



Portable Radiation Portal Monitors

Assessment Report

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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 commercially available equipment and systems and develops knowledge products that provide relevant equipment information to the emergency responder community. The SAVER Program mission includes:

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

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: “What equipment is available?” and “How does it perform?” These knowledge products are 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 managed by the National Urban Security Technology Laboratory (NUSTL). NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, coordinating with other organizations and ensuring flexibility and responsiveness to first responder requirements.

NUSTL provides expertise and analysis on a wide range of key subject areas, including chemical, biological, radiological, nuclear and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation and technologies. NUSTL developed this report to provide emergency responders with information obtained from an operationally oriented assessment of portable radiation portal monitors, which fall under AEL reference number 15SC-00-PMON titled Monitors, Portal.

For more information on NUSTL’s SAVER Program or to view additional reports on portable radiation portal monitors or other technologies, visit www.dhs.gov/science-and-technology/SAVER.

U.S. Department of Homeland Security



System Assessment and Validation for Emergency Responders

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EXECUTIVE SUMMARY

In December 2016, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted an operationally oriented assessment on portable radiation portal monitors (PRPMs).

Five PRPMs operating in pedestrian scanning mode were assessed by emergency responders at the Brookhaven National Laboratory in Upton, New York. The criteria and scenarios used in this assessment were derived from the results of a focus group of emergency responders with experience using PRPMs. The assessment addressed 25 evaluation criteria in four SAVER categories: Capability, Deployability, Maintainability and Usability. The overall results of the assessment are highlighted in the below table.

Product	Overall Score	Overall	Usability	Deployability	Capability	Maintainability
WB Johnson Instruments AM-801		4.2	4.2	4.4	4.1	4.2
Ludlum Measurements, Inc. Model 52-1-1		4.0	4.0	4.4	3.9	3.7
Technical Associates, Inc. PPVM		3.4	3.4	3.3	3.3	3.7
Rapiscan Systems TPM-903B		3.1	2.8	3.4	3.8	2.7
Rapiscan Systems PM-704		2.8	2.8	2.7	3.2	2.4
	0 1 2 3 4 5 Least Favorable Most Favorable					

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1.0 INTRODUCTION

Portable radiation portal monitors (PRPMs) are used by police, security and emergency response personnel to quickly screen people for the presence of radioactive materials. The main application for these devices is monitoring large populations for contamination after a radiological or nuclear incident. They may also be used to screen people entering or leaving a sensitive area. PRPMs can be assembled and disassembled into transportable carrying cases. They contain non-spectroscopic detectors that measure gamma and beta radiation, and alarm when an elevated radiation field occurs while a person is in the portal or in the vicinity of the portal depending on the mode of operation. Although designed primarily for scanning pedestrians, many PRPMs have an option for vehicle scanning as well.

In December 2016, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted an operationally oriented assessment on PRPMs. The purpose of this assessment was to obtain information on PRPMs that will be useful in making operational and procurement decisions. The activities associated with this assessment were based on recommendations from a focus group of emergency responders with experience using PRPMs.

1.1 EVALUATOR INFORMATION

Five emergency responders from various jurisdictions and with at least 5 years of experience using PRPMs were selected to be evaluators for the assessment. Evaluator information is listed in Table 1-1. Prior to the assessment, evaluators signed a nondisclosure agreement, conflict of interest statement, photo release form and informed consent form.

Table 1-1 Evaluator Information

Evaluator	Years	State
Environmental Administrator, Radiation Protection	20+	FL
Director, County Department of Health	20+	NY
Emergency Manager, Registered Nurse, Retired Police Officer	20+	NY
Radiation Health Specialist, State Department of Health	10-15	NY
Health Physicist, Radiation Safety Officer	5-10	CO

1.2 ASSESSMENT PRODUCTS






Five products were selected and purchased for the assessment based on market research and the focus group's recommendations. Final selection was based on how well each product met the product selection criteria identified by the focus group:

- System assembles and disassembles into transportable package(s)
- System configures into a portal suitable for scanning pedestrians
- System detects occupancies within the portal
- System alarms on elevated radiation.

The products selected for assessment were the only commercially available products on the market that met all product selection criteria. The focus group recommended the inclusion of all five of these products in the assessment.

Table 1-2 presents the products that were assessed.

Table 1-2 Assessed Products

Vendor	Product	Product Image
Ludlum Measurements, Inc.	Model 52-1-1	
Rapiscan Systems	TPM-903B	
Rapiscan Systems	TSA PM704	
Technical Associates, Inc.	Portable Personnel and Vehicle Monitor (PPVM)	
WB Johnson Instruments	AM-801	

2.0 EVALUATION CRITERIA

The SAVER Program assesses products based on criteria in five established categories:

- **Affordability** groups criteria related to the total cost of ownership over the life of the product. This includes purchase price, training costs, warranty costs, recurring costs and maintenance costs.
- **Capability** groups criteria related to product features or functions needed to perform one or more responder relevant tasks.
- **Deployability** groups criteria related to preparing to use the product, including transport, setup, training and operational/deployment restrictions.
- **Maintainability** groups criteria related to the routine maintenance and minor repairs performed by responders, as well as included warranty terms, duration and coverage.
- **Usability** groups criteria related to ergonomics and the relative ease of use when performing one or more responder relevant tasks.

The focus group of emergency responders met in March 2016 and identified 47 evaluation criteria within five SAVER categories: Affordability, Capability, Deployability, Maintainability and Usability. They assigned a weight for each criterion's level of importance on a scale of 1 to 5, with 1 being somewhat important and 5 being of utmost importance. The SAVER categories were assigned a percentage to represent each category's importance relative to the other categories.

Products were assessed against 25 evaluation criteria within four SAVER categories; 22 other criteria recommended by the focus group, including the Affordability category criteria, were not assessed. Warranty, Availability of Parts, Standard Equipment Parts, Modularity, Maintenance Cost, Initial Cost, Repair Cost, Upgrade/Add-On Cost, Training Cost, Temperature and Relative Humidity Range, Ease of Calibration and Calibration Standards/Operational Checks were not assessed because these specifications are better assessed by individual agencies as part of the procurement process. Wireless Capability, Innovative Redesign, Networking of Power Cords, Ability to Eliminate Carrying Case, Person Identification, Camera and Remote Alarm were not assessed because all or most systems did not have these features. Water Resistance, Networking and Shielding/Crosstalk Reduction were not assessed because doing so would have been too difficult and time consuming, and would have required special equipment that was not available.

Table 2-1 presents the evaluation criteria and their associated weights as well as the percentages assigned to the SAVER categories. Refer to Appendix B for more thorough evaluation criteria definitions. Because the criteria in the Affordability category were not assessed, this category was removed from the assessment. The remaining category weights, which were originally weighted at 20 percent, were changed to 25 percent.

Table 2-1 Evaluation Criteria

SAVER CATEGORIES				
Affordability	Capability	Deployability	Maintainability	Usability
Overall Weight 0%	Overall Weight 25%	Overall Weight 25%	Overall Weight 25%	Overall Weight 25%
Evaluation Criteria				
Warranty Not Assessed	Emergency Event Throughput Weight: 5	Wheelchair Accessibility Weight: 5	Water Resistance Not Assessed	User-Friendly Control Weight: 5
Availability of Parts Not Assessed	Vertical (Head-to-Toe) Coverage Weight: 5	Innovative Redesign Not Assessed	Durability Weight: 5	Alarms/Alarm Configurability Weight: 4
Standard Equipment Parts Not Assessed	Ability to Meet Appropriate Detection Standards Weight: 4	Weight Weight: 4	Stability Weight: 5	Adjustable Count Time Weight: 4
Modularity Not Assessed	Shielding/Crosstalk Reduction Not Assessed	Storage Volume Weight: 4	Ease of Calibration Not Assessed	Data Logging Capability Weight: 3
Maintenance Cost Not Assessed	Source Localization Ability Weight: 4	Wheeled Carrying Case Quality Weight: 4	System Diagnosis or Self-Check Weight: 5	Moveable Display Weight: 3
Initial Cost Not Assessed	Background Subtraction and Reset Weight: 3	Ease of Setup and Disassembly Weight: 4	Decontaminability Weight: 4	Person Identification Not Assessed
Repair Cost Not Assessed	Networking Capability Not Assessed	Labelling or Color-Coding for Easy Assembly Weight: 4	Calibration Standards Operational Checks Not Assessed	Software Configurability Weight: 3
Upgrade Add-On Cost Not Assessed	Wireless Capability Not Assessed	Temperature and Relative Humidity Range Not Assessed	Ruggedness Weight: 4	Camera Not Assessed
Training Cost Not Assessed	Background Configurability Weight: 2	Battery Options and Battery Life Weight: 3		Remote Alarm Not Assessed
	Non-Emergency Throughput Weight: 2	Networking of Power Cords Not Assessed		
		Ability to Eliminate Carrying Case Not Assessed		

3.0 ASSESSMENT METHODOLOGY

Five products were assessed at Brookhaven National Laboratory (BNL) over 3 days. On the first day of the assessment, a BNL facilitator presented a safety briefing, which was followed by an overview of the assessment process, procedures and schedule by the NUSTL project manager. Specifications were provided for applicable criteria (e.g., battery operating time), and the specifications were confirmed by the vendors. Each product was then assessed in an indoor operational environment with the portals configured in pedestrian screening mode. Four products that have vehicle screening capability were subsequently assessed in an outdoor operational environment in vehicle screening mode.

