



System Assessment and Validation for Emergency Responders (SAVER)

Dive Lights Assessment Report

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System Assessment and Validation for Emergency Responders

Prepared by Space and Naval Warfare Systems Center Atlantic

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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 supported by a network of Technical Agents who perform assessment and validation activities. As a SAVER Program Technical Agent, the Space and Naval Warfare Systems Center (SPAWARSYSCEN) Atlantic has been tasked to provide expertise and analysis on key subject areas, including communications, sensors, security, weapon detection, and surveillance, among others. In support of this tasking, SPAWARSYSCEN Atlantic developed this report to provide emergency responders with information obtained from an operationally oriented assessment of dive lights, which fall under AEL reference number 03WA-01-ULHH titled Lights, Underwater, Personal.

For more information on the SAVER Program or to view additional reports on dive lights or other technologies, visit www.firstresponder.gov/SAVER.

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TABLE OF CONTENTS

Foreword.....	i
Points of Contact.....	ii
Executive Summary	v
1. Introduction.....	1
1.1 Evaluator Information.....	1
1.2 Assessment Products.....	1
2. Evaluation Criteria.....	3
3. Assessment Methodology.....	4
3.1 Phase I/Specification Assessment.....	4
3.2 Phase II/Operational Assessment.....	4
3.2.1 Setup Scenario	5
3.2.2 Dive Scenario.....	5
3.3 Data Gathering and Analysis	6
4. Assessment Results.....	6
4.1 Light Monkey Enterprises LLC 21 Watt 10-21 LED	10
4.2 Light & Motion Sola Dive 2000	11
4.3 Bigblue® Dive Lights/BoskUSA TL4000P	12
4.4 Underwater Light Dude LD-35 Primary Light (mini)	14
4.5 Underwater Kinetics Aqualite™ Pro 20°	15
4.6 Sartek Industries Inc. LED1200MICRO4L10	17
4.7 Tovatec Beacon Torch	18
4.8 Princeton Tec® Genesis™	20
5. Summary	21
Appendix A. Evaluation Criteria Definitions.....	A-1
Appendix B. User-Replaceable Parts	B-1
Appendix C. Attachment and Mounting Options	C-1
Appendix D. Assessment Scoring Formulas.....	D-1

LIST OF TABLES

Table 1-1. Evaluator Information	1
Table 1-2. Assessed Products	2
Table 2-1. Evaluation Criteria.....	4
Table 4-1. Assessment Results	7
Table 4-2. Criteria Ratings.....	8
Table 4-3. Key Specifications.....	9
Table 5-1. Product Advantages and Disadvantages.....	22

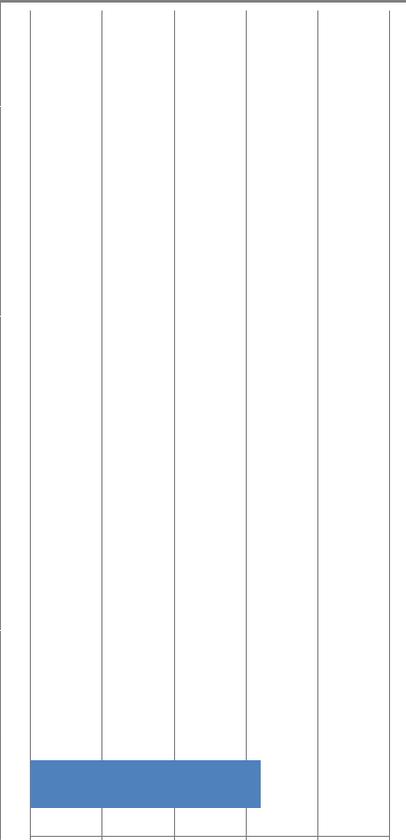
LIST OF FIGURES

Figure 3-1. Knife, Metal Pipe, and Inoperable Handgun Target Objects	5
Figure 3-2. Mannequin and Doll Target Objects	5
Figure 4-1. 21 Watt 10-21 LED.....	10
Figure 4-2. 21 Watt 10-21 LED On/Off Toggle Switch.....	10
Figure 4-3. Sola Dive 2000.....	11
Figure 4-4. Sola Dive 2000 Switch.....	12
Figure 4-5. TL4000P.....	12
Figure 4-6. TL4000P Power Button.....	13
Figure 4-7. LD-35 Primary Light (mini).....	14
Figure 4-8. LD-35 Primary Light (mini) Piezo Switch.....	14
Figure 4-9. Aqualite Pro 20°	15
Figure 4-10. Aqualite Pro 20° Rotary Switch.....	16
Figure 4-11. LED1200MICRO4L10	17
Figure 4-12. LED1200MICRO4L10 Rotary Knob.....	17
Figure 4-13. Beacon Torch	18
Figure 4-14. Beacon Torch Bezel Switch.....	19
Figure 4-15. Beacon Torch Canister Configuration	19
Figure 4-16. Beacon Torch Protected Lock Slide.....	19
Figure 4-17. Genesis	20
Figure 4-18. Genesis Power Button.....	20

EXECUTIVE SUMMARY

Dive lights are primarily used by public safety divers to provide additional illumination during dive operations that are conducted in poorly-lit conditions. Such conditions may occur during nighttime dives, as well as when searching inside sunken vessels or vehicles, examining underwater structures, and diving at great depths. In April 2015, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted an operationally oriented assessment of dive lights.

Eight dive lights were assessed by public safety divers. The criteria and scenarios used in this assessment were derived from the results of a focus group of public safety divers with experience using dive lights. The assessment addressed eight evaluation criteria in four SAVER categories: Capability, Deployability, Maintainability, and Usability. The overall results of the assessment are highlighted in the following table.

