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Science and Technology

U.S. Department of Homeland Security



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 U.S. Department of Homeland Security Authorized Equipment List (AEL).

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?"

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Summary

Automated External Defibrillators

(AEL reference number 09ME-03-DEAE)

In order to provide emergency responders with information on currently available automated external defibrillator (AED) capabilities, limitations, and usability, the Space and Naval Warfare Systems Center (SPAWARSYSCEN) Atlantic conducted a comparative assessment of AEDs for the SAVER Program in June 2008. Detailed findings are provided in the complete Automated External Defibrillator Assessment Report, which is available by request at <https://www.rkb.us/>.

Background

According to 2007 American Red Cross statistics, sudden cardiac arrest claims more than 200,000 lives in the United States annually. Sudden cardiac arrest occurs when the muscles of the heart beat irregularly, causing the interruption of normal blood flow patterns. Without treatment, irreversible brain damage or even death can quickly occur. Cardiopulmonary resuscitation (CPR) increases the chance of survival, but the survival rate can be greatly increased when CPR is used in conjunction with early defibrillation. In defibrillation, an electric shock stops the beating of the heart momentarily, giving it an opportunity to restart with normal rhythms. Chances of survival decrease by about 10 percent for each passing minute after sudden cardiac arrest, attesting to the urgency of early defibrillation.

AEDs are portable defibrillation devices used to assess a victim's heart rhythm and determine whether a shock should be administered to attempt to restore a normal heart rhythm. AEDs are lightweight, battery-operated, and transported easily. Many are located within community or public buildings, such as department stores or offices, for quick access. In addition, AEDs are easy to use and require minimal training. Most AED manufacturers provide training videos and literature with the purchase of an AED.

Assessment

A focus group of eight emergency response practitioners within the emergency medical services and firefighting communities met in February 2008 to identify equipment selection criteria, evaluation criteria, and assessment scenarios. Based on focus group recommendations and market survey research, eight AEDs were selected for assessment:

- Cardiac Science Corporation Powerheart AED G3 Pro
- Philips Medical Systems HeartStart FR2+
- Cardiac Science Corporation Powerheart AED G3 Plus
- Philips Medical Systems HeartStart FRx
- Defibtech Lifeline AED
- Welch Allyn AED 20
- Zoll Medical Corporation AED Pro
- Heartsine Technologies Samaritan PAD.

Four emergency responders served as assessment evaluators. The assessment was conducted in two - phases that focused on specific assessment criteria. Phase I was the operational assessment. It was based on the evaluators' interaction with each product. Evaluators assessed product performance for those criteria directly relating to the use of the product.

Phase II was the specification assessment. It was based on vendor-provided specifications. Evaluators assessed each product using those criteria related to features, pricing, and support information not being operationally assessed.

Assessment Results

Evaluators rated the AEDs based on the evaluation criteria established by the focus group. Each original criterion was assigned to one of the five SAVER Program categories, and each SAVER Program category was assigned a weighting factor to indicate - its impact on the total composite score. The SAVER Program category and composite scores are shown in table 1. Higher scores indicate better performance. To view how each AED scored against each of the evaluation criteria assigned to the SAVER Program categories, see table 2 (on page 8).

The following paragraphs provide a brief summary of the evaluator comments and feedback on each AED

SAVER Program Category Definitions

Affordability: This category groups criteria related to life-cycle costs of a piece of equipment or system.

Capability: This category 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 responder-relevant tasks.

Deployability: This category 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: This category groups criteria related to the maintenance and restoration of a piece of equipment or system to operational conditions by responders.

