



Night Vision Devices

Assessment Report

Revised January 2024

(Originally Published November 2022)



Science and
Technology





The “Night Vision Devices Assessment Report” was prepared by the National Urban Security Technology Laboratory—in conjunction with U.S Army Combat Capabilities Development Command (DEVCOM)—for the U.S. Department of Homeland Security, Science and Technology Directorate pursuant to Financial Transaction FTAR-18-00066.

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FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T). Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of federal, state, local, tribal, and territorial responders to address the homeland security mission. The laboratory assists responders with the use of technology to prevent, protect against, mitigate, respond to, and recover from homeland security threats and incidents. NUSTL provides expertise on a wide range of subject areas, including chemical, biological, radiological, nuclear, and explosive detection, personal protective equipment, and tools for emergency response and recovery.

NUSTL manages the System Assessment and Validation for Emergency Responders (SAVER) program, which provides information on commercially available equipment to assist response organizations in equipment selection and procurement. SAVER 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?” The SAVER program works with responders to conduct objective, practitioner-relevant, operationally-oriented assessments and validations of commercially available emergency response equipment. Having the right tools provides a safer work environment for responders and a safer community for those they serve.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, and coordinating with other organizations to leverage appropriate subject matter expertise. In conjunction with U.S Army Combat Capabilities Development Command (DEVCOM), NUSTL conducted an assessment of commercially available night vision devices (NVD). This equipment falls under the AEL reference number O30E-02-TILA titled “Optics, Thermal Imaging and/or Light Amplification,” and O4MD-01-LAMP titled “Equipment, Light Amplification.”

SAVER reports are available at www.dhs.gov/science-and-technology/saver.

Visit the NUSTL website at www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory, or contact the lab at NUSTL@hq.dhs.gov.



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EXECUTIVE SUMMARY

From March 29 through April 2, 2022, the Systems Assessment and Validation for Emergency Responders (SAVER) program conducted an operational assessment of commercially available night vision devices at Picatinny Arsenal in Dover, New Jersey. This assessment focused specifically on white phosphor, Gen-3 binoculars that use only image intensification or image intensification combined with a thermal imaging accessory.







Emergency responders use night vision technology to conduct surveillance, search and rescue, patrol, and tactical operations in low light or no-light conditions. Image intensification works in the visible and near infrared portions of the electromagnetic spectrum. Thermal imaging works in the mid-wave and long-wave portions of that spectrum. Image intensifiers can see through glass while thermal imagers do not work through glass and other thermally insulating materials.

Six subject matter experts, each with at least five years of experience using NVDs, served as evaluators for the assessment. They assessed six different night vision devices according to specifications and in operational scenarios. The scenarios included special weapons and tactics (SWAT), search and rescue, patrol, and surveillance.

Evaluators concluded that that three of the assessed night vision devices met all of their expectations and three met most of their expectations. Overall scores for the NVDs ranged from 3.73 to 4.15. The table below presents the overall scores as well as the category scores for each. Products are listed in order from highest to lowest overall score.

This assessment report provides emergency responders with information that can be used to guide their agencies in making operational and procurement decisions. Response agencies should consider overall capabilities, technical specifications and limitations of NVDs in relation to their agency's operational needs when making equipment selections.

Overall Scores Summary Table

Product	Overall Score	Overall	Capability	Deployability	Usability	Maintainability
Elbit/AN/PVS-31D		4.15	4.03	4.51	4.17	3.94
L3Harris/BNVD-1531		4.11	3.88	4.33	4.42	3.91
ACTinBlack/DNTVS		4.08	4.07	3.83	4.33	4.09
Carson Industries/BNVD		3.91	3.52	4.58	3.67	4.28
PRG Defense/NVG-51		3.85	3.73	4.06	3.75	3.95
Nightline, Inc./RNVG		3.73	3.81	3.82	3.67	3.49

Key: 1 (least favorable) to 5 (most favorable)

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1.0 INTRODUCTION

From March 29 through April 2, 2022 the System Assessment and Validation for Emergency Responders (SAVER) program assessed night vision devices (NVD), specifically white phosphor, Gen-3 binoculars, at Picatinny Arsenal in Dover, New Jersey. The purpose of the assessment was to obtain information on NVDs that will be useful in making operational and procurement decisions. The assessment activities were based on recommendations gathered from a focus group of subject matter experts with experience using NVDs that was conducted in September 2020. The “Night Vision Devices Focus Group Report” [1], as well as a market survey report [2] that includes specifications for 39 devices including binoculars, monoculars and bi-oculars, can be found in the SAVER Documents Library at www.dhs.gov/publication/night-vision-technologies-image-intensifiers.

1.1 Participant Information

Six subject matter experts assessed the night vision devices following assessment procedures developed by NUSTL and the U.S Army Combat Capabilities Development Command (DEVCOM). Evaluators were selected for the assessment based on their respective geographic location and experience using night vision devices. Each participant’s professional information is listed in Table 1-1.


Table 1-1 Evaluators’ Professional Background

Evaluator Discipline	Years of Experience	State
Federal Law Enforcement	15–20	AZ
Federal Subject Matter Expert	5–10	VA
Law Enforcement/Special Weapons and Tactics (SWAT)	5–10	AZ
Law Enforcement/SWAT	5–10	NJ
Law Enforcement/SWAT	5–10	NJ
Law Enforcement/SWAT	15–20	NY

1.2 Assessed Products

Six-night vision devices were selected and acquired for the assessment based on market research, end user feedback received from an exercise, and recommendations from the focus group. Product selection criteria identified specifications, attributes or characteristics a product should possess to be considered for the assessment. The assessment team established requirements when determining the scope of product types for the assessment; the product must be:

- Available commercial off the shelf.
- Configured as a binocular. Binoculars have two eyepieces, two image intensifier tubes and two objective lenses. Binoculars provide better depth perception than both monoculars and bi-oculars.
- Have Gen-3 image intensifier tubes. Gen-3 intensifier tubes incorporate improved materials and production methods providing enhanced resolution, sensitivity and detection range compared to previous generations of tubes.
- Use a white phosphor image intensifier tube. Image intensifier tubes can use green phosphor or white phosphor to convert energy into a viewable image. During the exercise mentioned



above, users of these devices found white phosphor provided a clearer image and led to less eye fatigue during extended use.







- Head or helmet mountable.

Based on market research and the focus group's recommendations, six products from six vendors were considered for the assessment. The products selected for assessment and their key specifications are shown in Table 1-2. All products assessed included a:

- Visual low battery indicator
- Built in infrared (IR) illuminator
- Focus range of 25 cm to infinity
- Diopter adjustment range of -6 to +2

Focus group participants recommended also assessing integrated night vision devices that combine image intensification and thermal imaging. To assess a device's ability to integrate with a thermal accessory, an Optics 1 Enhanced Clip-On Thermal Imager (ECOTI) was used. See Appendix B for information on this device.

Table 1-2 Assessed Products' Key Specifications

Product	Field of View	Dimensions (inches)	Weight (pounds)	Resolution	Battery Type	Battery Life (hours)	Manufacturer Suggested Retail Price (MSRP)
 <p>ACTinBlack/DTNVS</p>	40	3.07 x 4.05 x 4.25	1.12	64	CR123A	25	\$10,700– \$11,700
 <p>Carson Industries/BNVD</p>	40	4.5 x 3.75 x 3.5	.99	64	AA	20	\$7,500– \$10,500
 <p>Elbit/AN/PVS-31D</p>	40	2.8 x 4.2 x 4.1	1.10	64–81	AA (alkaline or lithium)	21+ alkaline/ 30 hours lithium	\$10,985
 <p>L3Harris/BNVD-1531</p>	40	4.6 x 4.5 x 3.6	1.23	72+	AA or 4 AA Pack	16 AA/50 4 AA Pack	\$10,500
 <p>Nightline, Inc./RNVG</p>	40	4.7 x 4.2 x 2.8	1.26	64	CR123A	16	\$9,000
 <p>PRG Defense/NVG-51</p>	51	4.4 x 4.6 x 2.9	1.35	72	CR123A/AA	20–25	\$8,820

2.0 EVALUATION CRITERIA

Evaluation criteria were based on recommendations from a SAVER focus group. The focus group on NVDs identified 30 evaluation criteria and assigned each criterion to one of the five established SAVER assessment categories described below:

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

The focus group participants assigned weights, indicating the level of importance of each evaluation criterion and the five SAVER assessment categories. Evaluation criteria were weighted on a 1 to 5 numerical scale, with 1 indicating that an evaluation criterion is of minor importance and a 5 indicating that an evaluation criterion is of utmost importance. Some criteria were designated “information only.” These criteria were not weighted nor scored, however, information on these specifications is included in this report.

The SAVER assessment categories were then assigned a percentage to represent each category’s importance relative to the other categories. Table 2-1 presents the formally assessed evaluation criteria and their associated weights as well as the percentages assigned to the SAVER categories. The Affordability category was removed upon recommendation of the assessment evaluators and no longer weighted resulting in a redistribution of weights for the other four categories. Definitions of the evaluation criteria can be found in Appendix A.

All products were assessed by specification and/or hands-on assessment against the 21 weighted evaluation criteria. The focus group identified five criteria as information only:

- Depth Perception and Humidity Range from the Capability category
- Extended Warranty, Initial Price and Life Expectancy from the (removed) Affordability category

These criteria were not scored, but if evaluators provided qualitative feedback, that information was recorded and included in this report. Four additional criteria identified by the focus group were not assessed. All devices have a visual low battery indicator and 1x magnification, so “Low Battery Indicator” and “Magnification” were not assessed. The other criteria, “Start-Up Time” and “Communication Integration” are not relevant to the devices included in the assessment.

Table 2-1 Evaluation Criteria

SAVER CATEGORIES			
Capability	Deployability	Usability	Maintainability
Overall Weight 39%	Overall Weight 22%	Overall Weight 22%	Overall Weight 17%
Evaluation Criteria			
Image Clarity Weight: 5	Durability Weight: 4	Comfort and Fit Weight: 4	Self-Maintainability Weight: 4
Battery Life Weight: 4	Mount Capability Weight: 4	Ease of Use Weight: 4	Vendor Accessibility Weight: 3
Focus Weight: 4	Size and Weight Weight: 4		Warranty Weight: 3
IR Illuminator Weight: 4	Accessories Weight: 3		Storage Weight: 2
Light Range Operability Weight: 4	Covertness Weight: 3		Sacrificial Lens Weight: 1
Thermal Integration Weight: 4	Battery Type Weight: 2		
Field of View Weight: 3			
Anti-Fog Weight: 2			

3.0 ASSESSMENT METHODOLOGY

Each product was assessed operationally and/or by reviewing specification. Throughout the assessment, evaluators worked in teams of two and were accompanied by a subject matter expert trainer from DEVCOM. A NUSTL data collector guided each team of evaluators as they completed assessment activities. Product vendors shadowed teams when their company's devices were being used. Evaluators also had access to reference material for each product. NUSTL compiled the product information four of the six manufacturers or vendors verified it.