Product	Overall Score	Overall	Usability	Deployability	Capability	Maintainability
Light Monkey Enterprises LLC 21 Watt 10-21 LED		4.1	3.8	4.5	4.2	3.8
Light & Motion Sola Dive 2000		3.9	4.0	3.8	3.8	4.2
Bigblue Dive Lights/BoskUSA TL4000P		3.8	3.8	3.7	4.2	3.6
Underwater Light Dude LD-35 Primary Light (mini)		3.8	3.8	3.7	4.2	3.6
Underwater Kinetics Aqualite Pro 20°		3.5	3.6	3.5	2.8	3.8
Sartek Industries Inc. LED1200MICRO4L10		3.4	3.4	3.0	3.4	3.8
Tovatec Beacon Torch		3.2	3.1	2.7	3.8	3.8
Princeton Tec Genesis		3.2	3.2	3.2	2.8	3.8
	0 1 2 3 4 5 Lower Higher					

1. INTRODUCTION

Dive lights are primarily used by public safety divers to provide additional illumination during dive operations that are conducted in poorly-lit conditions. Such conditions may occur during nighttime dives, as well as when searching inside sunken vessels or vehicles, examining underwater structures, and diving at great depths. In April 2015, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted an operationally oriented assessment of dive lights. The purpose of this assessment was to obtain information on dive lights 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 public safety divers with experience using dive lights.

1.1 Evaluator Information

Five public safety divers from various jurisdictions and with at least 7 years of experience using dive lights 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, and photo release form.

Table 1-1. Evaluator Information

Evaluator	Years	State
Law Enforcement, Dive Team Diver/Detective	20+	FL
Emergency Services, Marine Unit Diver	20+	TN
Law Enforcement, Dive Team Diver	16-20	WA
Law Enforcement, Search and Rescue Team Diver	11-15	AL
Law Enforcement, Marine Unit Diver	6-10	SC

1.2 Assessment Products

Eight 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 and listed in priority order below.

- Light output of 500 lumens or more
- LED light source
- Protected on/off control
- Variable brightness
- Adjustable beam angle
- Under 5 pounds.

The Sola Dive 2000 by Light & Motion met all product selection criteria, whereas the rest of the assessed products met the top three product selection criteria. Bigblue[®] Dive Lights/BosskUSA, Light Monkey Enterprises LLC, Sartek Industries Inc., and Underwater Light Dude each had

multiple products that met the top three product selection criteria. In these cases, the products selected for assessment were vendor recommended.

Table 1-2 presents the products that were assessed.

Table 1-2. Assessed Products

Vendor	Product	Product Image
Bigblue Dive Lights/BoskUSA	TL4000P	
Light & Motion	Sola Dive 2000	
Light Monkey Enterprises LLC	21 Watt 10-21 LED	
Princeton Tec	Genesis	
Sartek Industries Inc.	LED1200MICRO4L10	
Tovatec	Beacon Torch	

Vendor	Product	Product Image
Underwater Kinetics	Aqualite Pro 20°	
Underwater Light Dude	LD-35 Primary Light (mini)	

2. 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 public safety divers met in October 2014 and identified 10 evaluation criteria within four SAVER categories: 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. The focus group discussed the Affordability category but did not identify any evaluation criteria for that category.

Products were assessed against eight evaluation criteria. Heat Emission was not assessed to prevent potentially damaging the dive lights. Dry Weight was not assessed because evaluators determined that the weight of the dive lights would have negligible effect on diver fatigue. Table 2-1 presents the evaluation criteria and their associated weights as well as the percentages assigned to the SAVER categories. Refer to Appendix A for evaluation criteria definitions.

Table 2-1. Evaluation Criteria

SAVER CATEGORIES			
Usability	Deployability	Capability	Maintainability
Overall Weight 40%	Overall Weight 25%	Overall Weight 20%	Overall Weight 15%
Evaluation Criteria			
Ease of Use Weight: 4	Durability Weight: 5	Brightness Weight: 4	Ease of Maintenance Weight: 4
Mounting Versatility Weight: 4	Ease of Setup Weight: 4		
Ergonomics Weight: 3	Heat Emission Not Assessed		
Protected On/Off Control Weight: 3	Dry Weight Not Assessed		

3. ASSESSMENT METHODOLOGY

The products were assessed over three days. On the first day of the assessment, a subject matter expert (SME) and facilitators presented a safety briefing and an overview of the assessment process, procedures, and schedule to the evaluators. Each product was then assessed in two phases: (1) specification assessment and (2) operational assessment.

3.1 Phase I/Specification Assessment

During the specification assessment, evaluators assessed each product based on vendor-provided information. Product information was confirmed by vendors prior to the assessment.

3.2 Phase II/Operational Assessment

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. The SME and facilitators assisted the evaluators with product familiarization, and evaluators had access to the reference material included with each product. The products were assessed in two scenarios: (1) setup scenario and (2) dive scenario. Evaluators used the products one at a time and completed the assessment worksheets for each product before assessing the next product.

3.2.1 Setup Scenario

Evaluators performed vendor-recommended pre-dive maintenance after examining the dive lights and included components (e.g., mounts, chargers) for overall ruggedness and features that prevent unintentional activation/deactivation. While performing pre-dive maintenance, evaluators reviewed the replacement parts included with purchase of each dive light, as well as a list of additional user-replaceable parts available from the vendors, to determine if they were commonly available or proprietary. For a list of user-replaceable parts refer to Appendix B. Evaluators also inspected the attachment points on the dive lights and reviewed a list of mounting options available from the vendors to assess Mounting Versatility. For a list of attachment and mounting options refer to Appendix C. Evaluators prepared the dive lights for dive operations by replacing the batteries and/or connecting the light heads to the canisters for operation.

3.2.2 Dive Scenario

This scenario was conducted during the daytime and nighttime at Lake Keowee in Seneca, SC. The daytime dive included moving from light conditions to dark conditions. The dive course was set up at a depth of approximately 20 feet. Target objects—a knife, a metal pipe, an inoperable handgun, a mannequin, and a doll (Figure 3-1 and Figure 3-2)—were located along the course no further than 10 feet from the line.