Usability: This category 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.

and present the AED from the highest to lowest composite score. For the purposes of this SAVER Summary, the category scores are normalized and rounded to the nearest whole number. The complete

Table 1. Automated External Defibrillators (AEDs) Assessment Results¹

Automatic External Defibrillator	Composite Score	Affordability (7% Weighting)	Capability (33% Weighting)	Deployability (13% Weighting)	Maintainability (20% Weighting)	Usability (27% Weighting)
Powerheart AED G3 Pro	84	62	80	92	86	88
HeartStart FR2+	84	78	86	92	80	80
Powerheart AED G3 Plus	82	70	80	88	82	88
HeartStart FRx	82	78	86	90	80	80
Lifeline AED	80	80	80	94	86	72
AED 20	78	72	78	88	74	78
AED Pro	78	76	86	62	92	62
Samaritan PAD	66	78	62	78	68	58

Note:




¹ Scores contained in the assessment report may be displayed differently. For the purposes of the SAVER Summary, all SAVER category scores are normalized using a 100-point scale and rounded to the nearest whole number.

assessment report includes a breakdown of evaluator comments by individual criterion.

Powerheart AED G3 Pro

The Cardiac Science Corporation Powerheart AED G3 Pro and Philips Medical Systems HeartStart FR2+ each received the highest overall scores in the assessment. Evaluators commented that the G3 Pro has a color electrocardiogram (ECG) display, interchangeable pads, and an excellent warranty. They noted that the pads can be placed on the patient in either the upper right chest or lower left chest area. The G3 Pro has excellent visual prompts and the text does not wash out in the daylight. Evaluators commented that the G3 Pro can be cleaned according to OSHA bloodborne pathogen guidelines (i.e., with a 10 percent bleach and water mixture), and the battery is easy to remove and reinstall.




Evaluators stated the G3 Pro is expensive, not very rugged, and difficult to deploy on-site. It has a low IP rating, no contrast adjustment, and no audible warning when motion is detected. The top of G3 Pro's case is plastic and could be easily broken during use, and the lid closes during use, requiring reanalysis of the patient. Evaluators stated that the AED has to be removed from its case in order to install the battery, and the battery's expiration date is not visible without battery removal. They noted that the pad connector cables are difficult to plug in and unplug while wearing gloves, the AED does not clearly indicate when the self-test is being performed, and the user is not able to transfer care without changing pads. In addition, the shelf life of the pads was considered to be very low.

	 Pros <ul style="list-style-type: none"> Clearly marked pediatric pads Color ECG display Visual prompts Decontamination meets OSHA standards Interchangeable pads 7-year warranty
	 Cons <ul style="list-style-type: none"> Not very rugged Cannot transfer care without changing pads Limited event storage capacity Difficult to deploy on-site Replacement time
Powerheart AED G3 Pro	Composite Assessment Score: 84

HeartStart FR2+




The Philips Medical Systems HeartStart FR2+ tied with the Cardiac Science Corporation Powerheart AED G3 Pro in receiving the highest overall scores in the assessment. Evaluators indicated that the FR2+ is compact, lightweight, rugged, and offers a voice recording feature. They commented that the event viewer software suite is very comprehensive. Evaluators reported that the FR2+ is able to transfer care without changing pads with the use of an optional connector. The top of the case is identifiable by device name/manufacturer, the case has no Velcro®, and its zipper pull is bright yellow. In addition, evaluators agreed the pads are easy to open and provide a strong adhesive for operational use.

Although the battery prices were noted as being reasonable, evaluators considered the software suite, cables, and cases to be expensive. Evaluators stated the AED has a narrow storage temperature range, the visual prompts are difficult to read in daylight, and there is no contrast adjustment on the equipment. They commented that the FR2+ does not easily stay attached to the button studs on its case. The disposable battery has to be removed to check its expiration date, and it is hard to remove and install with gloved hands. Evaluators noted that the AED cannot detect a pacemaker, the picture on the pads is confusing, and the visual does not have a battery status indicator light.

