequency (i.e., from seconds to minutes to hours), and what happens when the file is full (e.g., data is overwritten, a new file is created, the device stops data logging, the user is notified).

Data transfer refers to the ease of transferring or downloading data, including the ease of connection using the cable or wireless interface and the ability for plug-and-play data transfer and access. The focus group noted that they prefer data transfer methods that do not require software to be installed.

Data storage refers to whether data are stored internally or on removable storage media. The focus group noted that they prefer standard data storage formats that can be opened with common computer programs such as a word processor or spreadsheet. Other considerations include the layout of the information presented.

3.2 Usability

Six Usability criteria were identified and defined by the focus group.

User interface refers to the readability of displays; backlight intensity or display brightness; and organization, understandability, and ease of menu navigation during pre-deployment and down-range operations. Other considerations include the ease of setting alarm limits, recording intervals, and other parameters; the ability to pre-configure and then lockout menu choices; the ability to password protect the advanced mode; the ease of password entry and change; and the ability to use and configure the device with minimal training.

Ergonomics refers to the number and type of attachment points, the availability of clips and straps, user-input button size and shape, and good tactile feel and feedback from buttons (e.g., positive click, other indication the button has been pushed). Other considerations include the ability to operate the device with one hand, gloves, or PPE. In general, it refers to handling and operation of the device down range or during measurements.

Alerts and notifications refers to the existence of alarms for lamp failure, pump failure, clogged filters, or other performance issues; plain text error notifications that describe the issue (i.e., not cryptic error codes); and configurable alarm levels. The focus group was interested in the behavior of the device upon saturation or overload (i.e., whether the device displays or records a zero value or provides an indication of overload). Other considerations include the ability to shut off alarms remotely and silence or suppress alarms for a short period of time (e.g., alarm acknowledgement button).

System diagnostics refers to the types of sensor health notifications available and the ability to configure the device health notifications (e.g., set the device to alarm on failure, provide regular acknowledgment of a working system).

Software refers to included personal computer software that supports real-time reporting during measurements and post-measurement analysis. Other considerations include the types and usefulness of the graphics output, the ability to operate or run required software without administrative rights on the computer, and the ability to configure the device from the computer. Users should also determine whether the software needs to be pre-loaded on the computer or the software can be loaded from the device.

Accessories refers to the variety of available accessories (e.g., calibration docking stations, lamp cleaning kits, lamp kits with different bulbs such as krypton or xenon bulbs, storage and carrying cases). The focus group was also interested in accessories that, based on user-selectable criteria, can physically capture a sample for further analysis using other instruments.

3.3 Affordability

Three Affordability criteria were identified and defined by the focus group.

Initial costs refers to the cost of the device, accessories, and software. Other considerations include warranty duration, scope, and cost; the cost and duration of service contracts; trade-in options; the life expectancy of the device; and which chemical libraries are available.

Maintenance costs refers to the cost of replacement parts, extended warranties, upgrades (e.g., software upgrades, library upgrades), and major components (e.g., batteries, wands, tubing, other special equipment).

Consumable costs refers to the cost of common consumable items (e.g., filters, calibration gas, lamps, clips, straps) and factors such as the life expectancy of lamps and the shelf life of calibration gas.

3.4 Deployability

Three Deployability criteria were identified and defined by the focus group.

Operational environment and ruggedness refers to how the environment (e.g., dust, temperatures, wind, humidity) affects the function of the device, whether the device is splash resistant or submersible, the drop and impact resistance of the device, and the recommended decontamination methods.

Start-up refers to the time required for the device to become fully operational once it is initially activated (e.g., time for warm up, internal checks), the ready procedures required when starting the device (e.g., starts in a ready state or requires configuration before use), the procedures and methods to perform a confidence (bump) test, the existence and usefulness of a system self-check, and if the device can be configured to start in a previously selected mode.

Portability refers to the size and weight of the device as well as how easy it is to carry or move.

3.5 Maintainability

Three Maintainability criteria were identified and defined by the focus group.

Maintenance tasks refers to the ease of and requirements for calibration. Other considerations include whether batteries, filters, and lamps can easily be changed in the field or if they require special tools.

Warranty and repair refers to maintenance contracts, service center locations (e.g., foreign, domestic), and if loaner devices are available.

Support refers to the availability and usefulness of technical support, user manuals, and support documents, as well as the existence of reach-back support. The focus group was interested in knowing the duration(s) and variety of available vendor training, how often the training is offered, and which certifications are available, as well as if a “train-the-trainer” course is offered.