One at a time, evaluators proceeded along the line using the dive lights to look at the target objects to determine if the dive lights were bright enough to permit recognition. Evaluators also used the dive lights to read their dive gauges. Evaluators activated the dive lights, changed between modes, and adjusted the light beam while completing the line course. The dive lights were used in a mounted configuration while wearing dive gloves during the daytime dive and in a handheld configuration (with the exception of the canister lights) without dive gloves during the nighttime dive to assess Brightness, Ergonomics, and Ease of Use.

Upon completion of each dive, evaluators noted whether the dive lights were accidentally activated or deactivated during the dive. Upon completion of all dive operations, evaluators performed vendor-recommended post-dive maintenance and inspected the dive lights and included components to determine if any damage occurred during the assessment.



Figure 3-1. Knife, Metal Pipe, and Inoperable Handgun Target Objects



Figure 3-2. Mannequin and Doll Target Objects

3.3 Data Gathering and Analysis

Each evaluator was issued an assessment workbook that contained vendor-provided information, assessment procedures, and worksheets for recording criteria ratings and comments. Evaluators used the following 1 to 5 scale:

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.

Criteria that were rated multiple times throughout the assessment were assigned final overall ratings by the evaluators. Facilitators captured advantages and disadvantages for the assessed products as well as general comments on the dive lights assessment and the assessment process. 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 the 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 D. In addition, evaluator comments for each product were reviewed and summarized for this assessment report.

4. ASSESSMENT RESULTS

Overall scores for the assessed products ranged from 3.2 to 4.1. 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. Assessment Results

Product	Overall Score	Overall	Usability	Deployability	Capability	Maintainability
Light Monkey Enterprises LLC 21 Watt 10-21 LED		4.1	3.8	4.5	4.2	3.8
Light & Motion Sola Dive 2000		3.9	4.0	3.8	3.8	4.2
Bigblue Dive Lights/BoskUSA TL4000P		3.8	3.8	3.7	4.2	3.6
Underwater Light Dude LD-35 Primary Light (mini)		3.8	3.8	3.7	4.2	3.6
Underwater Kinetics Aqualite Pro 20°		3.5	3.6	3.5	2.8	3.8
Sartek Industries Inc. LED1200MICRO4L10		3.4	3.4	3.0	3.4	3.8
Tovatec Beacon Torch		3.2	3.1	2.7	3.8	3.8
Princeton Tec Genesis		3.2	3.2	3.2	2.8	3.8
	0 1 2 3 4 5 Lower Higher					

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. Refer to Appendix A for evaluation criteria definitions. Regarding Ease of Maintenance, all maintenance procedures were easily accomplished. Table 4-3 presents vendor-provided key specifications for the assessed products. All of the dive lights are negatively buoyant with a dry weight of less than 6 pounds. The Princeton Tec® Genesis™ is powered by two CR123 batteries. All other lights are powered by a proprietary, rechargeable battery. In addition, all of the dive lights included batteries and can be stored with batteries installed; however, Light Monkey Enterprises LLC cautioned against this since the light could be accidentally switched on in storage causing the LED to burn out, and Bigblue Dive Lights/BoskUSA, Princeton Tec, and Tovatec recommended the batteries be removed/disconnected for extended storage periods.

Table 4-2. Criteria Ratings

KEY									
Category	Evaluation Criteria	21 Watt 10-21 LED	Sola Dive 2000	TL4000P	LD-35 Primary Light (mini)	Aqualite Pro 20°	LED1200 MICRO 4L10	Beacon Torch	Genesis
Usability	Ease of Use								
	Mounting Versatility								
	Ergonomics								
	Protected On/Off Control								
Deployability	Durability								
	Ease of Setup								
Capability	Brightness								
Maintainability	Ease of Maintenance								

Table 4-3. Key Specifications

Key Specification	21 Watt 10-21 LED	Sola Dive 2000		TL4000P	LD-35 Primary Light (mini)	Aqualite Pro 20°	LED1200 MICRO 4L10	Beacon Torch	Genesis
MSRP	\$1,345	\$799		\$546	\$1,545	\$325 ¹	\$1,065	\$499 ²	\$130
Warranty Duration	1 year	2 years		1 year	3 years ³	Lifetime ⁴	Lifetime	1 year	1 year
Body Style	Canister	Torch		Torch	Canister	Torch	Canister	Torch	Torch
Beam Angle	6°	12°	60°	10°	8.2°	20°	8° ⁵	11°	10°
Brightness (lumens)	1100	150 300 600	500 1000 2000	400, 1000, 2000, 4000	800, 2100, 3500	160, 300, 430, 750	1200	750, 1250, 2500	400, 650
User-Replaceable Battery				✓		✓	✓		✓
Battery Runtime	5 hours	0.9 to 3.7 hours		2 to 20 hours	1.7 to 10 hours	1.6 to 12 hours	4 hours	2 to 12 hours	3 to 24 hours
Strobe Mode		✓			✓				✓
Dimensions (inches, LxWxH or LxD)	C: 9.0x3.0 LH: 4.0x4.5	4.0x2.1		4.1x2.8	C: 5.5x2.6 LH: 3.0x2.0	5.0x1.5	C: 5.4x2.4 LH: 4.0x2.0	10.6x1.3x2.8	5.5x1.5
Weight (pounds)	C: 4.50 LH: 1.30	0.56		1.31	C: 1.80 LH: 1.38	0.40	C: 2.50 LH: 0.50	2.38	0.45
Depth Rating (feet)	500	300		328	656	500	1000	400	328
Notes: ✓—product is equipped with corresponding feature Blank cell—product is not equipped with corresponding feature Dimensions/Weight—length (L); width (W); height (H); diameter (D); canister (C); light head (LH) ¹ MSRP includes the cost of an optional hand mount kit ² MSRP includes the cost of an optional canister kit ³ Excludes the battery, which has a 1-year warranty ⁴ Lifetime on defects in materials and workmanship, 10 years for plastics, 3 years for rubber, 1 year for LEDs and electronics, and 90 days for batteries ⁵ Beam angle must be selected from the following options at time of purchase: 8°, 25°, or 45°									

4.1 Light Monkey Enterprises LLC 21 Watt 10-21 LED

The 21 Watt 10-21 LED (Figure 4-1) received an overall assessment score of 4.1 and costs \$1,345. A battery charger, hard Goodman handle, and 1-year warranty are included with purchase.