During the operational assessment, evaluators assessed each product based on their hands-on experience using the product after becoming familiar with its proper use, capabilities and features. BNL facilitators and NUSTL staff members assisted the evaluators throughout the assessment, and vendor representatives were on hand to answer technical questions. The vendors provided an equipment familiarization session during each product assessment.

3.1 PEDESTRIAN SCREENING

Evaluators assessed each product in its standard configuration for screening pedestrians for the first two days of the assessment. Evaluators assessed the products in four scenarios: (1) portal deployment, (2) equipment familiarization, (3) community reception center screening and (4) employee contamination screening. Evaluators were broken into two teams for each scenario. Team A had three evaluators and Team B had two evaluators. Teams worked together to assemble the portals, operate them, and screen individuals (BNL facilitators and NUSTL staff members) passing through the portal as part of the scenarios. Through a series of rotations, each evaluator used each product and provided scores and comments for each product before assessing the next product.

3.1.1 PORTAL DEPLOYMENT SCENARIO

Emergency responders are often asked to deploy PRPMs at remote locations such as school gymnasiums and sporting event parking lots. They must transport the PRPM, assemble it, power it up and initialize it before any screening can occur. This scenario simulated a portal deployment. Starting with the PRPM system packed in its carrying case, evaluators were asked to work as a team and perform the following tasks:

- Carry or wheel the system to the designated deployment area
- Assemble the system
- Install batteries and power up the system
- Go through the start-up process including background acquisition, system checks, etc.



Figure 3-1 Evaluators assembling a PRPM

3.1.2 EQUIPMENT FAMILIARIZATION SCENARIO

Once the system was assembled and operational, the vendor representatives provided an equipment familiarization session for the evaluators that included an overview of the system's detectors, modes of operation, display screens, software and menus. Vendors also trained the responders on how best to use the product, including but not limited to:

- Perform calibration or operational checks (if needed)
- Read displays and access display screens using the control panel
- Set alarm parameters and other key performance parameters
- Screen pedestrians in walk-through mode and stop-and-count mode
- Download data to a computer

3.1.3 COMMUNITY RECEPTION CENTER SCENARIO

Emergency response planning for radiological and nuclear events involves monitoring the population for radiological contamination that may be deposited on the skin and clothing. Many emergency response agencies would operate community reception centers in public spaces such as school gymnasiums to screen individuals for contamination should such an event occur. The main emphasis of the community reception center scenario was to simulate a large-scale population monitoring event with individuals lined up at the PRPMs for screening.

Evaluators were told to initialize the system in walk-through mode with the system default settings. BNL facilitators and NUSTL staff members then provided a series of exercises designed to gauge PRPM performance in a community reception center scenario. The following exercises were provided:

- A source carrierⁱ walked a 2-microcurieⁱⁱ cesium-137 source through the portal three times with the source midway between the portal side panels.
- Several source carriers simulated a line of approximately 20 people being screened and walked through the portal with various sources, some of which were blanks, and returned to the end of the line.
- A source carrier walked a radiation source through the portal four times, with sources in a different quadrant of the portal each time.
- A source carrier in a wheelchair was pushed through the portal monitor twice, once with a source and once without.

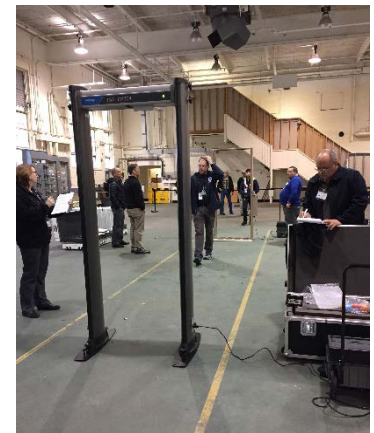


Figure 3-2 Evaluators screen a line of source handlers

ⁱ Source carriers were BNL personnel who were trained to safely handle radiation sources while minimizing exposure.

ⁱⁱ The FEMA Radiological Emergency Preparedness-21 standard states that a portal used for contamination screening should alarm on a 1-microcurie cesium-137 source; however, a 1-microcurie source was not available at the site, and the exercise was not designed as a standard conformance test. It was simply to provide a source that should alarm the portals.

Evaluators were then allowed to change alarm settings and other parameters, and the exercises were repeated several times. Some evaluators asked for source handlers to walk through the portal with sources in positions that could elude detection, such as having the source over their head or down near their feet or tucked into their clothing. These exercises were provided as requested. Cobalt-60, cobalt-57, and barium-133 sources were also used as part of the exercises.

3.1.4 EMPLOYEE CONTAMINATION SCREENING SCENARIO

Emergency response personnel may perform drills and inspections at nuclear power plants or respond to incidents in which they may be contaminated with radioactive material. Agencies often screen their employees and vehicles for contamination after such events. Such screening is typically performed with longer count times than used in walk-through screening. For this scenario, evaluators were asked to perform the following activities:

- Set the portal to stop-and-count mode with a short count time (approximately 5 seconds)
- Screen several persons, some with sources and some without sources
- Screen at least one person in a wheelchair
- Set the count time to approximately 20 seconds and repeat each exercise.
- Lantern mantles containing a small amount of the naturally occurring radionuclide thorium-232 were used to simulate low-level contamination that may be detected with stop-and-count mode.

3.2 VEHICLE SCREENING

Four of the five products included in this assessment have either vehicle screening as a standardⁱⁱⁱ feature or optional vehicle screening kits^{iv}. Evaluators assessed each of these four products in vehicle screening mode on Day 3 of the assessment. In the morning, assessment participants gathered at an outdoor test facility at BNL and a facilitator provided a safety briefing and overview of the vehicle assessment process. Evaluators worked together to assemble each PRPM product with their vertical panels on opposite sides of a roadway. Systems were set up in series with approximately 10 feet between them so that a vehicle could drive through all four portals. The main challenges of the assembly process were finding a level spot for each vertical panel and getting the vertical panels aligned so that the occupancy sensors were functional.



Figure 3-3 Assembly of PRPMs in vehicle mode

ⁱⁱⁱ The PPVM does not have a top panel and can thus be configured for pedestrians or vehicles.

^{iv} The vehicle kits for the TPM-903 and AM-801 were purchased. The vehicle kit for the 52-1-1 was loaned by a vendor representative.

3.2.1 VEHICLE SCREENING SCENARIO

Emergency responders often use PRPMs to screen vehicles at traffic chokepoints such as the entrance to parking areas at high profile events. The vehicle screening scenario simulated a traffic chokepoint screening event. With the PRPMs assembled along a test roadway, a source truck was driven through the chokepoint, and evaluators observed whether or not the systems alarmed and noted other important performance information such as whether it gave an indication of the location of the source in the vehicle. The tests were repeated several times using sources of different radionuclides and activities and with the sources in various locations within the truck.

Since vehicle screening is not the main application for PRPMs and not all products contained this feature, scores and comments for vehicle screening are presented separately in Appendix A. Furthermore, scoring included a subset of the criteria used for assessing the portals in pedestrian screening mode.

3.3 DATA GATHERING AND ANALYSIS

Each evaluator was issued a folder containing vendor-provided information, specifications and product score sheets. Evaluators used the following 1 to 5 scale to score the criteria for each product:

- 1.) The product meets none of my expectations for this criterion
- 2.) The product meets some of my expectations for this criterion
- 3.) The product meets most of my expectations for this criterion
- 4.) The product meets all of my expectations for this criterion
- 5.) The product exceeds my expectations for this criterion

Refer to Appendix B for evaluation criteria definitions. Criteria with multiple scoring factors were assigned final overall scores by the evaluators. Facilitators captured comment related to each of the evaluation criteria as well as overall advantages and disadvantages of the assessed products. Once assessment activities were completed, evaluators had an opportunity to review their criteria ratings and comments for all products and make adjustments as necessary.

At the conclusion of assessment activities, an overall assessment score, as well as category scores and criteria scores, were calculated for each product using the formulas referenced in Appendix C. In addition, evaluator comments for each product were reviewed and summarized for this assessment report.

4.0 ASSESSMENT RESULTS

Overall scores for the assessed products ranged from 2.8 to 4.2. Table 4-1 presents the overall assessment score and category scores for each product. Products are listed in order from highest to lowest overall assessment score throughout this section. Calculation of the overall score uses the raw scores for each category, prior to rounding; products with the same rounded overall score are in order based on the raw data.