	 Pros <ul style="list-style-type: none"> Very rugged Can transfer care without changing pads Voice recording feature Clearly marked pediatric pads Compact and lightweight
	 Cons <ul style="list-style-type: none"> Narrow storage temperature range Initial cost Daylight washes out text Pad connector cables are too short and get tangled
HeartStart FR2+	Composite Assessment Score: 84

Powerheart AED G3 Plus

Cardiac Science Corporation Powerheart AED G3 Plus received the second highest overall score. Evaluators stated it is very affordable and has an excellent warranty, and they indicated that the AED's overall performance outweighed their concerns about its ruggedness and deployability. The G3 Plus pads




	 Pros <ul style="list-style-type: none"> • Number of shocks per battery • Clearly marked pediatric pads • Decontamination meets OSHA standards • Lightweight • Affordable initial cost • 7-year warranty
	 Cons <ul style="list-style-type: none"> • Not very rugged • Cannot transfer care without changing pads • Difficult to deploy on-site • Replacement time
Powerheart AED G3 Plus	Composite Assessment Score: 82

are interchangeable and can be placed on the patient in either the upper right chest or lower left chest area. The audio prompts were considered easy to follow. Evaluators commented that the text does not wash out in the daylight. The G3 Plus can be cleaned according to OSHA bloodborne pathogen guidelines. It was easy to remove the disposable smart battery, and its shelf life was considered very good. Evaluators explained that the AED attaches to its case and the shoulder strap attaches to the bottom of the case, making the equipment easier to use.

Evaluators noted the G3 Plus IP rating is low, the AED is not as easy to deploy on-site as some of the other devices, and the pad connector cables are difficult to plug in and unplug while wearing gloves. They agreed that the AED should be more water resistant for pre-hospital use. The G3 Plus is not able to transfer care without changing pads, and evaluators found it somewhat difficult to change the pads. They noted the top of the case is very flimsy/unstable and could be easily broken during use. They also noted that the case is not labeled as an AED. Evaluators stated that the shelf life of the G3 Plus's pads is short, the audio prompts are excessive for EMT use, and there is no contrast adjustment on the visual text prompts. Evaluators stated that there is no battery status indicator light and the battery's expiration date is not visible without battery removal. They noted that the AED does not clearly indicate when the self-test is being performed. The case lid closes during operation, which requires reanalysis and increased assessment time. In addition, evaluators considered the batteries and cases to be expensive.

HeartStart FRx

The Philips Medical Systems' HeartStart FRx also received the second highest overall score in the

	 Pros <ul style="list-style-type: none"> • Can transfer care without changing pads • Sensitive interference/artifact detection • Gives CPR prompts • Small and lightweight • Affordable initial and recurring costs
	 Cons <ul style="list-style-type: none"> • Narrow storage temperature range • Low event storage capacity • Pads are too sticky • No visual prompts or display screen • Audio prompts are hard to hear in loud environments • Pad connector cables are too short • No shoulder strap • Dark color
HeartStart FRx	Composite Assessment Score: 82

assessment. Evaluators agreed the AED is affordable, and they were impressed with its compact size, light weight, CPR prompts, and ruggedness. They commented that the event viewer software suite is very comprehensive. Evaluators reported that the FRx is able to transfer care without changing pads with the use of an optional connector. It uses adult pads with a clearly marked key that reduces the energy delivered during a shock on children, instead of pediatric pads. They stated that the FRx can detect a pacemaker and it seems to appropriately detect interference/motion and reanalyze. In addition, the AED can give CPR prompts. Evaluators stated that a brightly colored Pelican case is included with the FRx.




Although the battery, pads, and cables were noted as being affordable, evaluators agreed the viewer software suite and optional connector are expensive. They stated that the AED has a narrow storage temperature range and may need heat insulation. They considered the shelf life of the pads to be short to moderate, and the picture on the pads was described as being a bit confusing. Evaluators noted that the size of the pads could be problematic for very small children, even with anterior/posterior placement. The audio prompts are hard to hear in a loud environment, there is no display screen, no visual prompts, and the battery status indicator light is very small. Evaluators reported that the disposable battery has to be removed to check its expiration date, and it is hard to remove and install the battery with gloved hands. Evaluators also stated that the device does not indicate when it is

performing a self-test, and the self-test does not include a check of the pads or pad connector cables.