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

Usability

The 21 Watt 10-21 LED received a Usability score of 3.8. The following information is based on evaluator comments:

- The on/off toggle switch (Figure 4-2) on the canister was easy to operate, with or without dive gloves, and using one hand. The switch is located on the large-diameter canister so the ease of accessing it is dependent on where the canister is mounted.
- The light head was mounted on an adjustable hard Goodman handle. The canister could be attached to a belt or clipped to the diver with a bolt snap or carabineer. Double-ended snaps, bolt snaps, and a soft Goodman handle are available for purchase from the vendor.
- The light was fairly comfortable to wear; however, the hard Goodman handle was not easily adjusted underwater because it required a screwdriver. Overall, the size and buoyancy of the light did not interfere with dive operations.
- The on/off toggle switch (Figure 4-2) was recessed and located on top of the canister. To prevent unintentional activation while in storage, the light had a lockout feature that was activated by installing the canister lid rotated 180 degrees. The light did not accidentally activate or deactivate during the assessment.



Figure 4-1. 21 Watt 10-21 LED



Figure 4-2. 21 Watt 10-21 LED On/Off Toggle Switch

Deployability

The 21 Watt 10-21 LED received a Deployability score of 4.5. The following information is based on evaluator comments:

- The light head and canister have solid construction with minimal water intrusion points, a heavy duty on/off toggle switch, and a thick protected cable with strain relief. The charging connectors also appeared to be heavy duty. There was no noticeable wear and tear at the end of the assessment.
- The light was easy to set up. The connectors on the light head were color coded, which made connecting the light head to the canister easy. The O-rings were easy to remove and replace. The light featured an internal rechargeable battery. Charging the

battery was easily done by removing the lid and plugging the charging cable leads into the receptacles inside the top of the canister.

Capability

The 21 Watt 10-21 LED received a Capability score of 4.2. The following information is based on evaluator comments:

- The light had a narrow, powerful beam that provided adequate illumination. It was powerful enough to penetrate turbid water. Overall, all of the target objects were located during both the daytime and nighttime dives.

Maintainability

The 21 Watt 10-21 LED received a Maintainability score of 3.8. The following information is based on evaluator comments:

- There were no pre-dive maintenance procedures. Post-dive maintenance procedures consisted of rinsing with fresh water.

4.2 Light & Motion Sola Dive 2000

The Sola Dive 2000 (Figure 4-3) received an overall assessment score of 3.9 and costs \$799. A soft Goodman handle, a battery charger, a carrying case, an owner's manual, and a 2-year warranty are included with purchase.

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

Usability

The Sola Dive 2000 received a Usability score of 4.0. The following information is based on evaluator comments:

- It was easy to activate/deactivate the light, change brightness settings, and adjust the beam angle, with one hand, with or without dive gloves. In addition, there were LEDs on the light that indicated the level of brightness.
- The light had a soft Goodman handle. A hand strap, soft T-handle, and pistol grip are available for purchase from the vendor.
- The light was very comfortable to wear and hardly noticeable when wearing it. The size and buoyancy of the light did not interfere with dive operations.



Figure 4-3. Sola Dive 2000

- The switch (Figure 4-4) had a lockout feature. The diver rotated the switch 90 degrees to prevent unintentional activation and/or deactivation while in operation. To disengage the lockout feature, the diver rotated the switch back 90 degrees. The light did not accidentally activate or deactivate during the assessment.



Figure 4-4. Sola Dive 2000 Switch

Deployability

The Sola Dive 2000 received a Deployability score of 3.8. The following information is based on evaluator comments:

- The light appeared to be rugged and of solid construction; however, the switch got stuck during two of the daytime dives. There was no noticeable wear and tear at the end of the assessment.
- The light was easy to set up. The light featured an internal rechargeable battery. Charging the battery was easily done by plugging the charging cable into the back of the light.

Capability

The Sola Dive 2000 received a Capability score of 3.8. The following information is based on evaluator comments:

- The light illuminated the target objects well during both the daytime and nighttime dives. However, sometimes the light was not as bright as expected during the day, and it took some effort to locate all of the target objects. The light featured spot and flood beam modes.

Maintainability

The Sola Dive 2000 received a Maintainability score of 4.2. The following information is based on evaluator comments:

- There were no pre-dive maintenance procedures. Post-dive maintenance procedures consisted of rinsing with fresh water.

4.3 Bigblue® Dive Lights/BosskUSA TL4000P

The TL4000P (Figure 4-5) received an overall assessment score of 3.8 and costs \$546. A battery charger, a soft Goodman handle with mounting plate, a lantern handle, a wrist lanyard, an instruction manual, and a 1-year warranty are included with purchase.

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



Figure 4-5. TL4000P

Usability

The TL4000P received a Usability score of 3.8. The following information is based on evaluator comments:

- The light was easy to activate and deactivate, with or without dive gloves, by pushing the power button (Figure 4-6). It was easy to change brightness settings by pushing the power button to cycle through the levels of brightness.
- The light had a soft Goodman handle with mounting plate, a lantern handle, and a wrist lanyard. The mounting plate had to be fastened to the light before being attached to the soft Goodman handle. It was easy to switch between the soft Goodman handle and lantern handle.
- Although somewhat bulky, the light was comfortable to wear, and its size and buoyancy did not interfere with dive operations. However, the light was not held securely in the soft Goodman handle.
- The power button (Figure 4-6) was recessed, making an accidental activation or deactivation unlikely to occur. The light did not accidentally activate or deactivate during the assessment.