Table 4-1 Overall Ratings

Product	Overall Score	Overall	Usability	Deployability	Capability	Maintainability
WB Johnson Instruments AM-801		4.2	4.2	4.4	4.1	4.2
Ludlum Measurements, Inc. Model 52-1-1		4.0	4.0	4.4	3.9	3.7
Technical Associates, Inc. PPVM		3.4	3.4	3.3	3.3	3.7
Rapiscan Systems TPM-903B		3.1	2.8	3.4	3.8	2.7
Rapiscan Systems PM-704		2.8	2.8	2.7	3.2	2.4
	0 1 2 3 4 5 Least Favorable Most Favorable					

Table 4-2 presents the criteria ratings for each product. The ratings are graphically represented by colored and shaded circles. A green, fully shaded circle represents the highest rating. A red, unshaded circle represents the lowest rating. Refer to Appendix B for evaluation criteria definitions.

Table 4-2 Criteria Ratings



































































































































Key		Product Name				
Lowest Rating      Highest Rating						
Category	Evaluation Criteria	AM-801	Model 52-1-1	PPVM	TPM-903B	PM-704
Capability	Emergency Event Throughput					
	Vertical (Head-to-Toe) Coverage					
	Ability to Meet Appropriate Detection Standards					
	Source Localization Ability					
	Background Subtraction and Reset					
	Background Configurability					
	Non-Emergency Throughput					
Deployability	Wheelchair Accessibility					
	Weight					
	Storage Volume					
	Wheeled Carrying Case Quality					
	Ease of Setup and Disassembly					
	Labelling or Color-Coding for Easy Assembly					
	Battery Options and Battery Life					
Maintainability	Durability					
	Stability					
	System Diagnosis or Self-Check					
	Decontaminability					
	Ruggedness					
Usability	User-Friendly Controls					
	Alarms/Alarm Configurability					
	Adjustable Count Time					
	Data Logging Capability					
	Movable Display					
	Software Configurability					

Table 4-3 presents vendor-provided key specifications for the assessed products.

Table 4-3 Key Specifications

Key Specification	AM-801	Model 52-1-1	PPVM	TPM-903B	PM-704
MSRP	\$11,725	\$12,543	\$18,700	\$14,950	\$15,130
Vehicle Kit Cost	\$573	\$1,650	\$0	\$725	Not available
Warranty Duration	2 years	1 year	1 year	1 year	1 year
GSA Schedule	GS-07F-0147T	No	No	GS-07F-0147T	GS-07F-0147T
Detector Type	Plastic scintillator	Plastic scintillator	Plastic scintillator	Plastic scintillator	Plastic scintillator
Detector Quantity	4	4	2	2	2
Detector Size	36 x 3 x 1.5 in	NA	44 x 12 x 1.5 in	72 x 3 x 1.5 in	72 x 3 x 1.5 in
Weight *	110 pounds	100 pounds	128 pounds	110 pounds	190 pounds
Portal Width	36 in	32 in	24 to 240 in	32 in	32 in
Portal Height	84 in	81 in	No upper bar	84 in	80 in
Carrying Case Size	47 x 24 x 18 in	47 x 24 x 12 in	2 detectors, each: 52 x 15 x 6 in	85 x 25 x 13 in	91 x 27 x 18 in
Secondary Carrying Case Size	Vehicle Kit 32 x 24 x 17 in	None	Control Case 2 x 17 x 10 in	None	None
Battery Configuration †	9 D-cells	6 D-cells	Sealed lead acid car battery	6 D-cells	8 D-cells
Battery Life	10 hours	24 hours	28 hours	24 hours	10 hours
Operating Temperature	-4°F to 104°F	-4°F to 122°F	32°F to 158°F	-4°F to 122°F	-4°F to 122°F
Operating Relative Humidity	5 to 95%	NA	5 to 95%	NA	5 to 95%
Notes:		Abbreviations:			
* Does not include weight of carrying case		MSRP = Manufacturer's Suggested Retail Price			
† All units can be powered by alternating current or battery		GSA = General Services Administration			
		NA = Information not available			
		In = Inches			
		°F = Degrees Fahrenheit			

4.1 WB JOHNSON INSTRUMENTS, AM-801

The AM-801 (Figure 4-1) received an overall assessment score of 4.2 and has a manufacturer's suggested retail price (MSRP) of \$11,725. The system contains four separate plastic scintillator detectors, an occupancy sensor and counter, aluminum and stainless steel housing, control panel with video graphics array color touch screen and a wheeled carrying case.

The following sections, broken out by SAVER category, summarize the assessment results.

4.1.1 CAPABILITY

The AM-801 received a Capability score of 4.2. The following information is based on evaluator comments:

- Individuals could be screened satisfactorily with a high rate of throughput. There was an approximately 3-second reset between screenings in walk-through mode, and evaluators were able to screen 10 people per minute while still detecting all sources.
- The portal alarmed when sources were placed high/low and left/right within the portal. With a height of 84 inches, it is taller than most other portals, yet performed well detecting high sources.
- The control panel display showed four detector zones and indicated clearly and correctly which zone activated during an alarm. This allowed evaluators to see the location of the source by portal quadrant.
- System software allowed evaluators to set the acceptable level of background, acquired a continuous background average that updated frequently, and allowed evaluators to reset the background as needed with a reset button. Evaluators felt there was more versatility and customization of background measurements than with other models.

4.1.2 DEPLOYABILITY

The AM-801 received a Deployability score of 4.4. The following information is based on evaluator comments:

- The system in its case was light enough to be moved by a single person. One evaluator commented that it is not easily moved by a single person, but is still manageable.
- The system comes in a carrying case that is approximately 48 inches long, can fit in a closet, and can be transported in most passenger vehicles.
- The carrying case was of good quality. Components fit tightly into the case and were protected by a large amount of foam. The handles and wheels functioned adequately. One evaluator thought that the latches were slightly weak and could be improved. The case could probably be made smaller if components were arranged more efficiently and the amount of foam was reduced.



Figure 4-1 AM-801 side view with carrying case in the background

- The system was very easy to set up and disassemble. It took a team of two evaluators approximately 3 minutes to assemble the portal, and it was functioning in 5 minutes from start to finish. No tools were needed, except perhaps a step stool for someone who is not tall. Instructions in the manual were clear and illustrated well.
- Components were labelled to show where they connect with other components. One evaluator thought the labels should be larger or colored for improved clarity. It should also be noted that the labels on the base were missing, and this caused some confusion at first. The vendor representative said that this was a mistake during the manufacturing process and added the labels with a marker; this cleared up the confusion.
- Wheelchair accessibility was generally good. A 36-inch portal width allowed wheelchairs to pass through easily and allowed individuals to wheel themselves through. An evaluator with medical experience said that it was wide enough for all patient stretchers. The bottom plate was low enough to allow a wheelchair to pass through without tilting the front wheels. One problem encountered was that the optical sensor malfunctioned due to reflection from the wheelchair when it was stationary within the portal. The solution was to switch to area mode, which allows measurements even when there is no indication of a portal occupancy.
- The system ran from alternating current (AC) power and had a backup battery option of 9 D-cell batteries which will last 10 hours by specification. Evaluators felt that this was adequate, but not great. An operational period can often exceed 10 hours. There was significant sound feedback when running on battery power. This was eliminated when switched to AC power.

4.1.3 MAINTAINABILITY

The AM-801 received a Maintainability score of 4.1. The following information is based on evaluator comments:

- A well-made aluminum and stainless steel construction provided good durability. There were no observable weaknesses on the exterior. Mechanical connections were very strong, and the clips used to hold components together were user-friendly, which can prevent injuries.
- A very thin, strong baseplate provided excellent stability for the portal while still letting wheelchairs to pass through easily. The system could easily handle bumps and vibrations.
- The system appeared well designed and rugged.
- The system is constructed with smooth, flat surfaces that should allow for easy decontamination, although there are a few crevices and perforations for beta detection windows that would make decontamination a little more difficult. The system can be covered with plastic if need be.
- Detector health indication was displayed on screen with green for functioning and red for a malfunctioning detector. Battery voltage was also displayed, but there was no alert

given for low battery conditions. Evaluators would like to have had a color change displayed or audible warning given for a low battery state, which occurs at 10 volts or lower.

4.1.4 USABILITY

The AM-801 received a Usability score of 4.2. The following information is based on evaluator comments:

- The controls were very user-friendly and intuitive. One evaluator said that it was “absolutely the easiest control panel I have ever seen.” Menu options could be adjusted individually in a very quick manner, and a power cycle was not needed for adjusted parameters.
- There were audible, verbal and visible alarms that were sufficient and adjustable. Sounds could be turned off or adjusted in volume.
- An adjustable count time of 1 to 30 seconds was available when in stop-and-count mode. It was very easy and intuitive to set this parameter and it could be done on the fly without turning the system off. Changing modes between walk-through, stop-and-count and area monitor was straightforward through an easily accessible menu.
- Although not assessed operationally, it was determined that data offloading could not be done without the use of a special printer that would need to be purchased. Alternatively, there is a \$2,000-option that allows the product to be part of a meshed network with other units and wireless capable computers. This would allow the recording of all count and alarm data.
- The color touch screen was intuitive, easy to read, easy to use, and displayed all the information needed by emergency responders. It was not moveable, but would be easier to read in sunlight than other screens tested.
- Software configurability was excellent. The system had the widest range of changeable parameters and could be configured to the evaluators’ needs.