Lifeline AED

Defibtech's Lifeline AED received the third highest overall score. Evaluators were impressed with the Lifeline AED's light weight, ruggedness, ease of deployment, and flexible battery requirements. They indicated that the AED is able to transfer care without changing pads with the use of an optional adapter. It easily detects motion, gives an audible warning when motion is detected, and begins reanalyzing. Evaluators noted the prompts include a "call for help" and continual CPR prompts. The AED has only two easy-to-understand buttons, can be cleaned according to OSHA bloodborne pathogen guidelines, and is considered easy to handle and put into operation. Evaluators agreed the batteries, adult pads, and cases are very affordable.




Evaluators commented that Defibtech software is required to open a file for viewing/printing on a computer. They expressed concern that the Lifeline AED may not be freeze-resilient and may need heat insulation. Evaluators reported that the pads are excessively sticky and the shelf life of the pads is short. The Lifeline AED cannot detect a pacemaker. It has no text, no display screen, no indication of joules delivered, and no visual indication of effectiveness. In addition, evaluators stated that the "check pads" LED receives bleed-over light from other LEDs. They noted that there is no battery status indicator light, the self-test does not include a check of the pads and pad connector cables, and the unit makes a sound while charging.

	 Pros <ul style="list-style-type: none"> • Easy to deploy on-site • Very rugged • Can transfer care without changing pads • Clearly marked pediatric pads • Lightweight • Affordable initial and recurring costs • Decontamination meets OSHA standards
	 Cons <ul style="list-style-type: none"> • Storage temperature range • No display screen • Bulky pediatric pads • Cannot program prompts • Excessively sticky pads • No shoulder strap or case • Replacement time
Lifeline AED	Composite Assessment Score: 80

AED 20

Welch Allyn's AED 20 and Zoll Medical Corporation's AED Pro each received the fourth highest overall score. The AED 20 has an excellent storage temperature range, a bright display in daylight, and easily adjustable volume and contrast. Evaluators stated the AED has an EMS mode. The storage temperature range was considered excellent and the AED 20 appeared well insulated. Evaluators reported that the AED 20 uses adult pads with a pediatric energy reducing adapter, instead of pediatric pads. The AED 20 has good audio prompts, even during noisy operations. Evaluators agreed the volume and contrast are easily adjusted with soft keys on the front of the device. They noted that the battery's shelf life is good and the battery status indicator light appears on the AED after it is turned on. Evaluators also stated that the AED 20 automatically analyzes following correct attachment of the pads to the patient's chest. In addition, they agreed that the adult pads are reasonably priced.

Evaluators considered the AED 20 to be very expensive and not rugged. They stated that there is no way to detect compressions and the device does not provide ECG readouts. Evaluators indicated that the device's IP rating is low, it does not have enough water resistance for pre-hospital use, and it is impractical for use in the pre-hospital field because there is no protection for the screen. They stated that the AED 20 is not able to transfer care without changing pads, the pads stick a little to the gloves, and the shelf life of the pads is short. The AED 20 cannot detect a pacemaker, and the sound is too low when background noise is present. Evaluators reported that the AED 20 cannot be cleaned according to OSHA bloodborne pathogen guidelines, and it appears to be difficult to clean because it has lots of crevasses.

	 Pros <ul style="list-style-type: none"> • Storage temperature range • Easy to adjust volume and contrast • Bright display in daylight • Pad connector cable length • 5-year battery shelf life
	 Cons <ul style="list-style-type: none"> • Not very rugged • Cannot transfer care without changing pads • No shoulder strap or case • Decontamination does not meet OSHA standards • Initial cost
AED 20	Composite Assessment Score: 78

Evaluators noted the battery is difficult to remove and install, and it easily pinches fingers. They found it difficult to attach the pads while holding the AED 20 since there is no shoulder strap and it is relatively heavy.