Figure 4-6. TL4000P Power Button

Deployability

The TL4000P received a Deployability score of 3.7. The following information is based on evaluator comments:

- The light appeared to be very rugged. There was no noticeable wear and tear on the light at the end of the assessment. However, the stitching for the Velcro[®] on the soft Goodman handle began to fray by the end of the assessment.
- The light was quickly assembled for deployment. The battery and O-ring were easily removed and replaced. However, because the battery terminals were not marked, the battery could be incorrectly installed, potentially causing damage to the light. In addition, the O-ring required silicone grease to be applied prior to use but none was provided.

Capability

The TL4000P received a Capability score of 4.2. The following information is based on evaluator comments:

- The light had an extremely bright beam that illuminated target objects well during both the daytime and nighttime dives.

Maintainability

The TL4000P received a Maintainability score of 3.6. The following information is based on evaluator comments:

- There were no pre-dive maintenance procedures. Post-dive maintenance procedures consisted of rinsing with fresh water.

4.4 Underwater Light Dude LD-35 Primary Light (mini)

The LD-35 Primary Light (mini) (Figure 4-7) received an overall assessment score of 3.8 and costs \$1,545. A mini canister with top cable gland, a battery charging cradle, a hard Goodman handle, a soft Goodman handle, bolt snaps, and a 3-year warranty (battery, 1-year) are included with purchase.



Figure 4-7. LD-35 Primary Light (mini)

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

Usability

The LD-35 Primary Light (mini) received a Usability score of 3.8. The following information is based on evaluator comments:

- The light was easy to activate and deactivate, with or without dive gloves, by pressing the piezo switch (Figure 4-8) on the light head for 3 to 5 seconds. However, the switch had a low profile and did not provide any tactile feedback when pressed, resulting in it being difficult to know if the switch was activated. It was easy to change brightness settings by repeatedly pressing the piezo switch for 1 second to cycle through the levels of brightness.
- In addition to the hard and soft Goodman handles, the light head can also be attached to a buoyancy control device (BCD) or belt with the integrated bolt snap when not in use. The canister had bungee loops and a cloth strap that allowed it to be clipped onto a BCD or belt.
- The soft Goodman handle was padded, comfortable, and easy to adjust. It was easy to remove the light head from the soft Goodman handle underwater by snapping it out of a clip. Overall, the size and buoyancy of the light did not interfere with dive operations, but the cable was too long.



Figure 4-8. LD-35 Primary Light (mini) Piezo Switch

- The piezo switch (Figure 4-8) was not protected; however, it had to be pressed constantly for 3 to 5 seconds to activate/deactivate the light. The light did not accidentally activate or deactivate during the assessment.

Deployability

The LD-35 Primary Light (mini) received a Deployability score of 3.7. The following information is based on evaluator comments:

- The light appeared to be rugged and had a sheathed cable and minimal water intrusion points. There was no noticeable wear and tear at the end of the assessment.
- The light was somewhat difficult to set up because it required manipulation of a thin retaining wire for the canister top. If the retaining wire is not properly installed, the canister top will not seal properly. The light featured an internal rechargeable battery.

Capability

The LD-35 Primary Light (mini) received a Capability score of 4.2. The following information is based on evaluator comments:

- Overall, the light had a bright beam that illuminated target objects well during both the daytime and nighttime dives.

Maintainability

The LD-35 Primary Light (mini) received a Maintainability score of 3.6. The following information is based on evaluator comments:

- Pre-dive maintenance procedures consisted of inspecting and cleaning O-rings, which required care when reattaching the canister lid to the canister body. Post-dive maintenance procedures consisted of rinsing with fresh water.

4.5 Underwater Kinetics Aqualite™ Pro 20°

The Aqualite Pro 20° (Figure 4-9) received an overall assessment score of 3.5 and costs \$290. A battery charging cradle; a wrist lanyard; and operating instructions are included with purchase. The Aqualite Pro 20° warranty is lifetime on defects in materials and workmanship, 10 years for plastics, 3 years for rubber, 1 year for LEDs and electronics, and 90 days for batteries. An optional hand mount kit was purchased separately at a cost of \$35, making the total cost as assessed \$325.



Figure 4-9. Aqualite Pro 20°

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

Usability

The Aqualite Pro 20° received a Usability score of 3.6. The following information is based on evaluator comments:

- Even though two hands were required, it was easy to activate/deactivate the light and change brightness settings, with or without dive gloves, by turning the rotary switch (Figure 4-10) located on the end of the handle.
- A wrist lanyard was the only attachment or mounting option that was included with the light. The optional hand mount kit was sturdy but also had many pieces that could be easily lost.
- The light was comfortable to wear, but the hand mount's adjustment strap had to be set up prior to diving. The size and buoyancy of the light did not interfere with dive operations. However, when the light was not mounted, it required two hands to adjust settings, which sometimes interfered with dive operations.
- The rotary switch (Figure 4-10) is unlikely to be accidentally turned. The light did not accidentally activate or deactivate during the assessment.



Figure 4-10. Aqualite Pro 20° Rotary Switch

Deployability

The Aqualite Pro 20° received a Deployability score of 3.5. The following information is based on evaluator comments:

- There was no noticeable wear and tear at the end of the assessment. The hand mount was not recommended by the evaluators for public safety use. It was comprised of many pieces, which could be lost, and was difficult to assemble.
- The light was easy to set up. The light head twisted off, exposing the battery, which made for quick and easy battery changes. However, the battery could be incorrectly installed, potentially causing damage to the light, because the battery terminals were not clearly marked.