3.1 Assessment Activities

During the operational assessment, evaluators became familiar with each product's uses, capabilities and features. Evaluators assessed each night vision device in five scenarios:

- Start-Up/Product Familiarization
- SWAT
- Search and Rescue
- Patrol
- Surveillance

All scenarios except Start-Up/Product Familiarization were executed after sunset (but no earlier than 8:00 PM EST) in low- or no-light conditions and in staged environments that simulated operational conditions. Evaluators were instructed to use the NVD's IR illuminator at their discretion as they would in normal operations. Evaluators used the helmet mounted NVDs one at a time and provided feedback via a NUSTL administered questionnaire for each product at the completion of each scenario.

3.1.1 Start-Up/Product Familiarization

Evaluators began their assessment of each NVD by participating in a familiarization session that included a discussion of features, specifications and uses of the product. The technology vendor – or, in their absence, a DEVCOM subject matter expert trainer – led the session. Evaluators also had access to reference material for each product. NUSTL compiled the product information then four of the six manufacturers or vendors verified it

Following product familiarization, evaluators affixed a Wilcox mount to their helmets and then mounted the NVDs. Evaluators then set up the device for deployment, including powering on the device and adjusting the settings as needed.

Evaluation criteria assessed during this session included:

- Battery life
- Battery type
- Self-maintainability
- Vendor accessibility
- Warranty
- Storage
- Sacrificial lens



Figure 3-1 Product Familiarization Session

Image credit: DEVCOM

3.1.2 SWAT

The SWAT scenario took place at the “Shoot House,” as shown in Figure 3-2, set to simulate an at-home drug laboratory. While wearing night vision devices, evaluators approached and scanned the perimeter of the building. They checked each door prior to entering through the pre-identified door (at the furthest end of the building). Evaluators maneuvered through the building as covertly as possible while searching for objects and people. This required adjustments of the NVDs between near and far distances.

Evaluators moved through and cleared rooms while searching for and manipulating objects. This included finding and reading an index card with numbers on it, using those numbers to open a combination lock, removing the lock, unbolting the door, reading labels on containers and using restraints when apprehending someone acting as a suspect.

During this scenario, a flash of light, at 18,000 lumens, was used to simulate a flash pan to assess the bright light cutoff capabilities of the NVDs.

Evaluation criteria assessed during this scenario included:

- IR illuminator
- Light range operability
- Durability
- Mount capability
- Size and weight
- Accessories
- Covertness
- Comfort and fit
- Ease of use



Figure 3-2 Shoot House Views

Image credit: DEVCOM

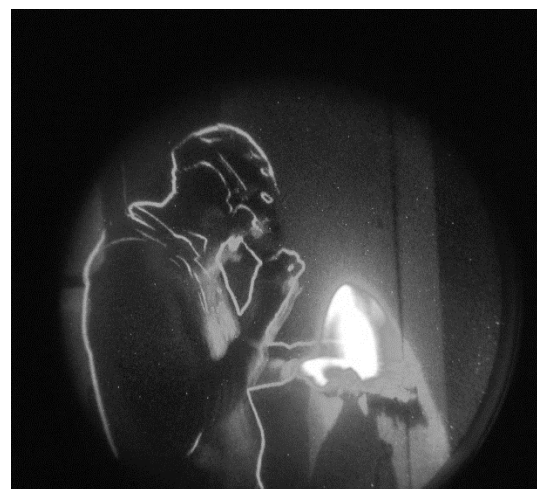


Figure 3-3 Responder Opening Combination Lock in Shoot House as Shown Through an NVD

Image credit: DEVCOM

3.1.3 Search and Rescue

The search and rescue scenario took place in a wooded area, as shown in Figure 3-4. While wearing NVDs, evaluators entered the wooded area to search for a “missing person.” Evaluators located a poster affixed to a tree near the in the woods, which provided the identity (i.e., the name and an image) of the missing person along with a description of items they may have been carrying. Objects that matched the description, including a marked backpack, were scattered along the route along with decoy objects that differed from the poster’s description.

Evaluators located and identified the objects associated with the missing person in order to assist with confirming the identity of the missing person once located. This scenario was then repeated with the ECOTI thermal accessory.

Evaluation criteria assessed during this scenario included:

- Image clarity
- Focus
- IR Illuminator
- Field of view
- Size and weight
- Covertness
- Comfort and fit
- Ease of use
- Anti-fog
- Mount capability
- Thermal integration



Figure 3-4 Wooded Area Views

Image credit: DEVCOM



Figure 3-5 Evaluators in the search and rescue scenario walking with the backpack (left) and investigating the missing person sign (right)

Image credit: DEVCOM

3.1.4 Patrol

The patrol scenario took place within two train cars on an elevated platform as shown in Figure 3-6. One train car's windows and doors were covered to simulate blackout conditions. The other car allowed for ambient (post-sunset) light to pass through but was filled with fog to simulate a foggy or smoked-filled environment. Additionally, filament line and copper wire were present near the farthest end of the trains to simulate trip wires.

While wearing NVDs, two evaluators entered the train cars and simultaneously walked through each train car (one in the darkened car and one with ambient light using the thermal accessory) while focusing on a target at the far end of each car. This required quickly adjusting focus from near to far. Evaluators searched the train cars for a mock weapon and bombs. Each train car was outfitted with three backpacks in varying locations (on the ground under a seat, on the luggage rack and on a seat). Each backpack was filled with varying items such as a mock weapon, mock explosive device, clothing, documents and electronics. The floors and walls within the cars were taped to mark distances, so that evaluators could verbalize the distances when they identified the simulated trip wires. Evaluators then swapped train cars and repeated the patrol in the alternate environment.

Evaluation criteria assessed during this scenario included:

- Image clarity
- Focus
- IR Illuminator
- Light range operability
- Field of view
- Anti-fog¹
- Durability
- Mount capability
- Size and weight
- Accessories
- Comfort and fit
- Ease of use
- Thermal integration

¹ The anti-fog criterion tested in this assessment refers to condensation formed on the lens during various activities, *not* vision capability in foggy or smoked-filled environments



Figure 3-6 Train Car Views

Image credit: DEVCOM



Figure 3-7 During the patrol scenario, an evaluator searches a bag (top) and another walks through a train car (bottom)

Image credit: DEVCOM

3.1.5 Surveillance

The surveillance scenario took place in the “Tactical Village” as shown in Figure 3-8. This scenario simulated surveillance of an area of interest with the night vision devices. Evaluators performed surveillance from the top of a multi-story building constructed of stacked shipping containers. The outdoor village, including its structures, nearby paved roadway, pedestrian bridge and grass covered test area served as the “area of interest” being surveilled. Within the surveyed area, street lights and vehicle headlights were present.

Objects and actions for the evaluators to identify in this setting included:

- Bicycles
- Backpacks (some containing heat packs to test thermal imaging)
- Mock weapons
- A person loitering or walking
- Eight-inch tall letters affixed to bicycles and persons

While wearing the night vision devices, evaluators continuously scanned the area of interest to identify objects and actions in a low-light outdoor environment from close range (~25 meters), mid-range (50-75 meters), and long range (~125 meters) standoff/viewing distances. This scenario was repeated with the ECOTI thermal accessory.

Evaluation criteria assessed during this scenario included:

- Image clarity
- Focus
- Light range operability
- Field of view
- Anti-fog
- Durability
- Mount capability
- Size and weight
- Accessories
- Covertness
- Comfort and fit
- Ease of use
- Thermal Integration



Figure 3-8 Tactical Village views

Image credit: DEVCOM



Figure 3-9 Evaluators using NVDs during the surveillance scenario

Image credit: DEVCOM

3.2 Data Gathering and Analysis

After each scenario, NUSTL data collectors used a questionnaire to record the evaluators' scores for each product according to the evaluation criteria listed in section 2.0. The questionnaire included specific questions for each criterion that the data collectors read to the evaluators. Evaluators then scored the criteria using 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 my expectations for this criterion.
- 5) The product exceeds my expectations for this criterion.

Once the assessment activities were completed, evaluators had an opportunity to review their criteria ratings and comments for all products and to adjust them if necessary. Criteria that were rated multiple times throughout the assessment were assigned final averaged ratings by the evaluators.

While evaluators discussed products and criteria, data collectors captured their comments on advantages and disadvantages, as well as general comments regarding the assessed products and on the assessment process. The evaluators' comments are summarized in this assessment report.



Figure 3-10 NUSTL data collectors documenting feedback from evaluators during familiarization (top) and following operational scenarios (bottom)

Image credit: DEVCOM

4.0 ASSESSMENT RESULTS

Overall scores for the night vision devices ranged from 3.73 to 4.15. The assessment results are presented in Table 4-1 and Table 4-2, while additional details and evaluator comments on each product are provided in sections 4-1 through 4-6. Criteria identified as “information only” by the focus group [1] were not scored, but where evaluators provided qualitative feedback, that information was included in this report. If a criterion had no significant feedback, it is not included in the product sections.

Table 4-1 presents the overall assessment score and SAVER category scores for each product. Products are listed in order from highest to lowest overall score throughout this section. Calculation of the overall score uses the raw scores for each category, prior to rounding. Products with the same overall score are listed in order based on the raw data. (See Appendix C for additional detail on these calculations.)

Table 4-1 Assessment Results

Product	Overall Score	Overall	Capability	Deployability	Usability	Maintainability
Elbit/AN/PVS-31D		4.15	4.03	4.51	4.17	3.94
L3Harris/BNVD-1531		4.11	3.88	4.33	4.42	3.91
ACTinBlack/DNTVS		4.08	4.07	3.83	4.33	4.09
Carson Industries/BNVD		3.91	3.52	4.58	3.67	4.28
PRG Defense/NVG-51		3.85	3.73	4.06	3.75	3.95
Nightline, Inc./RNVG		3.73	3.81	3.82	3.67	3.49


Key: 1 (least favorable) to 5 (most favorable)

Below, Table 4-3 presents the average evaluation criteria scores the products received from the evaluators for each evaluation criterion. The darker the shade of blue the higher the rating.