AED Pro

The Zoll Medical Corporation’s AED Pro tied with the AED 20 in receiving the fourth highest overall score. - Evaluators stated the device is well insulated and very rugged. They considered the AED Pro’s IP rating and watertight seal on the battery compartment to be excellent. Evaluators noted the device is able to transfer care without changing pads with the use of an optional adapter. They commented that the top of the AED Pro’s case is identifiable by device name/ manufacturer, the shelf life of the pads is very good, and the pictures on the pads are easy to understand. Evaluators noted the visual prompts do not washout in the daylight. The AED Pro can be cleaned according - to OSHA bloodborne pathogen guidelines. The AED - Pro performs self-tests periodically, when pads are unplugged and when the AED is powered on. Evaluators considered the self-tests to be easy, noting that they check the pads, cables, and batteries. - Evaluators also stated that the batteries and adult pads are very affordable.




Evaluators considered the AED Pro to be expensive, bulky, heavy, and difficult to deploy on-site. They noted its infrared data transfer is impractical due to the cost of the software that must be purchased, amount of time required for each download, and insensitive infrared reader. Evaluators explained that the infrared




reader has to be held close to the AED throughout the entire process, making it difficult, inconvenient, and tiring. The AED Pro case is black and not very visible, and its zipper pull is black and hard to access. Evaluators reported that the pads are very sticky, bulky, and difficult to open and peel off. The pad attachment was also considered complicated, and there were no audio/visual directions found for the user. Evaluators stated that the center sternal section does not allow the pads to be placed in the correct place on all patients (i.e., very small or larger patients). The device cannot detect a pacemaker, and it did not detect - motion even when the manikin was intentionally shaken. Evaluators noted the audio prompt is hard to hear with background noise because the speakers are located on the side. They stated the AED Pro does not provide audio/visual CPR prompts or visual prompts for shock time and joules delivered. The battery is difficult to remove and install because the top of the case must be opened in order to access the battery. Evaluators explained that the AED Pro is more difficult to deploy on-site when it cannot be set down because the shoulder strap is unusable and the device has to be held. Evaluators reported that it takes excess time to apply the complicated pads, and it is difficult to make a shock using very short pad connector cables. They explained that this can result in a dangerous situation, because the emergency responder has to remain close to the patient during the shock unless he or she puts the AED down. Evaluators noted that it is difficult to unzip the case due to the location of its strap and suggested that it would be easier to open if the strap was attached to the bottom of the case instead.

Samaritan PAD

The Heartsine Technologies’ Samaritan PAD received the lowest overall assessment score. Evaluators indicated that the device is affordable, very rugged, lightweight, and compact. They explained that the - device can be cleaned with a 70 percent isopropyl alcohol and water mixture although it cannot be cleaned according to OSHA bloodborne pathogen guidelines. Evaluators noted the battery is easy to remove/install because it is a single-use battery attached to the pads. The AED performs quick, automated self-tests and a green light continuously flashes if the battery is okay. Evaluators also considered the battery/pad combinations to be very affordable.

Evaluators stated the Samaritan PAD is difficult to deploy on-site and noted that it cannot be set to -

	<div>  </div> <div> Pros </div> <ul style="list-style-type: none"> • Very rugged • Storage temperature range • Number of shocks per battery • Event storage capacity • Clearly marked pediatric pads • Decontamination meets OSHA standards • Easy and comprehensive automatic self-test • Affordable recurring costs
	<div>  </div> <div> Cons </div> <ul style="list-style-type: none"> • Impractical infrared data transfer • Dark color • Difficult to use pads • Bulky and heavy • Pad connector cables are too short • Difficult to deploy on-site • Initial cost
AED Pro	Composite Assessment Score: 78