Capability

The Aqualite Pro 20° received a Capability score of 2.8. The following information is based on evaluator comments:

- Divers had to get close to target objects they were trying to identify, because the light was not very bright during both the daytime and nighttime dives. Overall, all target objects were difficult to locate.

Maintainability

The Aqualite Pro 20° received a Maintainability score of 3.8. The following information is based on evaluator comments:

- Pre-dive maintenance procedures consisted of inspecting and cleaning O-rings. Post-dive maintenance procedures consisted of rinsing with fresh water.

4.6 Sartek Industries Inc. LED1200MICRO4L10

The LED1200MICRO4L10 (Figure 4-11) received an overall assessment score of 3.4 and costs \$1,065. A canister with latch closure and straight standard cable entry, a battery charger, a hard Goodman handle, a soft Goodman handle, a light head bolt snap, belt and back plate mounts, system instructions, and a lifetime warranty are included with purchase.



Figure 4-11. LED1200MICRO4L10

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

Usability

The LED1200MICRO4L10 received a Usability score of 3.4. The following information is based on evaluator comments:

- Overall, the light was easy to activate and deactivate, with or without dive gloves, by turning the large rotary knob (Figure 4-12).
- There were multiple attachment and mounting options available, including hard and soft Goodman handles. However, the hard Goodman handle had too many screws that had to be loosened to adjust the handle. During adjustment, one of the screws with its washer came out and could have easily been lost. A light head bolt snap that attaches the light head to a BCD or carabineer was included. The canister was only attachable to the diver by a metal belt loop that may damage a diver's wet suit, dry suit, or other equipment.
- The hard Goodman handle was comfortable when used with dive gloves but not without. It had sharp edges and was not easily adjusted underwater because it required a screwdriver. The soft Goodman handle was preferred over the hard Goodman handle. The size and buoyancy of the light did not interfere with dive operations.
- The rotary knob (Figure 4-12) required significant effort to turn, making accidental activation and deactivation unlikely. The light did not accidentally activate or deactivate during the assessment.



**Figure 4-12.
LED1200MICRO4L10
Rotary Knob**

Deployability

The LED1200MICRO4L10 received a Deployability score of 3.0. The following information is based on evaluator comments:

- The canister was constructed of thick metal and appeared to be rugged. However, the battery connections, charger cables, and latches on the side of the canister appeared to be weak. There was no noticeable wear and tear on the light at the end of the assessment.
- Overall, the light was easy to set up. The proprietary battery was easy to remove and replace.

Capability

The LED1200MICRO4L10 received a Capability score of 3.4. The following information is based on evaluator comments:

- During the nighttime dive, the light was extremely bright, almost too bright to see target objects directly in front of it. During the daytime dive, the light did not illuminate the target objects well. The inoperable handgun was sometimes difficult to locate with the fixed, narrow beam of light.

Maintainability

The LED1200MICRO4L10 received a Maintainability score of 3.8. The following information is based on evaluator comments:

- Pre-dive maintenance procedures consisted of inspecting and cleaning O-rings. Post-dive maintenance procedures consisted of rinsing with fresh water.

4.7 Tovatec Beacon Torch

The Beacon Torch (Figure 4-13) received an overall assessment score of 3.2 and costs \$379. A battery charger, a wall plug adapter set, a wrist lanyard, a lamp cover, a carrying case, maintenance oil, spare O-rings, a quick-start guide, and a 1-year warranty are included with purchase. An optional canister kit was purchased separately at a cost of \$120, making the total cost as assessed \$499. The canister kit consisted of an interconnecting cable for the light head and light body, a battery holster, a hard Goodman handle, and a soft Goodman handle.



Figure 4-13. Beacon Torch

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

Usability

The Beacon Torch received a Usability score of 3.1. The following information is based on evaluator comments:

- Overall, it was difficult to activate/deactivate the light and change brightness settings by turning the bezel switch (Figure 4-14) on the light head, when mounted and

wearing dive gloves. In addition, two hands were required to operate the light's controls. The light was easier to operate when handheld and while not wearing dive gloves.

- The light had hard and soft Goodman handles for use in the canister configuration. The light head was not secure in the hard Goodman handle. Activating the light was difficult because the light head would slip while manipulating the switch.
- When in the canister configuration (Figure 4-15), the light head was too bulky. When in the torch configuration, the light was easy to hold and comfortable in the hand. However, the torch configuration was large and heavy. When in either configuration, there was some interference with dive operations due to the size of the light.
- The light had a protected lock slide (Figure 4-16) to prevent accidental activation. The light did not accidentally activate or deactivate during the assessment; however, the bezel switch could be bumped and the light accidentally turned on.



Figure 4-14. Beacon Torch Bezel Switch



Figure 4-15. Beacon Torch Canister Configuration



Figure 4-16. Beacon Torch Protected Lock Slide

Deployability

The Beacon Torch received a Deployability score of 2.7. The following information is based on evaluator comments:

- The light's housing appeared to be well constructed. The charging port was covered by the tail cap and sealed with an O-ring. The canister interconnecting cable connection failed, which allowed water to enter the light head, resulting in the light shutting off during the assessment.
- There was minimal setup required. The light featured an internal rechargeable battery. Charging the battery was easily done by plugging the charging cable into the bottom of the light.

Capability

The Beacon Torch received a Capability score of 3.8. The following information is based on evaluator comments:

- Overall, the light was bright enough to allow target object identification in both the daytime and nighttime dives. It was powerful enough to penetrate turbid water.

Maintainability

The Beacon Torch received a Maintainability score of 3.8. The following information is based on evaluator comments:

- Pre-dive maintenance procedures consisted of inspecting and cleaning O-rings. Post-dive maintenance procedures consisted of rinsing with fresh water while manipulating the bezel switch to ensure all sand and/or dirt was removed.