Table 4-2 SAVER Scorecard Key

SAVER Scorecard Key				
This product _____ of my expectations for this criterion				
meets none	meets some	meets most	meets all	exceeds all

Table 4-3 SAVER Scorecard of Evaluation Criteria

 Assessment Criteria		Manufacturers/Products					
		Elbit/AN/ PVS-31D	L3Harris/BNVD- 1531	ACTinBlack/DT NVS	Carson Industries/ BNVD	PRG Defense/NVG- 51	NightLine, Inc/ RNVG
Capability	Image Clarity	4.3	4.2	4.2	3.2	2.3	3.7
	Battery Life*	4.5	3.8	4.7	4.2	4.5	3.5
	Focus	4	4.5	4	3.2	3.5	3.5
	IR Illuminator	4.2	3.3	4.3	3.3	3.7	4.7
	Light Range Operability	4.2	4.5	4	3	4.2	3.7
	Thermal Integration	2.7	2.7	3.3	4	4	3.8
	Field of View	4.2	4	3.7	4	4.5	3.5
	Anti-Fog	4.4	4.2	4.5	3.6	3.8	4.5
Deployability	Durability	4.7	4.3	4	4.5	4.3	4.5
	Mount Capability	4.5	4.3	3.7	4.5	3.7	4
	Size and Weight	4.5	4.2	4.2	4.5	4	3.8



Manufacturers/Products

Assessment Criteria		Elbit/AN/ PVS-31D	L3Harris/BNVD- 1531	ACTinBlack/DT NVS	Carson Industries/ BNVD	PRG Defense/NVG- 51	NightLine, Inc/ RNVG
Deployability	Accessories	4.3	4.7	3.5	4.8	4.2	4
	Covertness	4.5	4	2.8	4.7	4	2.3
	Battery Type*	4.5	4.7	3.8	4.5	4.3	4
Usability	Comfort and Fit	4.5	4.3	4.2	4.3	4	3.2
	Ease of Use	3.8	4.5	4.5	3	3.5	4.2
Maintainability	Self-Maintainability*	3.8	4	4.3	4.3	4	4.2
	Vendor Accessibility*	3.8	4	3.7	4.7	3.5	3.3
	Warranty*	3.8	3.3	4.3	3.7	4.2	2.7
	Storage*	4.3	4.2	4.2	4.3	4	3.3
	Sacrificial Lens	4.3	4.5	3.5	4.6	4.3	4

* Indicates the criterion was assessed by specification only.

Editor's Note: The November 2022 Night Vision Devices Assessment Report contained minor graphical errors for some criteria in this table. This table above corrects those errors.

4.1 Elbit, AN/PVS-31D

The Elbit AN/PVS-31D can be flipped up and the tubes can be moved to the side. The AN/PVS-31D has an MSRP of \$10,985 and is available for purchase through the General Services Administration (GSA) schedule.

The Elbit AN/PVS-31D received an overall score of 4.15, which was the highest score of the devices assessed. Evaluator comments provided throughout the assessment are reported below, grouped by SAVER category listed in descending order of category weight.



Figure 4-1 Elbit, AN/PVS-31D

Image credit: DEVCOM

4.1.1 Capability

The Elbit AN/PVS-31D received a capability score of 4.03, the second highest in the category. The AN/PVS-31D met or exceeded expectations on all capability criteria except for Thermal Integration.

Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Image Clarity:** Two evaluators indicated the AN/PVS-31D exceeded their expectations, citing that the clarity was great without the thermal accessory. Four evaluators found the device met all expectations. Two evaluators noticed haloming (which occurs when a bright light source in the field of view results in rings around the light source) from outside light sources.
- **Battery Life:** The battery life for the AN/PVS-31D is 30 hours for an AA lithium or 21 hours for an AA alkaline battery. All evaluators indicated this met or exceeded their expectations. One evaluator indicated that the product met most of his expectations, with the exception of its not having battery pack capability.
- **Focus:** All six evaluators indicated that the AN/PVS-31D met all of their expectations for this criterion. They found it very easy to adjust focus and the image remained clear over long distances. One evaluator also noted it was somewhat difficult to bring images into focus at varying distances. Some found that the ECOTI mount location interfered with adjusting the focus.
- **IR Illuminator:** Five evaluators indicated the device's IR illuminator met all their expectations and one evaluator indicated that the product exceeded expectations. Evaluators remarked that the power level was not as high as they had expected. They had no issues using it but would have preferred if the illuminator was a little brighter.
- **Light Range Operability:** All evaluators indicated the AN/PVS-31D met or exceeded all their expectations for light range operability. When walking in front of flood lights, unless the gain was manually adjusted, the device became over saturated. Two evaluators noted that gain adjustments went into effect quickly.

- **Thermal Integration:** The AN/PVS-31D received its lowest score for Thermal Integration in the Capability category. Half of the evaluators indicated that the product met some of their expectations, while the other half stated that it met most of their expectations. Evaluators noted that the ECOTI's mount location led to issues adjusting focus. One evaluator remarked that too many adjustments were necessary to align the image from the binocular and the thermal image. The placement of the ECOTI also interfered with operating the IR illuminator. In one instance, the ECOTI fell off the mount and slippage of the accessory's rubber gasket impaired the evaluator's view.
- **Field of View:** All six evaluators indicated that the device met or exceeded all expectations for this criterion. Though one evaluator noted that they had to move their head around often because peripheral vision was limited.
- **Anti-Fog:** Three evaluators indicated that the AN/PVS-31D met all expectations for the anti-fog criterion; two evaluators indicated that the product exceeded expectations; and one evaluator did not score this criterion. One of the evaluators who scored the device as "met expectations" reported experiencing some lens fogging in the search and rescue scenario in the wooded area.
- **Depth Perception:** All six evaluators indicated that the device met or exceeded all of their expectations. An evaluator who indicated the product exceeded expectations for this criterion stated they experienced no notable depth perception issues when reaching or stepping.

4.1.2 Deployability

The AN/PVS-31D received a deployability score of 4.51, its strongest category score, with the device meeting and exceeding expectations for all criteria. Evaluator feedback was entirely positive for this category.

- **Durability:** The AN/PVS-31D can be submerged in 66 feet of water for two hours, meets MIL-STD-810 for shock resistance and is contamination resistant. Four evaluators indicated that the AN/PVS-31D exceeded expectations and two evaluators indicated that the product met all their expectations. One evaluator called the submergibility resistance impressive.
- **Mount Capability:** The device is compatible with Wilcox G24, Wilcox G22 and Norotos Lo Sto mounts, and can be seen mounted in Figure 4-2. Three evaluators indicated that this exceeded expectations and three evaluators indicated that it met all expectations. An evaluator noted that the mount felt secure, was easily adjustable for eye relief, comfortable and easily mounted.
- **Size and Weight:** The AN/PVS-31D measures 2.8 x 4.2 x 4.1 inches and weighs 1.10 pounds. All evaluators indicated that the device either exceeded or met all expectations.
- **Accessories:** Accessories include soft carrying case, eye cups, lens caps, demist shields, operator's kit (manual, quick reference card, lens paper) and G24 helmet mount. Two evaluators indicated these exceeded expectations and four evaluators indicated the product met all expectations for this criterion. One evaluator, who rated the device as "met all of their expectations," would have liked an extra external battery pack to be included standard with purchase.

- **Covertness:** Three evaluators indicated that the AN/PVS-31D exceeded expectations and three evaluators indicated that the product met all expectations for Covertness. Evaluators noted that the eye cups sit close to the face, as shown in Figure 4-2, limiting light splash from the device.
- **Battery Type:** The AN/PVS-31D operates on one alkaline or lithium AA battery. All six evaluators indicated that this exceeded or met all their expectations.

4.1.3 Usability

The AN/PVS-31D received a usability score of 4.17. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Comfort and Fit:** Three evaluators indicated that the device's comfort and fit exceeded expectations and three evaluators indicated that the product met all expectations. Evaluator commented that the device required frequent adjustment of the back straps on the helmet to ensure they were tight, that a counterweight would have been helpful, that and the bracket padding could be improved.
- **Ease of Use:** Five evaluators indicated that the AN/PVS-31D met all expectations noting that adjusting the interpupillary distance (IPD), which refers to the distance between the centers of the pupils of the eyes to which the two eyepieces of a binocular must correspond, was intuitive and could be locked in. They also found gain control to be intuitive. One of the evaluators did note that the tubes moved during operations. One evaluator indicated that the product "met most expectations" but remarked that they often missed the IR illuminator and gain knobs when trying to adjust them and ended up hitting the battery or mount instead.

4.1.4 Maintainability

The AN/PVS-31D received a maintainability score of 3.94. Evaluator feedback on criteria related to this SAVER category included:

- **Warranty:** The AN/PVS-31D includes a two-year warranty for the system and one year for parts and accessories. All evaluators found this to meet all or most of their expectations.
- **Storage:** Four evaluators indicated that the AN/PVS-31D met all expectations and two evaluators indicated that the product exceeded expectations. Three were satisfied with the temperature storage conditions, one noted that the high temperature of 159.8 degrees Fahrenheit was one of the highest storage temperatures seen.



Figure 4-2 An evaluator wears the Elbit AN/PVS-31D with eye cups

Image credit: DEVCOM



Figure 4-3 An evaluator wears the Elbit AN/PVS-31D with the lenses flipped up

Image credit: DEVCOM

4.2 L3Harris, Binocular Night Vision Device (BNVD)-1531

The BNVD-1531 has a lens orientation that can be flipped up and to the side. Each lens can also flip up independently. The BNVD-1531 has an MSRP of \$10,500 and is available for purchase via the GSA schedule. The device includes a one-year warranty for the unit and a two-year warranty for the image intensifier tubes.

The BNVD-1531 received an overall score of 4.11. Evaluator comments provided throughout the assessment are reported below, grouped by SAVER category listed in descending order by category weight.

4.2.1 Capability

The BNVD-1531 received a capability score of 3.89. Evaluator feedback on criteria related to this category included:

- **Image Clarity:** Two evaluators indicated the BNVD-1531 exceeded their expectations. Three indicated that the BNVD-1531 met all of their expectations for image clarity. One evaluator stated that the image was very clear especially when on patrol at the correct focus. Another evaluator commented that it was difficult to get the right focus on medium distances. One evaluator indicated it met some of their expectations, noting the image was not clear, especially at a distance.
- **Battery Life:** The BNVD-1531 has a battery life of 16 hours. This met all expectations of five of the six evaluators. One of the five commented that the battery life of the BNVD-1531 would allow them to man a perimeter barricade for a full shift. Another evaluator indicated that it met most of their expectations but that 16 hours of battery life seemed low. The device can also be used with an optional battery pack that has a battery lifetime of 50 hours.
- **Focus:** Half of the evaluators indicated that the device exceeded their expectations for the focus criterion, while the other half indicated it met all of their expectations. Evaluators commented that the BNVD-1531 was both quick and easy to focus. One evaluator said that the focus adjustment took a lot of turning.
- **IR Illuminator:** Three evaluators indicated that the IR illuminator met all expectations; two of whom said it worked as expected. Two evaluators said that it met most expectations: one commented that they had issues with the button to activate the IR illuminator and the other said they would have preferred to activate the illuminator using a knob. One evaluator said that it met some of their expectations, but they would have preferred not to have to press the button twice to activate the illuminator.