4. EVALUATION CRITERIA ASSESSMENT RECOMMENDATIONS

The focus group provided recommendations on whether the evaluation criteria should be assessed operationally or according to vendor-provided specifications. In an operational assessment, evaluators assess criteria based on their hands-on experience using the product. In a specification assessment, evaluators assess criteria based on product information provided by the vendor.

Table 4-1 presents the focus group's assessment recommendations for the evaluation criteria.

Table 4-1. Evaluation Criteria Assessment Recommendations

Category	Criteria	Operational	Specification
Capability	Performance	✓	
	Multi-Sensor Capability		✓
	Alarm Communication	✓	
	Detection Range	✓	✓
	Chemical Library		✓
	Communication Interface	✓	✓
	Power Source	✓	✓
	Data Logging	✓	
	Data Transfer	✓	
	Data Storage	✓	
Usability	User Interface	✓	
	Ergonomics	✓	
	Alerts and Notifications	✓	
	System Diagnostics	✓	
	Software	✓	
	Accessories	✓	
Affordability	Initial Costs		✓
	Maintenance Costs		✓
	Consumable Costs		✓
Deployability	Operational Environment and Ruggedness	✓	✓
	Start-Up	✓	
	Portability	✓	
Maintainability	Maintenance Tasks	✓	✓
	Warranty and Repair		✓
	Support	✓	✓

5. ASSESSMENT SCENARIO RECOMMENDATIONS

The focus group identified the following as the most common applications in which they use handheld PIDs:

- Hazardous materials (HazMat) community–handheld deployment to a spill or event to characterize, map, and monitor the spill and area and the ability to mount a PID onto an unmanned aerial vehicle for airborne plume mapping;
- Personnel safety–attach a PID to personnel to monitor conditions or mount a PID on a robot to collect data prior to emergency responder entry;

- Monitor confined spaces–both over short (minutes to hours) and long (days) time periods;
- Plume detection–includes spills, area monitoring, and detection at the perimeter;
- Well dive–searching for body decomposition gases in a well or deep confined space;
- Leak detection–locate and characterize a point source;
- Spill response–verify a spill occurred, characterize its location and size, and verify the results of the cleanup; and
- Odor complaint–verify the presence of chemicals.

Based on these applications, the focus group recommended the following assessment scenario considerations in which products could be assessed using the recommended evaluation criteria (Table 4-1):

- Evaluate the display in sunlight, a dark room, and through a steamy PPE mask;
- Assess the ease of device operation in different positions or orientations and if the device weight prohibits holding the device above head level, at foot level, at a point source in an awkward location, or down into a large drum;
- Verify that the pump speed is adjustable and the device can draw a sample through up to 6 feet of tubing;
- Evaluate the time to take a sample through 6 feet of tubing;
- Assess if the user can change the alarm level while wearing PPE and if the device has different alarm modes (e.g., different sounds for different alarm types, different behavior on alarm, alarm acknowledgement methods);
- Evaluate how the device functions in hot conditions (especially the readability of screens), cold conditions (e.g., freezer), humid conditions (e.g., steam room), and dry dusty conditions;
- Verify the behavior of the device under failure modes, including blocked tubes, water in the pump, a clogged filter, and sensor saturation;
- Characterize the difficulty of expected minor field repairs or maintenance activities such as changing batteries, lamps, tubes, and filters;
- Verify detection of a selected chemical from 10 ppb to 100 ppm range and characterize device behavior on saturation;
- Characterize the options and difficulty of creating files, the ability to add information to these files such as meaningful file names or the location at which measurements were taken, file readability, and ease of transferring data to a computer;
- Characterize operation under battery power (e.g., operating time from full charge to low battery to simulate an area monitoring scenario, recharge time from full discharge, battery type);
- Verify the range and type of wireless communications and determine if the PID will interface to standard communication protocols;
- Evaluate start-up procedures, including start-up time and any user input required on start-up; and
- Characterize the usability of accessories such as docking stations, sampling tubes (e.g., how to attach and remove), wrist straps (e.g., attachment and use), vest attachments, and other attachment points or straps.

6. PRODUCT SELECTION RECOMMENDATIONS

The focus group participants recommended products from the following vendors be considered for the assessment:

- RAE Systems Inc.;
- MSA; and
- Dräger Safety Inc.

7. FUTURE ACTIONS

The focus group recommendations will be used to guide the development of the upcoming SAVER assessment. Once the assessment is complete, the results will be available through the SAVER section of the Responder Knowledge Base (RKB) website.

8. ACKNOWLEDGEMENTS

The SAVER Program thanks the focus group participants for their valuable time and expertise. Their insights and recommendations will guide the planning and execution of the handheld PIDs assessment as well as future SAVER projects. Appreciation is also extended to the home jurisdictions of the participants for allowing them to participate in the focus group.