4.8 Princeton Tec® Genesis™

The Genesis (Figure 4-17) received an overall assessment score of 3.2 and costs \$130. A soft Goodman handle, a wrist lanyard, system and maintenance instructions, and a 1-year warranty are included with purchase.



Figure 4-17. Genesis

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

Usability

The Genesis received a Usability score of 3.2. The following information is based on evaluator comments:

- Overall, the light was easy to activate and deactivate, with or without dive gloves, by pressing the power button (Figure 4-18), which also cycles through the levels of brightness with each successive push of the button. When mounted in the soft Goodman handle, the light moved around, requiring constant readjustment.
- A soft Goodman handle and a wrist lanyard were the only attachment and mounting options that were included with the light.
- When mounted in the soft Goodman handle, two hands were required to operate the light's controls. The light was comfortable to wear but fit loosely in the soft Goodman handle and fell out. The size and buoyancy of the light did not interfere with dive operations.
- The power button (Figure 4-18) was recessed. However, the light was accidentally activated a few times.



Figure 4-18. Genesis Power Button

Deployability

The Genesis received a Deployability score of 3.2. The following information is based on evaluator comments:

- The light appeared to be of rugged construction. There was no noticeable wear and tear on the light at the end of the assessment. However, stitching on the soft Goodman handle came apart at critical places, preventing the light from fitting securely.
- The light was easy to set up, and the batteries were easy to install.

Capability

The Genesis received a Capability score of 2.8. The following information is based on evaluator comments:

- The light was bright enough to identify target objects. However, some target objects were difficult to locate during both the daytime and nighttime dives. The light had a narrow beam that did not travel very far in the water.

Maintainability

The Genesis received a Maintainability score of 3.8. The following information is based on evaluator comments:

- There were no pre-dive maintenance procedures. Post-dive maintenance procedures consisted of cleaning with mild soap, rinsing with fresh water, and applying silicone to the O-rings.

5. SUMMARY

Dive lights are used by public safety divers to provide illumination during nighttime dives, as well as when searching inside sunken vessels or vehicles, examining underwater structures, and diving at great depths, among other applications. According to evaluators, dive lights that provide strong, bright illumination are preferred; however, too much light will create too much back scatter and obscure the scene. In addition, dive lights should be lightweight and compact and offer mounting options to assist with hands-free and/or one-handed operation. All hard and soft Goodman handles provide hands-free operation for the diver when properly adjusted. The option to leave batteries installed between dive operations is an important consideration. Lights that are powered by user-replaceable batteries are preferred over lights with an internal rechargeable battery in case battery power is lost during an operation. In addition, it was noted that spare O-rings for the dive lights would be useful. The advantages and disadvantages for the assessed products are highlighted in Table 5-1.

Emergency responder agencies that consider purchasing dive lights 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

Vendor/Product		Advantages	Disadvantages
 <p>Light Monkey Enterprises LLC 21 Watt 10-21 LED</p> <p>MSRP: \$1,345</p> <p>Overall Score: 4.1</p>	<ul style="list-style-type: none"> • Solid construction with minimal water intrusion points • No pre-dive maintenance • Lockout feature • Various attachment and mounting options, two cable clamps for added mounting versatility • One-hand operation 	<ul style="list-style-type: none"> • Large-diameter canister • Battery is not user replaceable (no backup battery option) 	
 <p>Light & Motion Sola Dive 2000</p> <p>MSRP: \$799</p> <p>Overall Score: 3.9</p>	<ul style="list-style-type: none"> • Mount fits comfortably on the hand • Small, compact, and lightweight design • No pre-dive maintenance • Lockout feature • Various attachment and mounting options • One-hand operation • Flood and spot beam • Battery indicator 	<ul style="list-style-type: none"> • Battery is not user replaceable (no backup battery option) 	
 <p>Bigblue Dive Lights/BosskUSA TL4000P</p> <p>MSRP: \$546</p> <p>Overall Score: 3.8</p>	<ul style="list-style-type: none"> • Bright, concentrated white beam • Soft Goodman handle with plastic mounting plate • No pre-dive maintenance • Battery indicator 	<ul style="list-style-type: none"> • Large-diameter light head 	
 <p>Underwater Light Dude LD-35 Primary Light (mini)</p> <p>MSRP: \$1,545</p> <p>Overall Score: 3.8</p>	<ul style="list-style-type: none"> • Solid construction with minimal water intrusion points (excluding battery connection) • Compact canister • Cable features abrasion-resistant sheath • Battery indicator 	<ul style="list-style-type: none"> • Battery is not user replaceable (no backup battery option) • O-ring and manipulation of a thin retaining wire makes assembly somewhat difficult • Piezo switch has a low profile and provides no tactile feedback when pressed 	

Vendor/Product		Advantages	Disadvantages
 <p>Underwater Kinetics Aqualite Pro 20°</p> <p>MSRP: \$325</p> <p>Overall Score: 3.5</p>	<ul style="list-style-type: none"> • Small, compact, and lightweight design • Sturdy mounting platform • Two rechargeable, proprietary batteries included with purchase 	<ul style="list-style-type: none"> • Better suited as a secondary light due to low brightness • The optional hand mount kit secures with small pieces that can be lost 	
 <p>Sartek Industries Inc. LED1200MICRO 4L10</p> <p>MSRP: \$1,065</p> <p>Overall Score: 3.4</p>	<ul style="list-style-type: none"> • Compact canister 	<ul style="list-style-type: none"> • Potentially multiple water intrusion points (sealed with silicone by vendor) • Metal dive belt attachment is difficult to slide belt through and may damage wet suit, dry suit, or other equipment 	
 <p>Tovatec Beacon Torch</p> <p>MSRP: \$499</p> <p>Overall Score: 3.2</p>	<ul style="list-style-type: none"> • Torch light can be used in canister configuration with optional canister kit 	<ul style="list-style-type: none"> • Large-diameter light head • Long, heavy handle • Battery is not user replaceable (no backup battery option) • Cable connection for canister kit permitted water to enter the light head 	
 <p>Princeton Tec Genesis</p> <p>MSRP: \$130</p> <p>Overall Score: 3.2</p>	<ul style="list-style-type: none"> • Small, compact, and lightweight design • Durable • No pre-dive maintenance • Battery indicator 	<ul style="list-style-type: none"> • Better suited as a secondary light due to low brightness • A soft Goodman handle and wrist lanyard are the only attachment and mounting options • Light is not secure in the soft Goodman handle • Although commercially available, single-use CR123 batteries can be expensive to replace 	

APPENDIX A. EVALUATION CRITERIA DEFINITIONS

The focus group identified 10 evaluation criteria, which are defined as follows.

