Homeland Security
Science and Technology

Summary

U.S. Department of Homeland Security
SAVER
System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions.

Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercial equipment and systems, and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

The SAVER Program 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?"

For more information on this and other technologies, contact the SAVER Program Support Office.

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Diver Propulsion Vehicles

(AEL reference number 03WA-01-PROP)

In order to provide emergency responders with information on currently available diver propulsion vehicles (DPVs), the Space and Naval Warfare Systems Center (SPAWARSYSCEN) Atlantic conducted a comparative assessment of DPVs for the System Assessment and Validation for Emergency Responders (SAVER) Program in August 2011. Detailed findings are provided in the Diver Propulsion Vehicles Assessment Report*, which is available by request at https://www.rkb.us/saver.*

Background

DPVs are valuable deployment tools for emergency response divers. DPVs can improve the mobility of divers and help them conserve energy during dive operations, such as underwater search and rescue/recovery, underwater investigation, and disaster assessments.

Assessment Methodology

Prior to the assessment, seven emergency responders were chosen from various jurisdictions to participate in a focus group. Participants were members of law enforcement or fire department dive teams. The group's primary objectives were to recommend evaluation criteria, product selection criteria, products, and possible scenarios for the assessment.

Based on focus group recommendations, market research, and availability, the following DPVs were purchased and assessed:

- Cuda Fury 1150, Dive Xtras Inc.;
- HDV T16, Halcyon Manufacturing;
- Magnus 950, Submerge Inc.; and
- Hollis® H-160, American Underwater Products.

Four responders served as evaluators for this assessment. All evaluators had experience on a law enforcement or emergency management dive team.

Evaluators were tasked to participate in two phases of the assessment: the specification assessment and the operational assessment. During the specification assessment, evaluators assessed the vehicles based on vendor-provided information and specifications. Hands-on experience with the vehicles during two scenarios served as the basis for the operational assessment.

Assessment Results

Evaluators rated the DPVs based on the evaluation criteria established by the focus group. The focus group assigned each criterion to one of the five SAVER categories, and then assigned a weight for its level of importance.

Once the criteria were weighted, the five SAVER categories were assigned a percentage value to represent the level of each category's importance relative to the other categories.

Table 1 displays the composite assessment scores as well as the category scores for each product. Higher scores indicate a higher rating by evaluators. The advantages and disadvantages of each vehicle, as identified by evaluators, are listed in table 2. To view how each DPV scored against the evaluation criteria assigned to the SAVER categories, see table 3. For product specifications, see table 4.

The following paragraphs provide a brief summary of evaluator comments and feedback on each DPV used during the assessment; the complete assessment report includes a breakdown of evaluator comments by SAVER category. The vehicles are listed from highest to lowest composite score.

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

Cuda Fury 1150

Cuda Fury 1150

The Cuda Fury 1150 received a composite score of 4.2. The following paragraphs provide a summary of evaluator comments and feedback on the Cuda Fury 1150.

The vehicle's electronics should survive flooding since the motor is water resistant. The DPV is shock resistant and features a one-piece rugged housing and double O-ring seals. The vehicle's oil/chemical resistance is important in case the DPV must be operated in a hazardous environment. The rechargeable battery has a long battery life (i.e., 500 charge cycles). The battery run time exceeded expectations; the battery charge was not depleted during the assessment activities. The DPV is easy to maneuver and steer. The propeller pitch is easy to adjust underwater without tools, though numbers or marks on the DPV to indicate the position of the propeller pitch setting would be helpful. The DPV features an electronic clutch to disengage the drive assembly should objects become entangled in the propeller; this feature is better than having a shear pin. The dead-man's switch immediately stops the DPV when the throttle control is released. The battery is easy to replace in the field and features a handle that makes it easy to lift. Post-dive procedures are simple, with easy-to-follow instructions. A spare parts kit containing extra O-rings and propeller parts is included with purchase and can be used for routine maintenance. Annual service can be performed by users. The warranty duration is great; however, extended warranties should be available.