4.2 LUDLUM MEASUREMENTS, INC., MODEL 52-1-1

The Model 52-1-1 (Figure 4-2) received an overall assessment score of 4.0 and has an MSRP of \$12,543. The system contains four separate plastic scintillator detectors, an infrared sensor for portal occupancy, a control panel with a liquid crystal display (LCD) screen, aluminum housing and a wheeled carrying case.

The following sections, broken out by SAVER category, summarize the assessment results.

4.2.1 CAPABILITY

The Model 52-1-1 received a Capability score of 4.0. The following information is based on evaluator comments:

- Individuals can be screened in 2 second walkthroughs with no detection issues, making for excellent throughput.

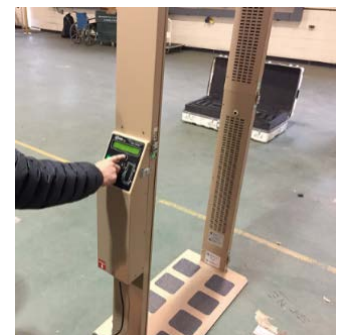


Figure 4-2 Model 52-1-1 side view with carrying case in the background

- A foot monitor is available as an option, but was not present on the unit that was assessed. The foot monitor increases sensitivity to sources near foot level. Nevertheless, evaluators found that it performed better than expected with low-elevation sources.
- The system accurately determined the quadrant (left/right, high/low) of the sources carried through the portal and gave proper indication with all alarms.
- The only way to manually reset the background is to turn the unit off and on. The background can be commanded to automatically reset at a programmed frequency by changing a parameter on the menu. However, any parameter change also requires a power cycle.

4.2.2 DEPLOYABILITY

The Model 52-1-1 received a Deployability score of 4.4. The following information is based on evaluator comments:

- The system is lightweight and easy to move. It is light enough for one person to move and deploy the system.
- The case is small enough to store and transport easily. It is small enough to fit in closets, can be stored upright or flat and will fit into almost any vehicle.
- The carrying case is light, rugged and easy to wheel around. Portal components fit well into foam cutouts within the case. The latches had room for improvement as they were a little difficult to open and close. One evaluator said that experience with this unit shows that latches must be properly closed, and that an accidental partial closure may cause them to fail under stress.
- The portal is extremely easy to assemble. Each component is marked with numbers and a color code to make connections easy. One person can assemble it in about 3 minutes without any tools. However, a flat coin or screwdriver is useful for opening the battery compartment.
- The portal's baseplate is not flat and creates a significant bump that hinders wheelchair accessibility. Wheelchairs will still go through, but must be tilted back to get past the baseplate. The portal width of 32 inches is smaller than other models, but will still accommodate a large wheelchair. However, individuals wheeling themselves through would lack elbow room requiring someone to assist them through.
- The system ran from AC power and had a backup battery option of 6 D-cells that will run for 24 hours by specification. This met the needs of all evaluators.

4.2.3 MAINTAINABILITY

The Model 52-1-1 received a Maintainability score of 3.9. The following information is based on evaluator comments:

- The portal is well constructed with a durable epoxy coating. Connections are simple and thus not prone to failure, and high quality heavy duty clips hold the unit together.

- The system has overall good stability, but could be knocked over sideways if struck hard enough. When pushing a wheelchair through, it sometimes felt like it might tip due to stress on the baseplate. Optional supports are available for increased stability.
- The system is well made, fits together well and is rugged enough to easily handle vibrations and bumps. One evaluator stated that experience with the unit shows that it handles frequent use well and is reliable over a long period.
- There are too many crevices in the system for it to be easily cleaned. The open grid on the side panels would be easy to contaminate, as would the anti-skid padding on the baseplate. However, disposable plastic sleeves can be purchased as an option to prevent contamination.
- Self-diagnostics include a low battery warning and a detector failure indicator. The system can continue operating with a failed detector. Furthermore, all parts are swappable with other units, including the display panel. This will allow a system to continue operating by using a part from another unit.

4.2.4 USABILITY

The Model 52-1-1 received a Usability score of 3.7. The following information is based on evaluator comments:

- The user-friendliness of the control panel could use improvement. The process of accessing the menus was not straightforward, and they were not intuitive once accessed. The manual may need to be consulted and there will be a bit of a learning curve. Once this is done, however, operation is not difficult. Menu parameters could be set with arrow keys and an enter key on the control panel.
- Alarm settings can be configured through the menu. Audible alarms could be turned off, but the visible alarm (flashing light) could not.
- Data logging was not tested, but it was determined that the system does not store data, but must be hooked up to a printer or computer to archive data. Otherwise, count and alarm data will be lost.
- The display was intuitive and easy to read. Volunteers with little training would have no problem with the display; however, it was fixed in place and not movable.
- Software configurability is generally good once you learn how to access the menus. There are many parameters that can be set, and the system can be configured in a variety of ways. A power cycle is required after all parameter changes.

4.3 TECHNICAL ASSOCIATES, INC., PORTABLE PERSONNEL AND VEHICLE MONITOR

The Portable Personnel and Vehicle Monitor (PPVM) received an overall assessment score of 3.4 and has an MSRP of \$18,700. The system contains two separate plastic scintillator detectors (44 x 12 x 1.5 inches each) in weatherproof plastic cases, an infrared sensor for portal occupancy, video camera and control box with a Hewlett Packard laptop computer.

The following sections, broken out by SAVER category, summarize the assessment results.

4.3.1 CAPABILITY

The PPVM received a Capability score of 3.4. The following information is based on evaluator comments:

- There are two modes available for walk-through screening. One mode detects only when the photo-beam is broken and another mode is continuous and does not use the photo-beam. Both worked well and all sources were found at a satisfactory rate.
- With a detection height of 44 inches, this portal has a significantly reduced amount of vertical coverage compared to the 72-inch detection heights of the other portals assessed. Nevertheless, sources could still be detected at head level.
- Source locations were accurately determined as left or right side, but there was no vertical localization capability.
- The background is continuously updated with a settable acquisition time, and a new background can also be commanded. However, the manual does not explain background settings well, and forcing a new background or changing the background settings requires an initialization cycle to occur.

4.3.2 DEPLOYABILITY

The PPVM received a Deployability score of 3.3. The following information is based on evaluator comments:

- There are three protective cases that come with the system as well as a collection of parts that did not come in a case including cables, an infrared photo-beam assembly, a camera, tripod, detector stands and a rubber cable protector. These parts were brought to the assessment and stored in cardboard boxes not provided by the vendor.
- Each case or box was light and easily deployable by a single person.
- Total storage volume was good. The entire system could be stored in a closet and transported in almost any passenger vehicle. While there were multiple cases, each was relatively small.
- The two detectors and the control module come in well-designed protective cases that provide good durability and water protection. However, cables and other parts are not packaged in a case, requiring an additional expense.



Figure 4-3 PPVM with camera set up in pedestrian mode

- System setup was not intuitive but could be performed in approximately 10 minutes. Detector placement was very easy, but aligning the infrared photo-beam on one detector with the photo-sensor on the other was tricky, required a screwdriver, and was more easily accomplished with two people.
- Attaching the cabling was difficult and confusing because labels or color codes were not provided. The cables that came with the system purchased for the assessment were very long and presented a trip hazard. However, the vendor representatives explained that these were custom cables made for a customer that required long cables, and were mistakenly shipped with this system.
- The variable width of the portal between the two detector panels made for good wheelchair accessibility. Other than the bump from the rubber cable cover running along the floor, there was easy movement of wheelchairs.
- The system ran on AC power with backup power from a 12-volt car battery. The battery is heavier and less convenient than the D-cells used in other systems.

4.3.3 MAINTAINABILITY

The PPVM received a Maintainability score of 3.3. The following information is based on evaluator comments:

- The detectors and control box are packaged in cases that provide excellent durability. However, the control case has many cable connections that are subject to wear and tear. The PC laptop and its interface also provide a weak point for durability.
- The detector cases have a high center of gravity, relatively small bases, and no overhead connecting panel. This design makes the detectors vulnerable to tipping. Another disadvantage is that if a detector moves inadvertently, the infrared occupancy beam and sensor may no longer align.
- The sealed protective cases can be decontaminated quickly using water. However, there are many cables and other components vulnerable to contamination that cannot be cleaned easily.
- The detectors and control box are very rugged, but the infrared beam and sensor look delicate and may break easily.
- Adequate system diagnostics are displayed on the laptop when the system initializes upon startup or upon any parameter change by the user.

4.3.4 USABILITY

The PPVM received a Usability score of 3.7. The following information is based on evaluator comments:

- The system is controlled through Windows-based software that is not intuitive and has many complex items in its menus. Users must go through a series of menus to modify parameters. One evaluator thought it was too complicated for use in emergency response operations. Another commented that it would be better to have a self-starting button-based system instead of a Windows program.