USABILITY

Ease of Use refers to how easy it is to activate the light, change between mode settings (e.g., constant-on, momentary-on, strobe), adjust the light beam from a spot beam to a flood beam, and operate the light while wearing dive gloves. Focus group participants noted that Ease of Use may be affected by the type (e.g., pressure, toggle, push button) and location of switches.

Mounting Versatility refers to the vendor-provided mounting options that permit hands-free operation (e.g., wrist/hand mount, helmet mount). It also includes the means by which the light can be attached/secured to the diver and/or diver equipment for retention when not in use.

Ergonomics refers to how easy it is to grip the light as well as how comfortable it is to wear while mounted. It also refers to the effects the size and buoyancy of the light have on dive operations (i.e., drags in current). Focus group participants noted the importance of the light and any attached components (e.g., cables) not interfering with dive operations.

Protected On/Off Control refers to how well features of the light prevent unintentional activation and/or deactivation while in storage or operation.

DEPLOYABILITY

Durability refers to the overall ruggedness of the light and included components (e.g., charging cradles/cables, mounts, light heads, switches, connection points, handles).

Ease of Setup refers to how easy it is to prepare the light for deployment, if it can be stored with batteries installed between dive operations, and if setup is intuitive. Ease of Setup also includes if the O-rings interfere with replacing the batteries and/or connecting the light head to the canister.

Heat Emission refers to the amount of heat emitted by the light during out-of-water use. The focus group noted that high heat emission could damage the light (e.g., lens) and other dive equipment (e.g., neoprene suit/gloves).

Dry Weight refers to the weight of the light and its effect on diver fatigue during out-of-water transport.

CAPABILITY

Brightness refers to how well the light beam illuminates objects.

MAINTAINABILITY

Ease of Maintenance refers to how easy it is to perform pre- and post-dive maintenance based on vendor recommendations. Ease of Maintenance also includes if the light features commonly available or proprietary replacement parts (e.g., O-rings), as well as if spare parts are available for purchase from the vendor and/or if any are included with purchase.

APPENDIX B. USER-REPLACEABLE PARTS

The Light & Motion Sola Dive 2000, Princeton Tec® Genesis™, and Tovatec Beacon Torch do not have user-replaceable parts.

Bigblue® Dive Lights/BoskUSA TL4000P

- Battery (proprietary)
- Battery Charger (proprietary)
- DC Charger (proprietary)

Light Monkey Enterprises LLC 21 Watt 10-21 LED

- Battery (proprietary)
- Stainless Steel Bands
- 10-21 Light Head (proprietary)

Sartek Industries Inc. LED1200MICRO4L10

- Canister Adapter with Light Head (proprietary)
- O-Rings
- Battery (proprietary)
- Lens and Cover
- Light Head, Plastic Clip
- LED/Reflector Module (proprietary)

Underwater Kinetics Aqualite™ Pro 20°

- Power Supply, Super Q/Aqualite Cradle USB (proprietary)
- Wrist Lanyard, Nitex Pro/Super Q/Aqualite (proprietary)
- O-Ring Kit, Aqualite (4)
- Aqualite Pro 20° Lamp Head (proprietary)

Underwater Light Dude LD-35 Primary Light (mini)

- Shock Cord Loops
- Handle Cover and Sewn Webbing
- Soft Handle, Elastic
- Charging Pins (proprietary)
- Metal Clips

APPENDIX C. ATTACHMENT AND MOUNTING OPTIONS

Bigblue® Dive Lights/BoskUSA TL4000P

- Soft Goodman Handle with Mounting Plate
- Lantern Handle
- Wrist Lanyard

Light & Motion Sola Dive 2000

- Soft Goodman Handle
- Soft, T-Handle
- Hand Strap
- Pistol Grip
- Photo Mount Kit
- Compact Camera Tray
- Action Camera Tray
- LocLine Mount Kit

Light Monkey Enterprises LLC 21 Watt 10-21 LED

- Hard and Soft Goodman Handles
- Double-Ended Snaps
- Bolt Snaps

Princeton Tec® Genesis™

- Soft Goodman Handle
- Wrist Lanyard

Sartek Industries Inc. LED1200MICRO4L10

- Hard and Soft Goodman Handles
- Light Head Bolt Snap
- Belt and Back Plate Mounts

Tovatec Beacon Torch

- Wrist Lanyard
- Canister Kit includes: Hard and Soft Goodman Handles and Battery Holster

Underwater Kinetics Aqualite™ Pro 20°

- Wrist Lanyard
- Hand Mount Kit

Underwater Light Dude LD-35 Primary Light (mini)

- Hard and Soft Goodman Handles
- Bolt Snaps

APPENDIX D. 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 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 Example¹

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

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 Score Formula

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

Overall Score Example¹

<u>Capability</u>	<u>Usability</u>	<u>Affordability</u>	<u>Maintainability</u>	<u>Deployability</u>	
(4.0 × 33%)	+ (4.2 × 27%)	+ (4.2 × 20%)	+ (3.8 × 10%)	+ (4.5 × 10%)	= 4.1

¹Examples are for illustration purposes only. Formulas will vary depending on the number of criteria and categories assessed and the criteria and category weights.