Figure 4-4 L3Harris, BNVD-1531

Image credit: DEVCOM



Figure 4-5 This profile view of an evaluator wearing a mounted L3Harris, BNVD-1531 illustrates its fit against the user's face

Image credit: DEVCOM

- **Light Range Operability:** The device exceeded expectations for half of the evaluators and met all expectations for the other half of evaluators. Feedback included that the BNVD-1531 did a good job of picking up light sources and performing in low light conditions. One evaluator mentioned that there was no lag recovering from the flash of light and the device handled headlights and streetlights well.
- **Thermal Integration:** Four evaluators indicated that the device met most of their expectations for thermal integration, while two indicated it met some of their expectations. One evaluator commented that the ECOTI sat too far away from the lens. Two evaluators experienced either shadowing or haloing in the image due to a reflection when the IR illuminator was activated. Another evaluator noted that the ECOTI projected a smaller image onto the lens than when used with another device. A fifth evaluator felt depth perception was reduced but ventured that with additional familiarity, they would likely have had a better experience.
- **Field of View:** Four evaluators indicated that the BNVD-1531 met all their expectations for field of view. One of these evaluators commented that the field of view was especially good in outdoor scenarios. Another said it exceeded expectations and one said it met some of expectations, attributing this to the BNVD-1531's sitting too far from his face.
- **Anti-Fog:** The BNVD-1531 exceeded expectations for two evaluators and met all expectations for another two on this criterion. Another evaluator indicated it met most expectations, adding that they experienced fogging inside the lens when performing the patrol scenario inside a train car (where a fog machine was activated). One evaluator did not rate the device for anti-fog; because they did not experience enough of the conditions that would produce condensation in the binocular. This could be an important criterion for use cases and missions where the operator is moving from controlled environments to outdoor weather environments.
- **Depth Perception:** Two evaluators indicated the device exceeded their expectations for depth perception. One stated that they were very impressed with how comfortable it was to walk while wearing them and the other stated that they had no issue with depth perception. Two evaluators indicated it met all their expectations for this criterion.



Figure 4-6 An evaluator attaches an ECOTI to the L3Harris BNVD-1531

Image credit: DEVCOM

4.2.2 Deployability

The BNVD-1531 received a deployability score of 4.33. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Durability:** The BNVD-1531 is rated as IP68 (See Appendix D) and meets the requirements of MIL-STD-810 (See Appendix E). Two evaluators said this exceeded their expectations and the other four evaluators said it met all of their expectations for this criterion.

- **Mount Capability:** During the assessment, the BNVD-1531 and all-night vision devices were mounted to evaluators' helmets via a dovetail mount. Three evaluators said the BNVD-1531 mounting exceeded their expectations. These evaluators commented that the device could be easily placed in the desired position and adjusted. Two evaluators said the mounting capability met all expectations. One evaluator said it met most expectations, adding that they would have liked to be able to adjust it closer to their face.
- **Size and Weight:** The BNVD-1531 measures 4.6 x 4.5 x 3.6 inches. This met or exceeded all evaluators' expectations.
- **Accessories:** The BNVD-1531 comes with a padded carrying case, battery pack and charging cable, eye cups, a neck cord, a manual, a quick reference guide, lens cleaning papers, lens covers and sacrificial lenses, some accessories are shown in Figure 4-7. Five evaluators indicated that the accessories that come with the BNVD-1531 exceeded their expectations while two indicated it met all their expectations. Two commented on the benefit of the included battery pack and two commented on the quality of the case.
- **Covertness:** Four evaluators said the device met all of their expectations for covertness while one said it exceeded their expectations and another that is met most of their expectations. The evaluator that said it exceeded their expectations liked that the device would automatically turn off when flipped up. The evaluator that said it met most of their expectations commented that it sat too far off the face causing light to escape the sides when not using eye cups.
- **Battery Type:** The device runs on a single AA battery, which met or exceeded all evaluator expectations.



Figure 4-7 The L3Harris BNVD-1531 comes with a storage case (top) and accessories (bottom)

Image credit: NUSTL

4.2.3 Usability

The BNVD-1531 received a usability score of 4.42, which was the best score in this category of the devices assessed. Evaluator feedback on criteria related to this SAVER category included:

- **Comfort and Fit:** Three evaluators indicated that the BNVD-1531 exceeded expectations for comfort and fit. Two of those three evaluators commented favorably on being able to flip one lens up while still operating the other. The other commented that it was beneficial that the device turns off when flipped up and back on when flipped down. Two evaluators indicated that the BNVD-1531 met all of their expectations. Finally, one evaluator, who commented that he could not get the device to fit well on his face, said that it met most of his expectations.

- **Ease of Use:** Three evaluators indicated that the device exceeded their expectations for this criterion. Two of these commented favorably on the one button functionality to turn the device on and off. The third evaluator commented that the device easy to use but would have preferred if IR illuminator were operated via a knob, which may have made it easier to operate under stress. The three other evaluators indicated that the BNVD-1531 met all their expectations, but one of them said they disliked the double tap feature to activate the IR illuminator.



Figure 4-8 An evaluator adjusts the L3Harris BNVD-1531

Image credit: DEVCOM

4.2.4 Maintainability

The BNVD-1531 received a maintainability score of 3.91. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Vendor Accessibility:** Customer service at L3Harris is available by phone from 8 AM to 5 PM Monday to Friday. Four evaluators said that met all their expectations for vendor availability. One evaluator said it exceeded their expectations because the device also comes with a manual and a quick reference card. The sixth said it met most of their expectations and clarified that they would like weekend support.
- **Warranty:** The standard warranty for the BNVD-1531 is one year for the whole unit and two years for the intensifier tube. Four evaluators said that this met most of their expectations and two said it met all their expectations. One evaluator would have preferred a longer warranty because of the amount of wear and tear the device is likely to experience.
- **Storage:** The storage temperature range for the device is -4 to 140 degrees Fahrenheit. Five evaluators said that range met all their expectations and one said that it exceeded their expectations for storage. One evaluator described the storage case saying it was large and protective and another said it was above their expectations for a case.
- **Sacrificial Lens:** Three evaluators said the device exceeded their expectations for being outfitted with a sacrificial lens. One evaluator particularly liked that the sacrificial lens came with the device in a labeled bag. The other three evaluators said it met all their expectations.

4.3 ACTinBlack, Dual Tube Night Vision System (DTNVS)

The DTNVS has lens orientation that can be flipped up and to the side. The DTNVS has an MSRP from \$10,700 to \$11,700, which includes soft carrying case and lens caps, as well as a two-year warranty for the complete unit. Half of the evaluators indicated this price was on the higher side. DTNVS tubes have an expected lifetime of 10,000 hours, which is typical for this type of product. While the external DTNVS housing is manufactured by ACTinBlack, the complete and final device was imported and distributed through Night Vision Inc.

The DTNVS received an overall score of 4.08. Evaluator feedback provided throughout the assessment are reported below, grouped by SAVER category listed in descending order or category weight.

4.3.1 Capability

The DTNVS received a usability score of capability score of 4.07. Evaluator feedback on criteria related to this category included:

- **Image Clarity:** All evaluators indicated that the DTNVS met or exceeded their expectations but some noted deficiencies such as a fishbowl-like streaking effect (possibly from the sacrificial lens), haloing, and blooming (i.e., a temporary lack of contrast).
- **Battery Life:** The DTNVS has an expected battery life of 25 hours, this met or exceeded expectations of all evaluators.
- **Focus:** The evaluators had mixed feedback on focusing the device. Four evaluators indicated the DTNVS met or exceeded their expectations. The other two evaluators indicated it met some of their expectations, noting that they struggled with focusing the device at close range. One evaluator attributed the difficulty to the design of the dials, which required finessing between both the front and back of the device to fine tune the focus.
- **Light Range Operability:** All of the evaluator's expectations were met on light range operability. Evaluators noted that the bright light cutoff worked well and did not affect use when a simulated flash pan was set off.
- **Thermal Integration:** The evaluators had mixed feedback on the DTNVS' ability to integrate with the ECOTI thermal accessory. Five evaluators stated that the DTNVS met all or most of their expectations while one stated the device met none of his expectations. One evaluator stated that there was a good picture from the ECOTI and that the alignment worked well with the DTNVS but noted that there was a lot of background noise in the image. Another evaluator experienced the IR Illuminator reflecting off of the ECOTI. Two other evaluators had issues with the lens on which the ECOTI was mounted flickering and cutting out, one of which rated it as meeting none of his expectations.



Figure 4-9 ACTinBlack, DTNVS

Image credit: DEVCOM



Figure 4-10 An evaluator adjusts the focus of the DTNVS

Image credit: DEVCOM

- **Field of View:** Most evaluators found that the field of view met all of their expectations. Two evaluators said the DTNVS met most of their expectations but noted that the distance from the eye to the device was still too great, causing the field of view to seem narrower than 40 degrees.
- **Depth Perception:** The majority of evaluators indicated there were no issues with depth perception while operating the DTNVS. One evaluator noted difficulty with adjusting the near focus and one noted blurring of a nearby object during one scenario.

4.3.2 Deployability

The DTNVS received a deployability score of 3.83. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Durability:** The DTNVS is rated IP67 and is designed to meet MIL-STD-810-G: Shock, Contamination. All evaluators found that the device met or exceeded all of their expectations. Features such as corrosion resistance and water submersion were noted as benefits of the system. Two evaluators experienced flickering of the DTNVS in one lens: one evaluator observed an estimated three to five degree droop in one lens and subsequent failure of the lens. This was attributed to an issue with building the device, specifically the number of screws on the device, at least 17 visible, to be maintained to ensure the device remains durable and functional.
- **Mount Capability:** Five evaluators said the DTNVS met all of their expectations. One evaluator indicated that the DTNVS met some of their expectations because they were unable to adjust the device close enough to their face when not using eye cups. Where the device sits on the face allowed light to escape from the device and impacts the ability to operate covertly when using the device.
- **Size and Weight:** The DTNVS measures 3.07 x 4.05 x 4.25 in. and weighs 1.12 pounds. This met or exceeded all of the expectations of evaluators.
- **Accessories:** The device comes with a carrying case and lens caps. All of the evaluators indicated that this met most or all of their needs, but one evaluator said they would have preferred a more structured case and external battery be included.
- **Covertness:** Two evaluators said all expectations were met, one said most and three said some were met. Most evaluators experienced light escaping from the device due to the gap present between the device and the evaluators' faces, when using the DTNVS without eyecups, as shown in Figure 4-11. One evaluator estimated that the light splash was visible from 10–15 feet away in the wooded environment.