- The detectors are highly sensitive, and visual and audible alarms are very clear. Alarms can be configured in many different ways, and audio alarms can be turned off completely. A suggested improvement for the software is to display the radiation level that caused an alarm until the alarm clears. Users must stop and review a history screen to get that information.
- A stop-and-count mode is available and can be fairly easily set through the Windows interface. It works well as long as the person stays within the portal for the set count time. There is no alarm if the person walks out before the count time is up.
- Data logging capability is superior to the other systems assessed as the data is stored on the laptop and easily accessible without special cables or other equipment. A video camera is included and will match a photo to alarm data. Retrieving the data is not a straightforward process, however, and requires some familiarization with the software.
- The display is located within the control case, which can be as far from the detectors as the length of the cables. This has the advantage of making the display highly portable. With long enough cables, it can be rotated away from sunlight or moved to a remote location.
- The software is highly configurable and gives operators numerous options. However, the lack of intuitiveness and user-friendliness requires that operators spend time learning the system.

4.4 RAPISCAN SYSTEMS, TPM-903B

The TPM-903B received an overall assessment score of 3.1 and has an MSRP of \$14,950. The system contains two plastic scintillator detectors on vertical pillars, a horizontal crossbar, an infrared occupancy sensor, polyvinyl chloride (PVC) housing, aluminum baseplates, a control panel with an alphanumeric LCD display and a hard wheeled carrying case.

The following sections, broken out by SAVER category, summarize the assessment results.

4.4.1 CAPABILITY

The TPM-903B received a Capability score of 2.8. The following information is based on evaluator comments:

- Screening throughput was generally satisfactory although there were times when the system was slow to cycle back to the ready state after an occupancy. The occupancy sensor may have been slightly misaligned during installation.
- There are 72-inch detectors on each vertical post that provide adequate vertical coverage.
- The system has very limited source localization capability. Left- and right-side counts can be displayed on the screen, but the system will not alarm in that mode.



Figure 4-4 Evaluators assembling the TPM-903B

- The system automatically updates the background, but does not provide a menu command to reset the background. This can only be done by cycling the system off and on. There is limited configurability of background parameters. Operators can set the background count time and the acceptable high and low levels for background measurements.

4.4.2 DEPLOYABILITY

The TPM-903B received a Deployability score of 3.4. The following information is based on evaluator comments:

- This system itself is fairly light, but it comes in a heavy case that requires two people to lift. The case makes it cumbersome for field deployment.
- The case is too large for most passenger vehicles. Agencies will need a truck, trailer, or minivan for field deployment.
- The carrying case is well made and provides very good protection with lots of padding within. There are handles on each side so that multiple people can lift it. Wheels on one side of the case facilitate movement when the other side of the case is lifted. Wheels on each side would be an improvement. One evaluator commented that the locking closures are flimsy and could use a quality upgrade.
- The system can be assembled in 5 to 10 minutes. Although tools are not needed, removing the battery covers and control panel weather cover is easier with a flathead screwdriver. The most difficult part of the assembly is threading one of the Ethernet cables through the vertical crossbar; this process was not made clear in the manual. Cable connections were intuitive and color coded.
- The only color coding on the major system components are yellow dots on each vertical crossbar that are supposed to be aligned so they face inward; however, this was not made clear by the manual. All cable connections were intuitive with color coding and numeric labels, although, the labels were a little too small and some fell off the cables during assembly.
- Wheelchair accessibility is good as the 32-inch portal width allows enough space for wheelchairs and stretchers to be pushed through and there are no bumps on the ground beneath the portal. Elbow room is limited for individuals wheeling themselves through the portal.
- The system runs from AC power with a backup battery option of 6 standard D-cell batteries that will last for 24 hours. Evaluators considered this an excellent battery life specification.

4.4.3 MAINTAINABILITY

The TPM-903B received a Maintainability score of 3.8. The following information is based on evaluator comments:

- The PVC construction provides good durability for the system. However, the Ethernet cable connectors are prone to wear and breakage and may require periodic placement.

- Despite the small aluminum baseplates on the vertical posts, the system is fairly stable and not easily moved or tipped over when assembled.
- The detectors appear to have a rugged design; however, the control panel is permanently attached to one of the vertical detector posts, making it vulnerable to damage during packing, assembly, and disassembly.
- Smooth surfaces on all parts make the system very easy to decontaminate.
- System diagnostics could use improvement. There is a power-on-self-test routine that evaluates the system during initialization. Once complete, no more diagnostic information is displayed unless accessed by the menu, and the system cannot alarm during menu access.

4.4.4 USABILITY

The TPM-903B received a Maintainability score of 2.7. The following information is based on evaluator comments:

- Menu controls are not intuitive or user-friendly, so the manual will need to be consulted often. The operator cannot tell if a parameter change was accepted without going through the menu a second time. The display is small and hard to read, and the green “ready” indicator light is so bright that it makes the display even harder to read.
- Alarms are very loud and the volume cannot be adjusted or turned off. The red “alarm” indicator light is likewise too bright and obstructs the display. The only alarm configurability is the sigma parameter.
- There is no stop-and-count mode available with this system. An extended count time cannot be set, and the system will not alarm for an extended count. The only workaround is to have a person stand in the portal in non-alarming mode and have an operator read the highest count rate from each detector.
- The system can store over 3,000 readings; however, the manual describes an outdated method of retrieving data using an RS-232 cable and a program that works with the Windows 95/98 or NT4 operating systems.
- The display is strapped to a vertical detector post and cannot be easily moved or adjusted. It is difficult to read because of the brightness of the indicator lights on the control panel.
- There is a very minimal set of parameters that can be set by the user from a menu that is not intuitive. One evaluator recommended having an easy mode and expert mode.

4.5 RAPISCAN SYSTEMS, PM-704

The PM-704 (Figure 4-5) received an overall assessment score of 2.8 and has an MSRP of \$15,130. The system contains two plastic scintillator detectors on vertical pillars, a horizontal crossbar containing a control panel with an alphanumeric LCD display, an infrared occupancy sensor, aluminum and molded plastic housing, aluminum baseplates and a hard wheeled carrying case.

The PM-704 has the same menus and system software as the TPM-903B. See Section 4.4 for comments related to these features.

The following sections, broken out by SAVER category, summarize the assessment results.



Figure 4-5 PM-704 with carrying case

4.5.1 CAPABILITY

The PM-704 received a Usability score of 2.8. The following information is based on evaluator comments:

- Screening throughput was adequate, but there is no information displayed besides alarm or no alarm. Some evaluators felt that this makes it inadequate for use in a community reception center.
- The detectors extend close to the floor and provide adequate vertical coverage.
- There is no method for source localization besides reading left- and right-side counts from the display. This reading is only available in a non-alarming mode and operators must stand within the portal with the top panel open to read the display.
- Backgrounds were continuously updated and could be reset only with a system reboot.

4.5.2 DEPLOYABILITY

The PM-704 received a Deployability score of 2.7. The following information is based on evaluator comments:

- This system is very heavy and comes in a heavy carrying case. Two people are needed to lift and wheel it around, and three or more people are needed to load and unload it.
- The carrying case is very large and will not fit in most passenger vehicles. It barely fit in a Dodge Caravan when the front passenger seat was moved all the way forward. Larger vehicles such as a truck, van or trailer will be needed for comfortable transport.
- The carrying case is made with high-quality material and provides thick padding for protection of system components. There are non-swiveling wheels and handles on only one side of the case, making transport very difficult. Transporting the case over a large distance is best done using dollies that are not provided.

- Setting up the portal proved difficult. The curved shape of the posts made matching up with the top bar very difficult, and the bolts used to attach the top are difficult to use and require a lot of manual dexterity. As a result, it takes a relatively long time to set up this portal. In addition, two people are needed for assembly due to the portal's weight and complexity of the tasks.
- Cables and electrical components are color coded, but the mechanical components are not. One group of evaluators put the system together backwards the first time and had to redo the assembly. The bottom bases were not adequately pictured in the manual.
- Wheelchair accessibility was good as there were no bumps and the portal width of 32 inches allowed wheelchairs to fit through, although not with much elbow room for self-propelling.
- The system runs on AC power with a battery backup option of 8 D-cells that will last for 10 hours. The installation of batteries was cumbersome due to the positioning of the battery holder in the top panel. Evaluators felt that the 10-hour battery life specification is good, but not excellent.

4.5.3 MAINTAINABILITY

The PM-704 received a Maintainability score of 3.2. The following information is based on evaluator comments:

- This system is very sturdy and made with quality parts. However, the screw threads in one of the bolts that hold the top panel to the sides were damaged after several assemblies. The difficulty of assembly could induce stress on parts that eventually cause breakage.
- Stability is good due to the weight of the system. It is hard to move once assembled and standing. However, it has a tendency to shake when bumped into. This could probably be improved with a better footplate design. The footplates are small and seem to be an afterthought that allows for portable use.
- All surfaces on the system are smooth and easy to decontaminate.
- The system appears to be rugged and should stand up well to rough usage. The main concern is damage during the difficult assembly process.