Table 1. Diver Propulsion Vehicle Assessment Results

Vehicle	Composite Score	Affordability (10% Weighting)	Capability (25% Weighting)	Deployability (27% Weighting)	Maintainability (15% Weighting)	Usability (23% Weighting)
Cuda Fury 1150	**4.2**	3.9	4.3	4.4	4.0	4.1
HDV T16	**4.1**	2.8	3.5	4.6	4.5	4.6
Magnus 950	**4.1**	3.9	4.5	4.2	3.0	4.4
Hollis® H-160	**3.9**	2.5	4.1	4.4	4.2	3.6

Particular care is required to avoid pinching the O-rings during assembly. The DPV is able to tow a second diver; however, it is somewhat difficult to adjust and control the speed while towing the second diver. While the DPV is easy to hold and control with one hand, holding the throttle control for more than a short period of time results in hand fatigue. The vehicle features eight throttle speeds, though speed is not easily changed and it takes time to master use of the throttle. The propeller is easily changed, but accessing and removing the battery O-ring is somewhat difficult and the maintenance instructions are insufficient. The battery charger has indicators for voltage, amps, and charging amps; however, the battery has a long charge time and it must be monitored while charging. The replacement battery cost may be expensive for agencies with limited budgets.

HDV T16

HDV T16

The HDV T16 received a composite score of 4.1. The following paragraphs provide a summary of evaluator comments and feedback on the HDV T16.

The DPV is easy to assemble and it appears durable, especially the one-piece rugged housing; however, it should be shock resistant and tested for oil/chemical resistance. The vehicle's performance is not impaired when towing a second diver. Changing speed is smooth and easy. The vehicle is very responsive, easy to maneuver, and equipped with a secondary hand grip on the shroud that helps make turns easier. The DPV features a mechanical clutch to disengage the drive assembly should objects become entangled in the propeller; additionally, the drive assembly will automatically re-engage when objects are cleared from the propeller. The dead-man's switch immediately stops the vehicle when the throttle control is released. The DPV has an on/off switch that prevents users from accidentally engaging the drive assembly during transport. It also has a bypass switch that connects the battery directly to the motor in case of control circuit failure, which allows the user to return to shore. The throttle control is comfortable and easy to operate with one hand; evaluators did not experience hand fatigue during the assessment. The propeller pitch is not adjustable, but the DPV has an easy-to-use variable speed throttle control. The battery charge time is reasonable, and there is no need to monitor the battery while it is charging. The battery is easy to replace in the field without tools and features a handle that makes it easy to lift. Post-dive procedures are simple and do not require proprietary tools, though care is needed to avoid pinching the O-ring. Routine maintenance is easily performed and does not require proprietary tools. The propeller can be changed without tools. The replacement battery cost is acceptable.

The rechargeable battery has a short battery life (i.e., 200 to 300 charge cycles) and the battery run time was less than the vendor specification; a low battery indicator would be helpful, as the DPV shuts off without warning when the battery is depleted. The warranty duration meets expectations; however, extended warranties should be available. Service maintenance on the O-rings and shaft seals must be performed by the vendor.

Magnus 950

Magnus 950

The Magnus 950 received a composite score of 4.1. The following paragraphs provide a summary of evaluator comments and feedback on the Magnus 950.

The small handle on the nose of the DPV helps when launching and recovering the vehicle. The DPV appears very durable due to its shock resistance and corrosion-resistant housing; however, it should be tested for oil/chemical resistance. The two-piece housing is less favorable. The battery run time exceeded expectations; additionally, when the battery began to lose power, the loss was gradual and noticeable, allowing the user time to return to shore. The vehicle performs well when towing a second diver. The rechargeable battery has a good battery life (i.e., 300 to 500 charge cycles). The DPV is easy to maneuver and steer. The propeller pitch adjustment is labeled with numbers to indicate the pitch and is easily adjusted underwater without tools.

The DPV features a mechanical clutch as well as a shear pin to disengage the drive assembly should objects become entangled in the propeller; the drive assembly will automatically re-engage when objects are cleared from the propeller. The dead-man's switch immediately stops the DPV when the throttle control is released. Routine maintenance is easily performed; however, more detailed maintenance instructions would be helpful. The vendor will train users to inspect the shaft seal for corrosion; if the shaft seal is corroded, the vendor will repair it at no cost for the duration of the warranty. Extended warranties, such as a 3-year pro-rated warranty for $500, are available.