Figure 4-11 Helmet-mounted DTNVS highlighting the gap between the user's eyes and the device

Image credit: DEVCOM

- **Battery Type:** The DTNVS uses a single CR123A for power. Five evaluators said all expectations were met for this criterion and one said most expectations were met, noting that they would have preferred the more common AA battery.

4.3.3 Usability

The DTNVS received a usability score of 4.33. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Comfort and Fit:** All evaluators indicated that the DTNVS met or exceeded their expectations, citing the ease of flipping up the device when mounted and the ability of the lens to be flipped up and widened outward, as shown in Figure 4-12.
- **Ease of Use:** All evaluators found the DTNVS to be intuitive and easy to use. This was partially based on the placement and design of the buttons, as well as the dials being easily adjustable while wearing gloves, the battery being easy to change and stoppers' preventing the tubes from collapsing.



Figure 4-12 DTNVS with lenses widened outward

Image credit: NUSTL

4.3.4 Maintainability

The DTNVS received a maintainability score of 4.09. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Self-Maintainability:** Three evaluators stated that the DTNVS exceeded their expectations for self-maintainability, two said it met all their expectations and one said it met most expectations. Two evaluators experienced issues with one lens of the DTNVS during operational scenarios. For one evaluator, the lens flickered and eventually stopped working when the thermal accessory and bracket was affixed to the device. For another evaluator, a lens drooped and stopped working even without the thermal accessory attached. Following the operational scenarios, the evaluator who experienced the drooping lens examined the device and noted that at least 17 small screws were visible on the device, some of which were loose resulting in the performance issues with DTNVS. A DEVCOM subject matter expert trainer further inspected the device and tightened the screws; this seemed to remedy the issues as no further evaluators experienced lens malfunctions. One evaluator noted that the number of screws and his experience during the assessment led him to believe that the DTNVS may need frequent maintenance.

- **Vendor Accessibility:** The vendor is available Monday through Friday from 10 AM to 5 PM EST via e-mail, text and phone. Two evaluators indicated that these hours met most of their expectations, while remaining evaluators stated that it met all of their expectations.
- **Warranty:** The DTNVS includes a two-year warranty with purchase. All six evaluators indicated that this either met all or exceeded their expectations. A four-year extended warranty is available at an additional cost.
- **Storage:** The device comes with an unpadded green case, as show in Figure 4-13. Five evaluators said the storage for the DTNVS met all or exceeded their expectations and one said it met most of their expectations remarking that the case was not rigid enough to provide sufficient protection for the night vision device.
- **Sacrificial Lens:** Half of the evaluators indicated that the sacrificial lenses met all of their expectations. The other evaluators rated the device as meeting most of their expectations for this criterion. One evaluator mentioned the sacrificial lens created fishbowl visuals during the assessment.



Figure 4-13 Side and front views of the DTNVS case

Image credit: NUSTL

4.4 Carson Industries, Binocular Night Vision Device (BNVD)

The Carson Industries (BNVD) can flip up and to the side. The BNVD has an MSRP from \$7,500 to \$10,500 based on tube performance specifications.

The BNVD received an overall assessment score of 3.91. The BNVD received the highest score among assessed devices in both the Deployability and Maintainability categories and scored the lowest among devices in the Capability category. Evaluator feedback provided throughout the assessment are reported below, grouped by SAVER category listed in descending order of category weight.



Figure 4-14 Carson Industries, BNVD

Image credit: DEVCOM

4.4.1 Capability

The BNVD received a Capability score of 3.52, which was the lowest score among the devices assessed. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Image Clarity:** The evaluators had mixed feedback on image clarity. Two evaluators found the device to meet all of their expectations. Three evaluators found it to meet most of their expectations. One of them experienced blemishes, another observed a reflective image and the other experienced a black line or imprint that lingered on the image when looking at a light source. The sixth evaluator indicated the device met some of his expectations, noting clarity was hindered when they moved quickly and the image cut out while moving.

- **Battery Life:** The BNVD has an expected battery life range of 20–25 hours, which met or exceeded all of the evaluators’ expectations.
- **Focus:** Evaluators gave mixed feedback on focus, with three evaluators indicating that the BNVD met most of their expectations and two finding that the device met all of their expectations. One, who rated this criterion met all expectations, stated the focus did not adjust quickly and that they needed to adjust both the front and back knobs to get a good picture. However, they found that reading information up close was clear. Another evaluator, who rated this criterion as meeting some of their expectations commented that the device had stiff focus manipulation. Two evaluators noted the difficulty of focusing the tube onto which the ECOTI was mounted.
- **IR Illuminator:** Four found that the IR illuminator met most of their expectations, while two of the evaluators stated that the illuminator on the BNVD met all their expectations. One evaluator found the IR button and power button too close together, which led to accidentally turning off the device when trying to turn on the IR illuminator. Another evaluator indicated that the illuminator “was effective and lit things up well” but two other evaluators would have liked it to be brighter.
- **Light Range Operability:** Evaluators had mixed feedback on light range operability. Four evaluators indicated the device met most of their expectations, one evaluator indicated that the device met all expectations, and one evaluator indicated that the device met some of his expectations. The evaluators stated that the device required the IR illuminator be on most of the time. Multiple evaluators also shared that the device turned off with the burst of sudden bright light during the SWAT scenario.
- **Thermal Integration:** Two evaluators indicated that the BNVD exceeded expectations for thermal integration, noting a seamless integration with the ECOTI. Two evaluators indicated that the device met all of their expectations, one of which emphasized the importance of the bracket not blocking the focus adjuster. One evaluator found the device met most of his expectations. This evaluator noted that flipping through the settings could be done easily but that the label displays were not visible without the thermal accessory. The sixth evaluator indicated that the device met some of their expectations, having chosen that option because attaching the ECOTI caused them to see an image of a circle inside a circle, which impacted their ability to use the device.
- **Field of View:** This BNVD has a field-of-view of 40 degrees which met or exceeded all expectations for five of the evaluators. The additional evaluator indicated that the BNVD met most of their expectations, attributing it to the small tubular view.
- **Depth Perception:** Five evaluators indicated that the device either met or exceeded all expectations for this criterion and one stated that it met most expectations citing some difficulty climbing stairs and walking in the woods.



Figure 4-15 Evaluator adjusting the Carson BNVD

Image credit: DEVCOM

4.4.2 Deployability

The BNVD received a deployability score of 4.58, the highest deployability score of the assessment . Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Durability:** The BNVD has an IP67 rating and, is MIL-STD-810 and MIL-PRF-49324 submersible to 66 feet. Evaluators determined that this met or exceeded all expectations.
- **Size and Weight:** The BNVD measures 4.5 x 3.8 x 3.5 inches and weighs 0.99 pounds, which met or exceeded all the expectations of evaluators.
- **Accessories:** The BNVD comes with eye cups, sacrificial windows, lens covers, demist shields, an IR spot/flood adapter, lanyard, lens cleaning kit, dovetail interface, batteries, a user's manual, and a carrying case as standard accessories. This exceeded expectations for all evaluators. One remarked that he would prefer an external battery to also come standard with purchase.
- **Covertness:** All evaluators indicated that the device either met or exceeded all expectations for this criterion. Evaluators stated that the device fit close to the eye. Light splash was not visible to others except for those within two feet or at a particular angle from the wearer.
- **Battery Type:** The BNVD uses a single AA for power, which met or exceeded all evaluator expectations.

4.4.3 Usability

The BNVD received a usability score of 3.67, which was tied for last in this category. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Comfort and Fit:** All evaluators indicated that the BNVD either met or exceeded all expectations. Feedback by the evaluators included that they liked the lens flip up, as shown in Figure 4-16, and out features. The light weight of the device contributed to its comfort. One evaluator did report, however, that the device was uncomfortable with the eyecups and removed them.
- **Ease of Use:** There was mixed feedback on the BNVD's ease of use. One evaluator indicated that the BNVD met all expectations. Four evaluators indicated that it met most of their expectations but stated that it required effort to learn the functions and locations of the four buttons on the device, as shown in Figure 4-17. Additionally, these evaluators noted that the Wilcox G24 mount obstructed access to the IR illuminator button and made it difficult to operate the power and gain buttons when wearing gloves. The IR illuminator button needed to be pressed twice quickly in order for it to function.



Figure 4-16 Carson BNVD mounted with lenses flipped up

Image credit: DEVCOM



Figure 4-17 Buttons (circled) of the Carson BNVD

Image credit: DEVCOM

One evaluator noted issues moving the interpupillary distance (IPD) adjustment, which moves each monocular assembly laterally to match the distance between the eyes, that were especially noticeable when cranking on the focus. The sixth evaluator indicated that the BNVD met some expectations; they attributed this lower score to difficulties locating the buttons under the mount and with activating the IR illuminator. This evaluator also experienced power to the lens cutting off when bending over while wearing the device.

4.4.4 Maintainability

The BNVD received a maintainability score of 4.28, which was the highest score in this category amongst the devices evaluated. Evaluator feedback on criteria related to this SAVER category included:

- **Self-Maintainability:** This criterion met or exceeded expectations for all evaluators. Evaluators found the maintenance and cleaning simple. One evaluator expressed, however, that he did not like that maintenance requires specialized tools.
- **Vendor Accessibility:** Carson is available via phone during standard business hours and via e-mail 24 hours a day. All evaluators found this met or exceeded all expectations.
- **Warranty:** The BNVD includes a one year warranty with purchase. Four evaluators indicated that this met all expectations and two evaluators said that it met most expectations.
- **Storage:** The BNVD has a storage temperature range of -59.8 to 185 degrees Fahrenheit. Two evaluators indicated that the device exceeded expectations and four evaluators indicated that the device met all expectations. One evaluator emphasized the importance of a wide storage temperature range.

4.5 PRG Defense, NVG-51

The NVG-51 has a polymer housing and a lens orientation that can be flipped up and to the side. It can also be operated as a single monocular. The NVG-51 has an MSRP from \$8,820 and is available on GSA schedule. Most evaluators were satisfied with this price.

The NVG-51 received an overall assessment score of 3.85. Evaluator feedback provided throughout the assessment are reported below, grouped by SAVER category listed in descending order of category weight.

4.5.1 Capability

The NVG-51 received a capability score of 3.73. Evaluator feedback on criteria related to this SAVER category included:

- **Image Clarity:** Four evaluators found the NVG-51 met some of their expectations for image clarity while two felt that it met most of their expectations. All users experienced significant haloming. Clarity was considered grainy and fuzzy by evaluators despite their still identifying many of the objects during the scenarios. One evaluator also experienced black shadows in bottom right corner after the light flash in the SWAT scenario.