4.5.4 USABILITY

The PM-704 received a Usability score of 2.4. The following information is based on evaluator comments:

- The control panel is extremely difficult to use because it is located in an unlit top panel compartment that is inaccessible during normal operation. Users must look up into the compartment to change settings. Menu options are the same as the TPM 903B.
- The large illuminated "stop" and "go" lights for alarms worked well and were aesthetically pleasing. Operators cannot turn off the audible alarms.

- As with the TPM-903B, an adjustable count time could not be set and data offloading involves the use of an RS-232 cable and use of software written for outdated operating systems.
- The display is not moveable, inaccessible during operation, located inconveniently, and difficult to read without a flashlight. The stop/go indicator lights provide the operational display. They work well, but evaluators would like to see more information about an alarm, especially if the system is to be used at a community reception center.

5.0 SUMMARY



PRPMs are valuable tools that emergency responders use to screen people and vehicles for radioactive contamination or illicit radiation sources. All the assessed products have plastic scintillation detectors that alarm on elevated levels of gamma and beta radiation. All products generally performed well in this core function, although there were differences in throughput, vertical detection coverage, and the ability to localize sources. All systems occasionally failed to alarm if a low-activity source was walked through at a brisk enough pace at high or low elevations. However, in multiple passes at such brisk walk-throughs, the portals would normally alarm and only occasionally fail to alarm.




There were significant differences in the ability to quickly assemble and initialize each product, use the menus to set parameters, read data from the screen, and use a variety of features that are valuable to emergency response screeners. For instance, some systems could acquire a new background measurement with a simple command, while other systems could only do this with a system reboot.

The advantages and disadvantages, as identified by the evaluators, for the assessed products are highlighted in Table 5-1.

Emergency responder agencies that consider purchasing PRPMs should carefully research each product's overall capabilities and limitations in relation to their agency's operational needs.

Table 5-1 Product Advantages and Disadvantages

Product	Advantages	Disadvantages
 <p>WB Johnson Instruments AM-801</p> <p>MSRP: \$11,725</p> <p>Overall Score: 4.2</p>	<ul style="list-style-type: none"> • Light and small package • Very easy to assemble • User-friendly interface makes operation easy • Very stable • Wheelchair accessibility • Rugged attachment mechanisms • Lots of useful information on screen during operation 	<ul style="list-style-type: none"> • Battery life could use improvement • Separate purchase of special printer or network module option needed for data logging.
 <p>Ludlum Measurements, Inc. Model 52-1-1</p> <p>MSRP: \$12,543</p> <p>Overall Score: 4.0</p>	<ul style="list-style-type: none"> • Light and small package • Easy, fast assembly • Hot swappable detectors and control unit • Sensitive detectors • Easy to operate • Easy to read display • Clear and configurable alarms 	<ul style="list-style-type: none"> • Wheelchair accessibility is hampered by bottom plate • Reboot is needed after any parameter change • Need plastic sleeves for decontaminability • Case latches known to fail when partially closed.

Product	Advantages	Disadvantages
 <p data-bbox="423 338 711 401">Technical Associates, Inc. PPVM</p> <p data-bbox="175 520 358 548">MSRP: \$18,700</p> <p data-bbox="467 520 672 548">Overall Score: 3.4</p>	<ul data-bbox="748 262 1036 541" style="list-style-type: none"> • Each case is light and portable • Variable width between detectors • Video camera • Best data logging ability • Advanced modes and features • Intuitive displays 	<ul data-bbox="1117 247 1474 554" style="list-style-type: none"> • Many accessories provided, but no storage case for them • Laptop computer is not rugged • Complex software requires training • Many cables • Cables cross portal path • Seems like a work in progress more than a finished product
 <p data-bbox="464 646 672 709">Rapiscan Systems TPM-903B</p> <p data-bbox="175 806 358 833">MSRP: \$14,950</p> <p data-bbox="467 806 672 833">Overall Score: 3.1</p>	<ul data-bbox="748 579 1057 793" style="list-style-type: none"> • Easiest system to decontaminate • PVC design provides ruggedness and durability • Fairly easy to assemble • Can be operated by one person 	<ul data-bbox="1117 569 1463 842" style="list-style-type: none"> • Large, heavy case • Need two or more persons to deploy • No stop-and-count mode • No source localization capability • Reboot is needed after any parameter change • Needs software upgrade
 <p data-bbox="464 940 672 1003">Rapiscan Systems PM-704</p> <p data-bbox="175 1100 358 1127">MSRP: \$15,130</p> <p data-bbox="467 1100 672 1127">Overall Score: 2.8</p>	<ul data-bbox="748 863 1068 1129" style="list-style-type: none"> • Aesthetically pleasing • Stop/go alarm lights make for simple operation • Good detector sensitivity • Easy to decontaminate • Suitable for primary screening at a location not requiring frequent redeployment 	<ul data-bbox="1117 863 1474 1129" style="list-style-type: none"> • Extremely large, heavy case • Need three or more persons to deploy • Difficult to assemble • Control panel is in top cabinet and inaccessible during operation • Same software as TPM-903B; needs upgrade

Appendix A. VEHICLE PORTAL RESULTS

Four PRPM systems were assessed in vehicle screening mode as described in Section 3.2. The vehicle screening assessment addressed 16 evaluation criteria in four SAVER categories: Capability, Deployability, Maintainability and Usability. These criteria are a subset of the criteria chosen by the focus group that were determined to be relevant to vehicle screening. The results of the vehicle screening assessment are presented here separately from the pedestrian mode screening results.

Table A-1 presents the overall vehicle screening assessment score and category scores for each product. Products are listed in order from highest to lowest overall score throughout this appendix.

Appendix Table A-1 Vehicle Screening Assessment Results

Product	Overall Score	Overall	Capability	Deployability	Maintainability	Usability
WB Johnson Instruments AM -801		4.0	4.1	3.9	3.6	4.3
Ludlum Measurements, Inc. Model 52-1-1		3.8	4.0	4.2	3.4	3.6
Technical Associates, Inc. PPVM		3.7	3.9	3.9	3.1	4.1
Rapiscan Systems TPM-903B		3.4	3.3	3.4	3.7	3.2
	0 1 2 3 4 5 Least Favorable Most Favorable					

Table A-2 presents the criteria ratings for each product. The ratings are graphically represented by colored and shaded circles. A green, fully shaded circle represents the highest rating. A red, unshaded circle represents the lowest rating.

Appendix Table A-2 Vehicle Assessment Criteria Ratings

Key		Product Name			
Lowest Rating					
Highest Rating					
Category	Evaluation Criteria	AM-801	Model 52-1-1	PPVM	TPM-903B
Capability	Drive-Through Throughput				
	Vertical Coverage				
	Source Localization Ability				
	Non-Emergency Throughput				
Deployability	Weight				
	Storage Volume				
	Wheeled Carrying Case Quality				
	Ease of Setup and Disassembly				
Maintainability	Durability				
	Stability				
	Decontaminability				
	Ruggedness				
Usability	User-Friendly Controls				
	Alarms/Alarm Configurability				
	Adjustable Count Time				
	Movable Display				

Relevant evaluator comments are also provided for each product.

A.1 WB JOHNSON INSTRUMENTS, AM-801

The AM-801 received an overall vehicle screening assessment score of 4.0. The vehicle kit has an MSRP of \$573 and includes its own wheeled carrying case with two bases, a drive-over cable, and detector panel caps.

The following sections, broken out by SAVER category, summarize the results.

A.1.1 CAPABILITY

The AM-801 received a Capability score of 4.1. The following information is based on evaluator comments:

- Detectors posts were set up approximately 10 feet from each other, but the electric eye that makes up the unit's occupancy sensor could not be aligned properly. This may have been due to the distance and amount of daylight present. The workaround to this problem was to operate the portal in area mode in which screening occurs continuously even without an occupancy.
- The system operated well in area mode and multiple sources with good throughput.
- Sources that were placed at the highest location within the truck were detected and caused alarms. Therefore, vertical detection coverage was considered good.
- The system correctly identified the location of the source in the truck as right/left or top/bottom. The display clearly showed counts as well as alarms in all quadrants.

A.1.2 DEPLOYABILITY

The AM-801 received a Deployability score of 3.9. The following information is based on evaluator comments:

- The vehicle kit came in a separate case that adds to the storage space required, but it was light enough to be carried and deployed by a single person and will fit in most passenger vehicles.
- The vehicle kit carrying case was made with high quality and is easily wheeled. Purchasers have the option of eliminating the separate case by receiving both the portal monitor and vehicle kit in the portal monitor case with the two vehicle baseplates instead of the single pedestrian mode baseplate. The vehicle plates would then have to be used when the portal is in pedestrian mode as well.
- Assembly was quick and easy, but the occupancy sensor could not be aligned as noted above and the system was operated in area mode. Evaluators suggested having a stronger infrared beam.