The thin throttle control wire and rubber straps that hold the latches in place may wear out over time. The vehicle has eight latches, which are difficult to close when assembling the DPV. The large throttle control handle is comfortable and easy to control with one hand, but sometimes results in slight hand fatigue. Post-dive procedures are easy, although the latches holding the housing in place had to be carefully latched and unlatched. The battery has a long charge time and it must be monitored while charging; the battery is also difficult to replace in the field because tools are required and there are small parts that could be lost. The replacement battery cost may be expensive for public safety agencies with limited budgets.

Hollis H-160

Hollis H-160

The Hollis H-160 received a composite score of 3.9. The following paragraphs provide a summary of evaluator comments and feedback on the Hollis H-160.

The DPV appears durable, especially the one-piece rugged housing and the double O-ring seals; however, it should be shock resistant and tested for oil/chemical resistance. The rechargeable battery has a long battery life (i.e., 500 charge cycles). The battery run time met expectations; additionally, when the battery began to lose power, the DPV warned the user by switching to low speed, allowing time to return to shore. The propeller pitch adjustment is labeled with numbers to indicate the pitch and is easily adjusted underwater without tools. The DPV features a mechanical clutch to disengage the drive assembly should objects become entangled in the propeller; the drive assembly will automatically re-engage when objects are cleared from the propeller. The battery has a short charge time, and there is no need to monitor it when it is charging. The battery is easy to replace in the field without tools; however, there are small parts that could be lost. Routine maintenance is easily performed, though the small ball bearings and spring in the propeller assembly could be easily lost when changing the propeller. The replacement battery cost is reasonable.

The vehicle is easy to assemble; however, the configuration of the O-ring at the base of the DPV makes the O-ring difficult to remove. The vehicle features an integrated light on its nose, but the control for the light is located near the nose and should be located closer to other controls. The DPV is able to tow a second diver, though it is somewhat difficult to adjust and control the speed when towing a second diver. Single-handed operation becomes easier with practice, but the DPV turned to the right when it was operated with one hand. The vehicle is very responsive and easy to maneuver and steer; however, hand fatigue occurred during the assessment due to the trigger-style throttle control. The throttle control features three settings, but it is sometimes difficult to stop, start, and maintain a constant speed. There is a delay in stopping the DPV when the dead-man's switch is released. Post-dive procedures are simple, though the nut that secures the housing is difficult to remove and replace. If the user is not trained in service maintenance, the DPV must be serviced by the vendor or an authorized dealer. The warranty duration is insufficient and extended warranties should be available.

Conclusion

All four products scored favorably overall, and the small range of scores between the vehicles indicates only slight differences in the overall performance of the DPVs. Evaluators stated that all of the vehicles would be

suitable for public safety diving operations requiring the use of a DPV. They also made the following observations about all of the products:

- Customer support was helpful when called for maintenance questions, and vendors provide priority service to public safety agencies;
- The size of the DPVs is favorable for public safety use;
- The DPVs are lightweight, permitting easy launch and recovery;
- The DPVs fit easily in a vehicle and were easily moved from a vehicle to a place of deployment;
- The maximum operating depths exceed that used in most public safety operations;
- The buoyancy of the DPVs was easily adjusted; and
- The propeller shrouds meet expectations for safety.

All reports in this series, as well as reports on other technologies, are available in the SAVER section of the Responder Knowledge Base (RKB) Web site at https://www.rkb.us/saver.

Table 2. Diver Propulsion Vehicle Advantages and Disadvantages

Vehicle	Advantages	Disadvantages
 **Cuda Fury 1150** Composite Score: 4.2	• Long battery run time • One-piece rugged housing and double O-ring seals • Spare parts kit • Battery charger with indicators for voltage, amps, and charging amps	• Battery O-ring difficult to access • Replacement battery cost
 **HDV T16** Composite Score: 4.1	• Ease of throttle control • Motor control circuit bypass switch • Secondary hand grip on shroud • One-piece rugged housing • Propeller that can be changed without tools	• Service maintenance must be performed by vendor • No low-battery indicator
 **Magnus 950** Composite Score: 4.1	• Corrosion-resistant housing • Long battery run time • Comfortable throttle control handle • Numbered adjustable propeller pitch • Extended warranties	• Two-piece housing with non-locking latches • Thin throttle control wire • Tools required to change battery
 **Hollis® H-160** Composite Score: 3.9	• One-piece rugged housing and double O-ring seals • Integrated light • Numbered adjustable propeller pitch	• Slow throttle control response • Trigger-style throttle control causes hand fatigue • Turns to the right during single-handed operation