Figure 4-18 PRG Defense, NVG-51

Image credit: DEVCOM

- **Battery Life:** The device has a battery life of 20-25 hours, which met or exceeded all expectations for all evaluators.
- **Focus:** Four of the evaluators stated that the NVG-51 met all their expectations for this criterion and found adjusting the focus straightforward. Two stated that it met most or some of their expectations. One of those evaluators commented that there was not much of a focus range (i.e., that there was not a big distinction when fully shifting the focus). Another evaluator felt it was difficult to recover a good image if the focus adjuster was moved too far and that it was difficult to attain a “crisp image.”
- **IR Illuminator:** Four of the evaluators felt that the illuminator on the NVG-51 met all their expectations. One commented that the IR illuminator enabled very bright, clear images. They also liked the pull and twist feature for powering on and adjusting the illuminator. Two evaluators stated it met most of their expectations, commenting that that the IR button’s location was too close to the focus knob and that the IR illuminator’s on/off light was not easily visible.
- **Light Range Operability:** All the evaluators stated the NVG-51 met or exceeded all of their expectations, stating that it was easy to adjust gain. One evaluator commented that the device recovered very well from the flashpan during the SWAT scenario.
- **Thermal Integration:** Four evaluators stated that thermal integration met most or all of their expectations. They found the mounting point on the NVG-51 ideal and noted that it allowed for easy adjustment of the ECOTI. The other two evaluators said the thermal integration met some of their expectations, one of whom noted that the 3D-printed mount was flimsy and made attaching the ECOTI difficult. When informed that a metal mount is available, they said that would likely fix the problem.
- **Field of View:** This device has a field of view of 51 degrees, which met or exceeded evaluators expectations. Most noted that they appreciated the wider view, but one evaluator did not really perceive the increase in view. Another evaluator found they had to bring the device very close to their face to get the full effect of the 51-degree field of view.
- **Anti-Fog:** Evaluators gave mixed feedback on the NVG-51’s anti-fogging capabilities. Three evaluators did not experience any lens fogging and three experienced some fogging during the different scenarios. Three evaluators commented that the NVG-51 met or exceeded their expectations, two felt that most of their expectations were met and did not score this criterion. One user commented that after storing them in the up position, fog was created by exposure to cool atmospheric air before the NVG-51 was flipped down for use.
- **Depth Perception:** The three evaluators who scored this criterion said it met all expectations. Most of the evaluators indicated they experienced no issues with depth perception while using the NVG-51, although one noted difficulty with adjusting the near focus to read up close while using the ECOTI.



Figure 4-19 Evaluator adjusting the ECOTI affixed to the PRG Defense NVG-51

Image credit: DEVCOM

4.5.2 Deployability

The NVG-51 received a deployability score of 4.06. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Durability:** The PRG-51 is rated as an IP67 and is designed to meet MIL-STD-810-G: Shock, Contamination. All evaluators found the device met or exceeded their expectations.
- **Mount Capability:** Four evaluators stated that the mount capability of the NVG-51 met all of their expectations, with one evaluator commenting it was easily mounted. Two evaluators indicated that it met most of their expectations. One attributed this score to his needing to readjust the device every time he raised or lowered it on the mount. The other evaluator reported the device wobbled with head movement.
- **Size and Weight:** The NVG-51 measures 4.4 x 4.6 x 2.9 inches and weighs 1.35 pounds. Most evaluators were satisfied with the NVG-51's size and weight. One evaluator who used a counterweight said the NVG-51 was comfortable to wear. One said that it met most of his expectations but commented that it seemed heavier than other devices, especially after two hours of use without a counterweight.
- **Accessories:** Standard accessories include soft carrying case, dovetail or Rhino mount adaptor, lens cloth, demist shield, eye cups and operator manual. All evaluators indicated that the included accessories met most or all of their needs, though one remarked they would have preferred a protective case.
- **Battery Type:** The NVG-51 met or exceeded all expectations for battery type. The evaluators liked the ability to use either AA or CR123A batteries.

4.5.3 Usability

The NVG-51 received a usability score of 3.75. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Comfort and Fit:** There was mixed feedback on the comfort and fit of the NVG-51. Five evaluators found the device to meet or exceed all of their expectations. One evaluator found that the device was more comfortable when the eyecups were removed. Another evaluator who stated that the device met most of their expectations but noted the eye cups were uncomfortable. They also could not get the lenses close enough together without hitting the bridge of their nose with eye cups on. One evaluator found the device to meet some of their expectations, attributing it to the positioning being difficult. Throughout the assessment the evaluator was unable to get the lenses appropriately positioned even after continuously adjusting both the NVG-51 and the helmet mount.
- **Ease of Use:** Feedback was mixed on the ease of use for the NVG-51. Three evaluators stated that the device met or exceeded expectations, commenting they had no issues with the controls.



Figure 4-20 ECOTI attached to PRG NVG-51 with the lenses flipped up

Image credit: DEVCOM

The other three said the NVG-51 met some or most expectations, mentioning that button placement was not intuitive and that two hands were necessary for making adjustments. Two evaluators continuously hit the front of the mount when reaching for buttons and making gain adjustments because of the way the mount blocked access to the power and gain adjustments. This resulted in evaluators often grabbing the wrong knob.

4.5.4 Maintainability

The NVG-51 received a maintainability score of 3.95. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Vendor Accessibility:** The vendor is available by phone during business hours. Evaluators had mixed feedback ranging from met all expectations to met some expectations.
- **Warranty:** The two-year system warranty and five-year tube warranty met or exceeded five evaluators' expectations. One evaluator who said the device only met most of his expectations cited \$100 cost for a two-week diagnostic analysis offered under the extended warranty.
- **Storage:** The NVG-51 has a storage temperature range of -58 to 122 degrees Fahrenheit. All evaluators said the NVG-51 met all expectations for storage. One commented a higher upper safe storage temperature limit, up to 185 degrees Fahrenheit, would be preferred in the event of that the device was stored in a hot car.

4.6 Nightline, Inc., Ruggedized Night Vision Goggle (RNVG)

The RNVG housing is made of solid billet 7075 aluminum and has a lens orientation that can be flipped up. The RNVG has an MSRP of \$9,000. Most evaluators found the base price to be reasonable but would have like the option of an extended warranty. The manufacturer indicated a system lifetime of five years, which evaluators found short.

The RNVG received an overall assessment score of 3.73. Evaluator feedback provided throughout the assessment are reported below, grouped by SAVER category listed in descending order of category weight.

4.6.1 Capability

The RNVG received a capability score of 3.81. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Image Clarity:** All evaluators indicated that the RNVG met most or all of their expectations for image clarity. Those who said it met all of their expectations did not experience visible blemishes or defects and found the device had good contrast and clarity in open areas, as well as the ability to see at both near and far distances. The two evaluators who indicated it met most of their expectations were unable to identify letters throughout operational scenarios the device, and experienced digital pixilation in the images.
- **Battery Life:** The RNVG runs on one CR123 battery with an expected lifetime of 16 hours. Three evaluators stated that all expectations were met and three said most expectations were met. Some thought 16 hours was sufficient since it would last a full shift and some thought it should have been longer.



Figure 4-21 Nightline, Inc., RNVG

Image credit: NUSTL

- **Focus:** The evaluators had mixed feedback on the focusing ability of the RNVG with half stating that most of their expectations were met and half saying all were met. Some evaluators noted it was difficult to focus on objects less than six inches away and required too much manipulation and time to properly focus at close range. They experienced difficulties while trying to enter a combination into a lock. Another evaluator noted difficulty with focusing on objects that were far away.
- **IR Illuminator:** The RNVG has a built-in IR illuminator with an adaptor for addition of a spot/flood light. The IR illuminator met or exceeded expectations for all evaluators with most evaluators noting that the illuminator provided strong, very bright light.
- **Light Range Operability:** The evaluators found the device met most or all of their expectations on light range operability. The RNVG does not have a system gain adjustment. Most evaluators experienced no issues with varying light conditions, noting limited haloing and perceiving no cutting off during the simulated flash pan in the SWAT scenario. One evaluator, however, found the streetlights blinding in the low-light conditions of the surveillance scenario.
- **Thermal Integration:** The evaluators had mixed feedback on the RNVG's ability to integrate with the ECOTI with four saying it met or exceeded expectations. Their comments included that the integration was seamless, they experienced no issues with focus adjustments with the ECOTI mounted, and the mounting bracket did not block the focus adjuster. One evaluator stated that the RNVG met most of their expectations although it was difficult to read letter labels throughout the scenarios when using the thermal accessory. Another evaluator experienced a major issue with a circle within a circle being displayed while the ECOTI was mounted. The image was not seamlessly integrated with the binocular image and he had difficulty using the full thermal mode.
- **Field of View:** The evaluators found that the 40 degrees field of view of the RNVG met most or all of their expectations. Three evaluators had issues with the positioning of the RNVG on the face saying it sat too high and not close enough to the eye—which diminished the field of view.
- **Depth Perception:** Five evaluators stated that the RNVG met or exceeded their expectations for this criterion with one stating that he had very good spatial awareness while walking. One evaluator rated the device as meeting only some of his expectations, saying he had difficulties with depth perception while using the RNVG during all activities.



Figure 4-22 Evaluator adjusting the focus on the Nightline RNVG with the ECOTI affixed

Image credit: DEVCOM

4.6.2 Deployability

The RNVG received a deployability score of 3.82. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Durability:** The RNVG has an IP68 rating and meets MIL-STD-810-G for contamination. This met or exceeded all evaluator's expectations for durability. A few of the evaluators liked the ruggedized metal housing of the device.

- **Mount Capability:** Five evaluators stated that the mount capability of the RNVG met or exceeded all their expectations, noting that it was easy to mount and adjust. One evaluator said it met some of his expectations, stating that the device could not be mounted close enough to his face. Figure 4-23 shows the distance between the eyepiece and face of an evaluator wearing the RNVG.
- **Size and Weight:** The RNVG measures 4.7 x 4.2 x 2.8 inches and weighs 1.26 pounds. Five evaluators said that the RNVG's size and weight met all expectations. One said that it met most of his expectations and stated that it seemed heavy and its poor fit made it seem heavier.
- **Accessories:** All of the evaluators indicated that the standard accessories – a soft carrying case, two eye cups, two sacrificial windows, two demist shields, lens tissue, a neck cord, two lens covers and a CR123A battery – were satisfactory. One evaluator would have liked an external battery pack to have been included as a standard accessory.
- **Covertness:** Three of the evaluators said that the RNVG met none or some of their expectations for covertness noting that the device did not automatically shut off when in the flipped-up position, making the lights and user clearly visible. Use without eyecups also resulted in light splash. The remaining three evaluators said the device met most of their expectations.
- **Battery Type:** The RNVG uses a single CR123 for power which met all evaluator's expectations. One evaluator noted that he would have preferred an AA battery as they operate better in colder temperatures.