A.1.3 MAINTAINABILITY

The AM-801 received a Maintainability score of 3.6. The following information is based on evaluator comments:

- The vehicle mode configuration appears durable and rugged enough for ordinary bumps and vibrations, but will likely not survive a collision with a vehicle. The one-piece rubber strip provided for drive-over cable protection is adequate and covers the entire space between the detectors, but may lose flexibility in cold weather.
- The large rectangular base plates provided in the vehicle kit gave the system good stability and will allow operation even on slightly uneven surfaces.

- Decontaminability is about the same in vehicle mode as in pedestrian mode. Placing disposable sleeves over the detector posts where there are crevices should be considered if this is a concern.

A.1.4 USABILITY

The AM-801 received a Usability score of 4.3. The following information is based on evaluator comments:

- This system was very intuitive, user-friendly and easily understood. Everything that a first responder would need to know is visible on screen. The touch screen control panel was easy to use, and menus are very intuitive.
- Alarms were clear and easily configured. There was a very good response to all sources driven through the portal. The only drawback was the occupancy sensor not working.
- When the occupancy sensor is working, a stop-and-count mode is available with an easily settable count time. Evaluators used an externally timed count in area mode, and this worked fine with the source truck parked within the portal.
- Although the display is not moveable, it is clear and easy to read at all times including in bright sunlight. All information is presented on the main screen in an intuitive manner.

A.2 LUDLUM MEASUREMENTS, INC., MODEL 52-1-1

The Model 52-1-1 received an overall vehicle screening assessment score of 3.8. The vehicle kit has an MSRP of \$1,650 and includes two detector pedestal stands, two detector end caps and a connection cable. The vehicle kit assessed was loaned to NUSTL by the vendor representative. End caps were not available and were not tested.

The following sections, broken out by SAVER category, summarize the results.

A.2.1 CAPABILITY

The Model 52-1-1 received a Capability score of 4.0. The following information is based on evaluator comments:

- The occupancy sensor was aligned properly and the system detected sources in drive-through mode with good throughput.
- Sources were detected with good vertical coverage.
- The system properly located sources based on left/right and top/bottom differentiation.

A.2.2 DEPLOYABILITY

The Model 52-1-1 received a Deployability score of 4.2. The following information is based on evaluator comments:

- The pedestrian portal system is light enough to be deployed by a single person, and the vehicle kit only adds two pedestal stands that are not heavy.

- The X-shaped pedestal stands do not come in their own case, but do not significantly add to the storage volume. They can be easily carried or placed in a separate case purchased by the user.
- The portal is very easy to set up in vehicle mode and the electric eye used for the occupancy sensor aligned without any issues. A flat-edge tool (coin or screwdriver) is helpful for opening the battery compartment.

A.2.3 MAINTAINABILITY

The Model 52-1-1 received a Maintainability score of 3.4. The following information is based on evaluator comments:

- The system is encased in metal and provides good ruggedness and durability. A high-quality connection cable is provided with the vehicle kit, but there is not a drive-over rubber strip provided to protect the cable. The manufacturer claims that the cable will survive repeatedly being driven over. If this is a concern, agencies can purchase their own rubber strip.
- The detector pedestal stands are well designed and provide very good stability for vehicle mode.
- Decontaminability is about the same in pedestrian or vehicle mode. There are many nooks and crannies on the vertical posts that would be hard to decontaminate, but plastic sleeves are available from the vendor to prevent this.

A.2.4 USABILITY

The Model 52-1-1 received a Usability score of 3.6. The following information is based on evaluator comments:

- Menus and controls are suitable, but not as intuitive as other models. Changing menu parameters requires a system reboot.
- Alarms are easily configurable and there was an excellent response on all alarms during source drive-throughs. The system could be improved by allowing configuration changes without the need to reboot.
- There is a stop-and-count mode available with a settable count time and it works well for screening for contamination. However, the menu is difficult to use and the system has to be restarted.
- The display screen is immobile but can be read easily even in sunlight. There are only two lines, however, and the data presented is not intuitive.

A.3 TECHNICAL ASSOCIATES, INC., PPVM

The PPVM received an overall vehicle screening assessment score of 3.7. There is no vehicle kit for this product because it is designed to operate in pedestrian or vehicle mode without need for additional equipment. There is no added cost for screening vehicles.

The following sections, broken out by SAVER category, summarize the results.

A.3.1 CAPABILITY

The PPVM received a Capability score of 3.9. The following information is based on evaluator comments:

- The system was set up, aligned properly, and did alarm on the sources driven through. Alarm resets were quick, allowing for good throughput.
- Based on the testing that was done, vertical coverage was as good as the other systems. However, the detector heights were smaller than the other systems tested.
- Sources were successfully localized as either on the left or right side of the truck. There is no top/bottom differentiation with this system.

A.3.2 DEPLOYABILITY

The PPVM received a Deployability score of 3.9. The following information is based on evaluator comments:

- Vehicle mode adds no extra weight or storage volume to the system. There are three protective cases and a fourth case is needed because several items (camera, cables, etc.) come with the system that need storage. Each case is deployable by a single person.
- Protective cases provided are very good quality and easily handled. A fourth case would be a big improvement. Spare items had to be transported in two cardboard boxes.
- System setup is fairly simple. Occupancy sensor alignment requires a screwdriver. There was no problem aligning the system, but it could be run in continuous mode without the sensor if need be. Color coding of cables would be helpful for assembly.

A.3.3 MAINTAINABILITY

The PPVM received a Maintainability score of 3.1. The following information is based on evaluator comments:

- The protective cases are very rugged, making this system the most likely to withstand a vehicle collision. This system is also the only one to have a dust cover protecting the occupancy sensor's electric eye. The PC laptop, however, is not inherently resistant to damage.
- The rubber strip drive-over cable protector did not provide a continuous cover and left some of the cable exposed. This part could use an upgrade.
- Detector stands provided adequate stability, but the detectors are vulnerable to tipping in the direction of travel. There is room for improvement in the detector stand design.
- Because the detectors are housed in protective cases, they could be decontaminated with soap and water. Other parts and cables would be difficult to decontaminate.

A.3.4 USABILITY

The PPVM received a Usability score of 4.1. The following information is based on evaluator comments:

- The Windows-based software interface provides many good features, but is complex and requires user training. A simpler “responder mode” would be a good improvement.
- Alarms can be configured as necessary and are loud and visible on screen when they occur. There is a lock-in mode (attended mode) that preserves alarm readings until cleared by an operator. Otherwise, they clear very quickly. Alarms are saved in a log file, but the file can be difficult to find.
- A stop-and-count mode is fairly easy to set up with a programmed count time. It works well and even allows a hand count if the occupancy sensor is not working.
- The display is in a separate case connected by long cables, so it is highly movable and can be set up far from detectors if need be.
- Information presented on display is clear and relevant. The bar graph display for detector responses is unique and intuitive. This is the only system that provides a camera and will display images of screened vehicles when there is an alarm.

A.4 RAPISCAN SYSTEMS, TPM-903B

The TPM-903B received an overall vehicle screening assessment score of 3.4. The vehicle kit has an MSRP of \$725 and includes two large metal baseplates, a connection cable with driver-over protection and detector caps. It is packaged in the same case that the rest of the system comes in.

The following sections, broken out by SAVER category, summarize the results.

A.4.1 CAPABILITY

The TPM-903B received a Capability score of 3.3. The following information is based on evaluator comments:

- The system aligned properly and detected sources as expected with good throughput. However, the occupancy sensor worked intermittently and did not detect some vehicles.
- Vertical detection coverage was good as sources were detected high in the truck.
- There is no source localization ability with this system in alarming mode. A software upgrade could provide left/right localization capability.

A.4.2 DEPLOYABILITY

The TPM-903B received a Deployability score of 3.4. The following information is based on evaluator comments:

- The system comes in a very large and heavy case. The vehicle kit adds somewhat to the weight with two fairly heavy baseplates that are needed for extra stability in vehicle mode.
- No additional storage volume is required by purchasing the vehicle kit as all parts fit in the original case. At least two people are needed to transport the case and it will not fit in most passenger vehicles.

- Assembly was quick and easy, but it was more difficult to initialize the system because the occupancy sensor did not work well at the distance required for vehicle screening.

A.4.3 MAINTAINABILITY

The TPM-903B received a Maintainability score of 3.7. The following information is based on evaluator comments:

- The PVC construction provides good durability and ruggedness, although it will not likely survive a collision with a vehicle.
- A one-piece cable cover provides excellent drive-over protection, but may lose flexibility in cold weather.
- Two large square sturdy baseplates provided very good stability for the system in drive-through mode.
- Smooth PVC surfaces make for easy decontamination of the system. In vehicle mode, there may be an issue with contamination getting in through the detector caps at the tops of the vertical posts if they are not on tight.

A.4.4 USABILITY

The TPM-903B received a Usability score of 3.2. The following information is based on evaluator comments:

- The system is not intuitive or user-friendly and operators will likely need to refer to the manual at times. Controls are fairly simple and can be operated with gloves.
- The system alarmed as expected. Audible and visible alarms were adequate and could be heard in noisy environments and seen in sunlight. The system could be improved with volume control on alarms and increased ease of configurability of alarms.
- There is no stop-and-count mode available with this system. However, an externally timed count can be performed in drive-through mode.
- The display is immobile, but can easily be read in sunlight. The information presented is not particularly useful or intuitive.