	 Pros <ul style="list-style-type: none"> • Very rugged • Clearly marked pediatric pads • Quick, automated self-tests • Compact and lightweight • Affordable initial and recurring costs • 7-year warranty
	 Cons <ul style="list-style-type: none"> • Cannot transfer care without changing pads • Can only store one event • Cannot be set to semi-automated operation • Cannot program prompts • No display screen • Difficult to use pads • Decontamination does not meet OSHA standards • Difficult to deploy on-site • Visual prompts • No shoulder strap • Replacement time
Samaritan PAD	Composite Assessment Score: 66

semi-automated operation. They noted the AED unnecessarily reanalyzes the patient's condition with the slightest movement, but it did not detect - intentional movement of the pads during analysis. The pads were considered difficult to open and very sticky. Evaluators commented that the device cannot detect a pacemaker, and some audio prompts (especially the CPR timer) are difficult to hear with background noise. They reported that the visual prompts are basic, without text, confusing due to multiple lights on the display, and difficult to see in low light conditions. The AED has Velcro fasteners that may cause decontamination issues, the battery is not rechargeable, and there is no shoulder strap.

Conclusion

Four representatives from EMS and firefighting communities across the nation successfully evaluated eight AEDs.

Overall, the Cardiac Science Corporation Powerheart - AED G3 Pro and Philips Medical Systems HeartStart FR2+ scored the highest, followed by the Cardiac Science Corporation Powerheart AED G3 Plus and Philips Medical Systems HeartStart FRx. The Defibtech, LLC Lifeline AED received the third highest overall score. The Welch Allyn Inc. AED 20 and Zoll Medical Corporation AED Pro received the fourth highest scores. The Heartsine Technologies, Inc. Samaritan PAD received the lowest overall score.




























































































































































































































































































































Evaluators' comments highlighted the following considerations when evaluating AEDs:

- It is important that the system provide quick, accurate heart rhythm analysis.
- Costs for batteries and pads should be reasonable due to the turnover of these items.
- Pad connector cables should be long enough to allow the AED to be used when it is set down, or when it is set on the floor and the patient is on an elevated platform. However, the cable length should be manageable to minimize tangling.
- An AED should include a shoulder strap, and its placements and length should be sufficient in case the AED cannot be set down.
- An AED should have a display screen that displays joules delivered, ECG readouts, and a visual indication of effectiveness.
- Prompts should be user-programmable to - allow for some flexibility.
- An AED may be unusable in extremely hot or cold climates depending on its operating and-storage temperature ranges.
- An AED should be compatible with Advanced Life Support (ALS) equipment.
- An AED should have an atomic clock capability or automatic time reset upon data download to ensure consistent/accurate times with other components of an incident (i.e., - dispatch time, on-scene time).
- An AED should be able to detect a pacemaker.
- An AED should be able to store multiple events since download is not always possible with every use.
- Battery and pads expiration dates and pad connector cables should be readily visible for routine maintenance. -
- Exact model replacement should be provided by the AED manufacturer in 24 to 48 hours, especially for smaller agencies that often do not have spare devices. -
- The AED manufacturer should offer an extended warranty option and training.

Emergency responder agencies that are considering purchasing AEDs should carefully consider the overall capabilities and limitations of each AED and the need of their agency.

All reports in this series as well as reports on other technologies are available by request at <https://www.rkb.us/>.

Table 2. SAVER Category and Criteria Scores

KEY									
Least Favorable	➔ Most Favorable								
									
Assessment Criteria									
Affordability									
Recurring costs									
Warranty									
Training									
Upgradeable									
Initial cost									
Capability									
Ruggedness									
Multi-equipment compatibility									
Operating temperature									
Storage temperature									
Number of shocks per battery									
Event storage									
Semiautomated operation									
Pediatric pads									
Programmable prompts									
Accurate time keeping									
Visual readout									
Preparation kit availability									
Deployability									
Ease to deploy on-site									
Weight									
Color									
Size									
Shape									
Maintainability									
Decontamination									
Battery									
Self-test									
Maintenance time									
Replacement time									
Usability									
Ease of opening the case									
Pads									
Interference/artifact detection									
Audio prompts									
Visual prompts									
Cables/cords									
Shoulder strap	