Figure 4-23 Evaluator wearing RNVG showing the distance between the eyepiece and face

Image credit: DEVCOM

4.6.3 Usability

The RNVG received a usability score of 3.67. Evaluator feedback on evaluation criteria related to this SAVER category included:

- **Comfort and Fit:** Three of the evaluators said the RNVG met all their expectations, noting that it was easy to flip up. Two said it met most and one said it met none of his expectations, commenting that the RNVG did not fit well and could not be adjusted vertically. These evaluators also stated that getting the device to fit their eyes (from side to side) took time and that they had to flip the device completely up when not in use, as shown in Figure 4-24.



Figure 4-24 Evaluator with Nightline RNVG in a flipped up position

Image credit: DEVCOM

- **Ease of Use:** The evaluators found the RNVG easy to use; with everyone saying the device met or exceeded expectations. However, one evaluator said it was sometimes difficult to adjust the focus for varying distances. Evaluators found it advantageous that the RNVG had a familiar, standard power button.

4.6.4 Maintainability

The RNVG received a maintainability score of 3.49. Evaluator feedback on criteria related to this SAVER category included:



- **Self-Maintainability:** Routine maintenance includes twice yearly nitrogen purging which can be completed in-house or by the manufacturer. Evaluators stated that all expectations were met or exceeded for this criterion.
- **Vendor Accessibility:** The vendor is available Monday to Thursday from 9 AM to 5 PM and Friday 9 AM to 3 PM via phone or e-mail. Four evaluators indicated that these hours met most of their expectations, while two said it met all of their expectations.
- **Warranty:** The RNVG includes a limited two-year warranty covering system and tubes and a 90-day warranty for consumable items. Four evaluators indicated that this met most of their expectations, while two said it met some of their expectations.
- **Storage:** Three evaluators indicated that the RNVG met all their expectations for this criterion, stating that the storage temperature range of -60 to 185 degrees Fahrenheit was large enough. Two said it met most and one said it met some of their expectations, commenting that the provided storage bag does not provide drop protection.
- **Sacrificial Lens:** Two evaluators indicated that the sacrificial lenses exceeded expectations, with one stating he was pleased that two sacrificial lenses were provided. Two said it met all of their expectations and two said it met some of their expectations for this criterion, with one of those evaluators stating that the lens was of lower quality and could negatively impact image clarity.




5.0 SUMMARY


From March 29 through April 2, 2022, NUSTL, in conjunction with DEVCOM, conducted a SAVER assessment of night vision devices at Picatinny Arsenal, New Jersey. Six first responder evaluators assessed the capability, usability, deployability, and maintainability of six commercially available night vision devices against 21 criteria. Table 5-1 summarizes the advantages and disadvantages of each product as identified by the evaluators. The Optics 1 ECOTI was attached to the assessed devices to provide thermal integration capabilities during certain scenarios. Information and feedback on the ECOTI thermal accessory were also gathered and is provided in Appendix B.

The overall scores indicate that three night vision devices met all of the evaluators' expectations and three met most of their expectations. Individual responder agencies that intend to purchase night vision devices should carefully research the capabilities and features of available instruments to identify the product best suited to their operational needs.

Table 5-1 Advantages and Disadvantages

Manufacturer/Product		Advantages	Disadvantages
 <p>Elbit/AN/PVS-31</p>		<ul style="list-style-type: none"> • Battery life of 30 hours with lithium and 21 hours with alkaline batteries • Easily adjusted focus • Lens orientation can be flipped up or to the side • Fit of device close to face allows for covertness. 	<ul style="list-style-type: none"> • Using thermal accessory impacts the ability to focus the device and to use the IR illuminator • Haloing from outside light sources • IR illuminator could be brighter
MSRP: \$10,985	Overall Score: 4.15		
 <p>L3Harris/BNVD-1531</p>		<ul style="list-style-type: none"> • Ease of use with single button operation • Bright light exposures do not impact operations • Accessories that come with the device, including a battery pack and a padded case 	<ul style="list-style-type: none"> • IR illuminator requires a double tap to power on or off • Using thermal accessory causes shadowing and impacts depth perception
MSRP: \$10,500	Overall Score: 4.11		

Manufacturer/Product		Advantages	Disadvantages
 <p>ACTinBlack/DTNVS</p>		<ul style="list-style-type: none"> • Battery life of 25 hours • Ease of use with single button operation • Lens orientation can be flipped up or to the side 	<ul style="list-style-type: none"> • Without eye cups, light splash visibility diminishes the covertness • Streaking and fishbowl effect from sacrificial lenses • Using thermal accessory impacts clarity of image and IR illuminator causes reflections
MSRP: \$10,700-\$11,700	Overall Score: 4.08		
 <p>Carson Industries/BNVD</p>		<ul style="list-style-type: none"> • Snug fit (close to the face) allows for covertness • Lens orientation can be flipped up or to the side 	<ul style="list-style-type: none"> • Image clarity hindered when moving quickly and when looking at light source • Four closely set buttons on the device impacts usability • Focus adjustment is coarse and slow to react
MSRP: \$7,500-\$10,500	Overall Score: 3.91		
 <p>PRG Defense/NVG-51</p>		<ul style="list-style-type: none"> • Battery life of 20-25 hours • Lens orientation can be flipped up or to the side • Wider (51°) field of view • Ideal thermal accessory mount location 	<ul style="list-style-type: none"> • Image clarity is diminished by haloing • Button placement is not intuitive • IR illuminator button placement may interfere with focus knob
MSRP: \$8,820	Overall Score: 3.85		

Manufacturer/Product		Advantages	Disadvantages
 <p>Nightline, Inc./RNVG</p>		<ul style="list-style-type: none"> • Ruggedized metal housing • IR illuminator provides strong, bright illumination over wide area • Location for thermal accessory does not impact focus adjustments 	<ul style="list-style-type: none"> • Digital pixilation and blur • Limited adjustments to accommodate comfort and fit • Field of view diminished by positioning on the face and lack of peripheral range • Lacks covertness due to light splash when wearing and lack of power cutoff when flipped up
MSRP: \$9,000	Overall Score: 3.73		



6.0 ACKNOWLEDGEMENTS

NUSTL thanks the assessment evaluators for their valuable time and expertise. Their insights and recommendations will assist responder agencies making procurement decisions and guide the planning and execution of future SAVER projects. Appreciation is also extended to their agencies for allowing the evaluators to participate in this SAVER assessment and to DEVCOM for providing subject matter experts and hosting the event.



7.0 REFERENCES

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Appendix A. EVALUATION CRITERIA DEFINITIONS

Capability

Image Clarity: The ability of the night vision device to provide a clear, high-resolution image with minimal *defects*, *blooming* and *haloing*. Image clarity is also affected by the user's ability to adjust the gain and focus with both manual and automatic controls.

- *Defects* are cosmetic blemishes on the display surfaces of the intensifier tubes.
- *Blooming* is temporary loss of contrast in an image and resembles an area that has been blotted out.
- *Haloing* occurs when there is bright light source in the field of view that results in rings around the light source.

Battery Life: The amount of time the primary power source will power the system. Back-up batteries and the device's ability for auto-shutoff should also be considered.

Focus: The mechanism and ability to focus the night vision device such as auto-focus or range of focus (near to far). Accessories such as an adjustable iris to help with focus should also be considered.

IR Illuminator: A night vision device that emits infrared (IR) light which allows for night vision ability in areas of total darkness. The intended range of the IR illuminator should also be considered. For example, IR illuminators could be either IR lasers, which are used for long distance surveillance, or IR Light Emitting Diode (LED) illuminators, which are used in confined spaces.

Light Range Operability: How well the device performs under varying light conditions and light controls such as automatic brightness control. The ability to adjust the gain allows the user to work for longer periods with reduced eye strain.

Thermal Integration: The devices with thermal imaging capabilities as well as features for turning the capability on and off and color differentiability.

Field of View: The degree of horizontal distance that can be viewed through the technology without additional lens options or accessories.

Anti-Fog: The devices ability to prevent fog or condensation from forming on the lens.


Deployability

Durability: The system's ability to withstand a variety of environmental conditions. This includes water, shock and drop resistance; varying temperatures; salt, fog, sand and dust conditions; and the ability for sanitization or disinfection. Military Specification (MILSPEC) or ingress protection (IP) ratings can serve as a means to evaluate night vision devices for durability.

Mount Capability: The ability for the night vision device to be affixed to various platforms such as the head, helmet and weapons.

Size and Weight: Both the physical dimensions and weight of the device.

Accessories: The ancillary equipment that comes with or can be purchased to complement the night vision devices such as illuminators, focus adjusters (e.g., iris), counterweights or stabilizers, lens caps and eye cups.



Covertness: Factors such as device color, the amount of light reflected off the device and the amount of light escaping from the eyepiece that contribute to an end user's ability to use the technology without being detected. Some participants would only consider black devices.

Battery Type: The ability of the technology to accept commercial off the shelf (non-proprietary) batteries and whether the batteries are rechargeable or hot-swappable.

Usability

Comfort and Fit: The fit adjustments, proper weight distribution, proper padding and the option to flip the lenses up or out when not in use.

Ease of Use: The intuitiveness of adjustments and configurations, including use with personal protective equipment such as gloves and helmet, ease of changing batteries, and adjustment of the focus, gain, diopter and other settings.

Maintainability

Self-Maintainability: The ease and ability to service the technology in-house. This includes the availability of instructions for maintenance, availability and cost of replacement parts and repair kits, and the ability to access the interior of the technology.

Vendor Accessibility: The resources and technical support provided by vendors, including manuals, reference materials, hours of vendor availability either by phone or online, response time, and training.

Warranty: The period of time and terms of coverage in which the vendor will repair or replace equipment that is not functioning properly.

Storage: The conditions required for storage (e.g., temperature) and the type of container the technology comes with (e.g., padded case, pouch).

Sacrificial Lens: The window that covers the objective lens and protects it from dust, scratches and abrasions. Specifically, responders are interested in the ease and cost of replacing the sacrificial lens.

Affordability

Extended Warranty: The length and cost of the extended warranty and what resources it includes.

Initial Price: The base purchase cost per unit.

Life Expectancy: The amount of time the major components (e.g., lenses and tubes of the technology are expected to operate before requiring replacement).

Appendix B. OPTICS 1 ENHANCED CLIP-ON THERMAL IMAGER

During the Night Vision Devices focus group, participants expressed interest in thermal imaging accessories that could be used to retrofit their current night vision devices. NUSTL identified and purchased the Optics 1 Enhanced Clip-On Thermal Imager (ECOTI) for use during the assessment. (The ECOTI is the only aftermarket thermal accessory currently available.) The ECOTIs were not formally evaluated by the subject matter experts as the devices do not fit the scope of this project, but evaluators shared general feedback.