Appendix B. EVALUATION CRITERIA DEFINITIONS

The focus group identified 47 criteria, which they defined as follows.

AFFORDABILITY

Warranty refers to the amount of time in which the vendor promises to repair or replace equipment that is not functioning properly, and the terms of such agreement.

Availability of Parts refers to the availability of parts from the vendor to replace worn-out or defective parts on the PRPM.

Standard Equipment Parts refers to the practice of incorporating standard commercial-off-the-shelf parts in the design of the product so that they are easily replaceable. Examples include D cell batteries and High-Definition Multimedia Interface (HDMI) cables.

Modularity refers to the ability to easily add, remove, and replace components of the system such as detectors, displays, or control panels.

Maintenance Cost refers to the accumulated costs associated with keeping the purchased equipment at operational status, including calibration, software upgrades, and technician travel for maintenance purposes.

Initial Cost refers to the up-front purchasing cost of the system and all necessary accessories.

Repair Cost refers to the accumulated costs associated with making repairs to the equipment, including replacement parts, labor, technician travel, and shipping to a repair facility.

Upgrade/Add-On Cost refers to the accumulated costs associated with making improvements, upgrades, or adding features and capabilities to the equipment.

Training Cost refers to the accumulated costs associated with training operators to use the equipment, including on-site training, off-site training, manuals, tutorials, etc.

CAPABILITY

Emergency Event Throughput refers to the number of persons per unit time that can be scanned for the presence of radiation during emergency response contamination screening.

Vertical (Head-to-Toe) Coverage refers to the ability of the PRPM to detect radiation from the top to the bottom of the portal.

Ability to Meet Appropriate Detection Standards refers to the ability to meet detection standards appropriate for PRPMs such as FEMA-REP-21.

Shielding/Crosstalk Reduction refers to the use of shielding, collimation or software algorithms that reduce the possibility that a radiation source or contaminated person in another screening lane will alarm a PRPM.

Source Localization Ability refers to the ability to determine information about the location of a source that passes through the portal. For example, if there are two detectors on each vertical panel, the PRPM could indicate whether the source is high or low and whether it is toward the left or right.

Background Subtraction and Reset refers to the ability to acquire an accurate background radiation measurement, subtract it from radiation measurements taken during portal occupancies, and reset back to acquiring background when appropriate.

Networking Capability refers to the ability to connect multiple PRPMs to a computing device (e.g., computer, tablet, smartphone, etc.) through a network configuration such as Ethernet.

Wireless Capability refers to the ability to communicate with an external computing device through a wireless interface such as Wi-Fi or Bluetooth.

Background Configurability refers to the ability to configure the system software so that the user has flexibility in how and when background measurements are acquired.

Non-Emergency Throughput refers to the number of persons or vehicles per unit time that can be scanned for the presence of radiation during interdiction screening or non-emergency contamination screening (such as scanning employees and vehicles for contamination).

DEPLOYABILITY

Wheelchair Accessibility refers to the degree to which the PRPM in normal operation allows persons in wheelchairs to pass through the portal and be screened. Emergency medical service gurneys should also be accommodated.

Innovative Redesign refers to incorporating innovative new concepts into the system to make it less like a traditional portal system.

Weight refers to the weight of the PRPM system including the carrying case, and the effect of the weight upon deployment for field use.

Storage Volume refers to the amount of space that the PRPM and its carrying case takes when packed for storage.

Wheeled Carrying Case Quality refers to the overall quality of the carrying case for the PRPM and the degree to which it facilitates easy transportation.

Ease of Setup and Disassembly refers to the amount of time needed to assemble the PRPM, turn it on, and have it become operational; and the ease with which this can be accomplished. Also included is the time needed for disassembly and the ease with which disassembly is accomplished.

Labelling or Color-Coding for Easy Assembly refers to the labelling or color-coding of parts for the purpose of easy and simple assembly. For example, a red mark on the top of the panel would match a red mark on the side panel to indicate that these parts connect in the area of the marks. Highly visible instructions on the portal would also facilitate assembly.

Temperature and Relative Humidity Range refers to the operating temperature range and operating relative humidity range as specified by the manufacturer.

Battery Options and Battery Life refers to the options provided for powering the system by battery and the number of hours that each battery option powers the PRPM for.

Networking of Power Cords refers to the ability to operate on alternating current power and to daisy chain the power cords from one PRPM unit to another instead of having to plug each power cord into a separate power outlet.

Ability to Eliminate Carrying Case refers to providing a design in which the carrying case is not needed. For example, the system could have rugged components that compactly connect to a wheelbase for easy storage and transport

MAINTAINABILITY

Water Resistance refers to the ability of the PRPM to operate in rain and other wet conditions.

Durability refers to the ability to remain in good condition over a long period of time and withstand heavy usage and wear.

Stability refers to the PRPM being constructed to stand with firmness and not be easily moved, shaken, or toppled when bumped into or handled roughly.

Ease of Calibration refers to the ease with which the required periodic calibration of the PRPM can be performed.

System Diagnosis or Self-Check refers to any features that give the user information about the health of the system, indicate maintenance that is needed (such as low battery condition), or provide a test routine that can be used to test whether or not system functions are working.

Decontaminability refers to the ability to effectively and easily clean or decontaminate the PRPM. This can be accomplished with a design that minimizes crevices on surfaces, provides the option of using disposable sleeves for contamination protection, or some other method.

Calibration Standards/Operational Checks refers to the specification on the part of the vendor of standard sources that can be used to provide a desired PRPM radiation reading when the PRPM is properly calibrated, the availability of such calibration standards, and the presence of operational checks within the system software that can be used to verify proper calibration of the system.

Ruggedness refers to the ability to withstand rough handling, drops, bumps, collisions, vibrations, turbulence, etc.

USABILITY

User-Friendly Controls refers to having buttons, switches, and control panels that provide useful, convenient, and intuitive control and operation of the PRPM. This also includes having controls that can be operated with gloves, respirators, and other personal protection equipment.


Alarms/Alarm Configuration refers to the overall quality and performance of radiation-related alarms, the ability to configure how alarms are triggered, and the ability to turn alarm types (e.g., audible, visible, vibrate, remote, etc.) on or off.

Adjustable Count Time refers to the ability to set the count time (aka, measurement time) for screening people or vehicles that are stationary within the portal.

Data Logging Capability refers to the storage of useful, relevant data associated with the operation of the PRPM and the ability to offload the data quickly and easily to an external computing device.

Moveable Display refers to having a display or control panel with display that can be easily moved or adjusted in a convenient manner to accommodate responder needs.

Person Identification refers to the ability to record and log data from a device such as a barcode reader or radio frequency identification reader that can identify the individual passing through the portal.



Software Configurability refers to how much and how easily PRPM operation can be adapted to responder needs based on software settings and parameters.

Camera refers to having a built-in camera to associate a photo or video stream with an alarm. This would be useful in the event that someone who passes through the portal sets off an alarm and flees.

Remote Alarm refers to the capability to send an alarm discreetly to a remote operator who is using a handheld unit such as a tablet or smartphone.

Appendix C. ASSESSMENT SCORING FORMULAS

The overall score for each product was calculated using the product's averaged criterion ratings and category scores. An average rating for each criterion was calculated by summing the evaluators' ratings and dividing the sum by the number of responses. Category scores for each product were calculated by multiplying the average criterion rating by the weight assigned to the criterion by the focus group, resulting in a weighted criterion score. The sum of the weighted criterion scores was then be divided by the sum of the weights for each criterion in the category as seen in the formula and example below.

Category Score Formula

$$\frac{\sum (\text{Average Criterion Rating} \times \text{Criterion Weight})}{\sum (\text{Criterion Weights})} = \text{Category Score}$$

Category Score Example^v

$$\frac{(4.3 \times 4) + (5 \times 4) + (4 \times 3) + (4.5 \times 3) + (4.5 \times 3)}{4 + 4 + 3 + 3 + 3} = 4.5$$

To determine the overall assessment score for each product, each category score was multiplied by the percentage assigned to the category by the focus group. The resulting weighted category scores were summed to determine an overall assessment score as seen in the formula and example below.

Overall Assessment Score Formula

$$\sum (\text{Category Score} \times \text{Category Percentage}) = \text{Overall Assessment Score}$$

Overall Assessment Score Example

<u>Capability</u>	<u>Usability</u>	<u>Affordability</u>	<u>Maintainability</u>	<u>Deployability</u>	
$(4.0 \times 33\%)$	$+ (4.2 \times 27\%)$	$+ (4.2 \times 20\%)$	$+ (3.8 \times 13\%)$	$+ (4.5 \times 7\%)$	$= 4.1$

^v Examples are for illustration purposes only. Formulas vary depending on the number of criteria and categories assessed and the criteria and category weights.