Table 3. Diver Propulsion Vehicle Criteria Ratings[1]

KEY Least Favorable → Most Favorable				
○ ◔ ◑ ◕ ●	**Cuda Fury 1150**	**HDV T16**	**Magnus 950**	**Hollis® H-160**
Affordability				
Service requirements	●	◔	◕	◔
Warranty	◕	◑	◕	◔
Battery cost	◔	◕	◑	●
Capability				
Battery type	●	◑	◕	◕
Battery run time	●	◑	●	◕
Workload performance	◕	●	●	◕
Expandability	●	◑	●	◕
Maximum operating depth	●	●	●	●
Deployability				
Size	●	●	●	●
Launch and recovery	●	●	●	●
Durability	●	◕	◕	◕
Ease of assembly	◑	●	◑	◕
Portability	●	●	●	●
Maintainability				
Battery charging	◑	●	◔	●
Field battery replacement	●	●	◔	◕
Post-dive procedures	●	●	◕	◕
Routine maintenance	◕	◕	◕	◑
Usability				
Throttle control	◑	●	◕	◑
Maneuverability	●	●	●	◕
Buoyancy	●	●	●	●
Propeller pitch adjustment	◕	●	●	●
Safety features	◕	●	◕	◑
Single-handed operation	◕	●	●	◑

Note:

[1] Averaged criteria ratings for each assessed product are graphically represented by colored and shaded circles. Highest ratings are represented by full green circles.

Table 4. Diver Propulsion Vehicle Specifications[1]

Specifications	Cuda Fury 1150	HDV T16	Magnus 950	Hollis® H-160
DPV cost	$6,600	$4,750	$6,600	$3,860
Replacement battery cost	$2,800	$1,000	$2,000	$955
Warranty	3 years	2 years	1 year	1 year
Extended warranty	Not available	Not available	Available	Not available
Separate corrosion/motor warranty	Not available	Not available	Available (5-year corrosion, 1-year motor)	Not available
Service requirements	Annual service recommended but can be done by user (no maintenance required for warranty)	O-rings and shaft seals should be serviced after 150 hours of use (warranty only covers maintenance performed by vendor)	Shaft seal should be inspected for corrosion every 6 months (if corrosion is present, return DPV to manufacturer for no cost repair and continuation of warranty)	If user is not trained in maintenance, recommend sending DPV to factory or authorized dealer for annual inspection and service
DPV length by hull diameter	29 x 8 inches	33 x 8 inches	28 x 9 inches	29 x 9 inches
Weight	42 pounds	46 pounds	50 pounds	48 pounds
Buoyancy	Neutral	Neutral	Positive	Neutral
Shock resistant	Yes	No	Yes	No
Oil/chemical resistant	Common hydrocarbons (petrol, diesel, oil)	No	No	No
Battery type	44 VDC Lithium-ion	24 VDC Nickel-metal hydride	50 VDC Lithium polymer	110 VDC Nickel-metal hydride
Battery life	500 charge cycles	200 to 300 charge cycles	300 to 500 charge cycles	500 charge cycles
Battery charge time	12 hours	8 hours	10 hours	5 hours
Battery run time at maximum speed	63 minutes	70 minutes	45 minutes	60 minutes
Maximum operating depth	600 feet	600 feet	450 feet	656 feet
Expandability (accessories that can be added)	Additional battery, harness, video-camera mount, light mount	Additional battery, light mount	Additional battery, video-camera mount, light mount, accessory mount	Harness

Notes:

[1] Information was provided by manufacturers and has not been independently verified by the SAVER Program.

DPV = diver propulsion vehicle
VDC = volts direct current