Product Overview

The ECOTI is a clip-on device that projects a thermal infrared image directly on to the optics of an image intensification (I²) night vision device without modification of existing hardware. The device has a 30 degree field of view. The ECOTI has fixed focus with a focus range of 2 meters (m) to infinity. It's range for recognition and detection is 150 m and 350 m respectively. The device features automatic gain control or digital user adjustable control. The device is capable of magnification at 1X and has a resolution of 21 line pairs per millimeters (lp/mm). Resolution refers to the image quality or object identification capability measured in lp/mm. The ECOTI is fully operational from no light to full sun and has no need for an IR illuminator.



Figure B-1 ECOTI

Image credit: Optics 1

The ECOTI operates on one internal CR123A battery, which has an estimated lifespan of greater than 3.5 hours at 73 degrees Fahrenheit or with an external battery pack of three AA batteries with an 8-hour lifespan at 73 degrees Fahrenheit. The device has a visual battery life indicator.

The ECOTI measures 2.0 x 1.7 x 2.4 inches and weighs 0.3 pounds, including the battery and mounting bracket and 0.21 pounds without the battery and bracket. The device does not use a sacrificial lens but its objective lens is coated with a rugged, diamond-like carbon material. This device can be mounted onto most binoculars with a bracket and has a lens orientation that can be flipped up.

The ECOTI has three modes of operation. In the first mode, the thermal sensor operates at maximum sensitivity, representing the maximum amount of thermal information in view. In the second mode, called "patrol mode," the thermal sensitivity is decreased, resulting in a decreased illumination of thermal objects in view. In the third mode of operation, called "outline mode," a thermal object has an outline that details the boundaries of the object. Thermal image brightness, or gain, can be controlled manually in each mode.

The ECOTI has an operating temperature range of -40 degrees to +122 degrees Fahrenheit and a storage temperature range of -58 degrees to +150 degrees Fahrenheit. It functions in 0 to 100 percent relative humidity. This device complies with MIL-STD-810 for shock and contamination resistance and it is water resistant to 66 ft for two hours.

The ECOTI has an approximate 10-year operational life. Its long-wave infrared sensor element has a typical lifespan of five years. The ECOTI's MSRP is \$7,650, which includes a soft nylon case, lens cloth, one CR123A battery, operator's manual, mounting bracket (BNVD or GPNVG) and a one-year warranty. Power/data cables, additional brackets, GPS battery pack and extended warranties are available for an additional cost. Customer support is available via email.

Responder Use and Feedback

The night vision devices being assessed were outfitted with ECOTI brackets on one lens of the binocular. Evaluators participated in a familiarization session with the technology vendor that included a discussion of features, specifications and use of the ECOTI. Following the training, evaluators affixed the ECOTI to the binocular to familiarize themselves with the device and its settings.

Evaluators used the ECOTI in three scenarios: patrol, surveillance and search and rescue. Throughout the scenarios, the NUSTL team placed heat sources, which evaluators quickly and easily identified using the ECOTI. Evaluators chose the operation mode that they preferred for each scenario and noted that toggling through those settings was easy. Evaluators found that the ECOTI would enhance their existing equipment. However, they also identified some compatibility and functionality issues with some night vision devices (as described in Section 4). The most common compatibility issues identified were related to mount compatibility, alignment and visual impacts.

Mount Compatibility

Currently, the ECOTI mount brackets are not universal. NUSTL purchased two different mounting brackets available, as shown in Figure B-3, which were not compatible with all the binoculars assessed. Optics 1 provided solutions, including 3D printed mounting brackets and alternate commercially available options, for those devices so that the ECOTIs could be used. Evaluators found the 3D-printed brackets to be not as durable or easy to use, especially when sliding the ECOTI into the bracket. Additionally, the location of the mounting bracket impacted the focus adjustments on one device, the Elbit ANPVS-31D. Evaluators reported that the placement of the bracket on the PRG Defense NVG-51 was in the perfect location and did not impact any adjustments on the device.



Figure B-2 Evaluators calibrating (top) and adjusting (bottom) the ECOTI

Image credit: DEVCOM



Figure-B-3 ECOTI mounting brackets

Image credit: NUSTL

Alignment and Visual Impacts

The thermal imaging capabilities of the ECOTI allowed evaluators to detect heat sources. Figure B-4 shows a view looking through the ECOTI in “outline mode” while in a wooded area.

The alignment of the ECOTI with binocular lenses impacted the image for some of the devices assessed. The alignment of the IR illuminator of three devices – the ACTinBlack DTNVS, Carson Industries BNVD and Elbit AN/PVS-31D – with the ECOTI also affected usability. In the case of the DTNVS, the IR reflected off of the ECOTI, and the BNVD and Elbit placement resulted in shadowing.

On the Carson Industries BNVD, use of the ECOTI also caused a circle within a circle image and impacted both the depth perception and the ability to center an image. The circle within a circle visual issue was also experienced by evaluators using the Nightline Inc. RNVG with the ECOTI.


Overall, evaluators found that use of the ECOTI enhanced their experience with the binoculars. It provided them with an additional resource that could benefit their operations in ways such as decreasing the amount of time required for search and rescue operations and allowing them to surveil broader areas.



Figure B-4 View through ECOTI in outline mode in a wooded area

Image credit: DEVCOM

Table B-1 ECOTI Advantages and Disadvantages

Manufacturer/Product	Advantages	Disadvantages
 <p>Optics 1/ECOTI MSRP: \$7,650</p>	<ul style="list-style-type: none"> • Ability to retrofit night vision devices to enhance capability • Usable on monoculars and binoculars • Three thermal modes of operation • Ease of menu navigation 	<ul style="list-style-type: none"> • Mounting brackets are not universal and may not be available for all night vision devices • Focusing the device when the ECOTI mounting bracket is attached can be challenging • Battery light indicator did not give sufficient time before power failure • Interference with IR illuminator

Appendix C. ASSESSMENT SCORING FORMULA

The overall assessment 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 criterion weight assigned by the focus group, thus resulting in a weighted criterion rating. 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

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

Category Score Example ⁱⁱ

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

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

Overall Assessment Score Formula

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

Overall Assessment Score Example

<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 × 13%)	+	(4.5 × 7%)	=
					4.1

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

Appendix D. INGRESS PROTECTION LEVELS (IP CODE)

This section provides information on the levels of ingress protection as specified by the 2-digit designations in the IEC 60529 standard [2]. Table D-1 provides levels of solid ingress protection (first digit). Table D-2 provides levels of liquid ingress protection (second digit).

Table D-1 Levels of Solid Ingress Protection per First Digit of IP Code

Digit	Object Size Effective Against	General Description
0	No Protection	No protection against contact and ingress of solids
1	> 50 mm	Large surfaces, e.g., back of hand, but no protection against deliberate contact with body part
2	> 12.5 mm	Prevents entry of fingers and similarly sized objects
3	> 2.5 mm	Prevents entry of tools, thick wires, etc.
4	> 1 mm	Prevents entry of most wires, screws, large ants, etc.
5	Dust Protected	Dust ingress not entirely prevented but does not enter in sufficient quantity to interfere with satisfactory operation of equipment
6	Dust Tight	No ingress of dust

Table D-2 Levels of Liquid Ingress Protection per Second Digit of IP Code

Digit	Water Exposure Protection	General Description
0	No Protection	No protection
1	Vertically dripping water	Vertically dripping water has no harmful effects
2	Dripping water, enclosure tilted up to 15 degrees	Vertically dripping water has no harmful effects when enclosure is tilted at an angle up to 15 degrees of normal vertical position
3	Spraying water	Water sprayed at angles up to sixty degrees from the vertical position has no harmful effects
4	Splashing water	Water splashed against the enclosure from any direction has no harmful effect

Digit	Water Exposure Protection	General Description
5	Water jets	Water projected by a nozzle (6.3 mm) against enclosure from any direction has no harmful effects
6	Powerful water jets	Water projected in powerful jets against the enclosure from any direction has no harmful effects
7	Temporary immersion in water	Ingress of water in harmful quantity is not possible when the enclosure is temporarily immersed in water under standard conditions or pressure and time
8	Continuous immersion in water	The equipment is suitable for continuous immersion in water under conditions more severe than for numeral 7

Appendix E. MIL-STD-810 LABORATORY TEST METHODS

This section provides information about laboratory test methods specified by MIL-STD-810. [3] Table E-1 provides the title and purpose of each test method.

Table E-1 Laboratory Test Methods as per MIL-STD-810

Method Number	Title	Purpose ⁱⁱⁱ
500	Low Pressure (Altitude)	Use low pressure (altitude) tests to determine if materiel can withstand and/or operate in a low-pressure environment and/or withstand rapid pressure changes.
501	High Temperature	Use high temperature tests to obtain data to help evaluate effects of high-temperature conditions on material safety, integrity, and performance.
502	Low Temperature	Use low temperature tests to obtain data to help evaluate effects of low temperature conditions on materiel safety, integrity, and performance during storage, operation, and manipulation.
503	Temperature Shock	Use the temperature shock test to determine if materiel can withstand sudden changes in the temperature of the surrounding atmosphere without experiencing physical damage or deterioration in performance.
504	Contamination by Fluids	Use contamination by fluids test to determine if materiel (or material samples) is affected by temporary exposure to contaminating fluids (liquids) such as may be encountered and applied during its life cycle, either occasionally, intermittently, or over extended periods.
505	Solar Radiation (Sunshine)	This method has two purposes, (1) to determine the heating effects of direct solar radiation on materiel, and (2) to help identify the actinic (photodegradation) effects of direct solar radiation.

ⁱⁱⁱ "Environmental Engineering Considerations and Laboratory Tests." Department of Defense. 2008. <<https://www.atec.army.mil/publications/Mil-Std-810G/Mil-Std-810G.pdf>>.

Method Number	Title	Purpose ⁱⁱⁱ
506	Rain	Determine the following with respect to rain, water spray, or dripping water: (1) The effectiveness of protective covers, cases, and seals in preventing the penetration of water into the materiel; (2) The capability of the materiel to satisfy its performance requirements during and after exposure to water; (3) Any physical deterioration of the materiel caused by the rain; (4) The effectiveness of any water removal system; and (5) The effectiveness of protection offered to a packaged materiel.
507	Humidity	Determine the resistance of materiel to the effects of a warm, humid atmosphere.
508	Fungus	Assess the extent to which materiel will support fungal growth and how any fungal growth may affect performance or use of the materiel.
509	Salt Fog	Determine the effectiveness of protective coatings and finishes on materials. It may also be applied to determine the effects of salt deposits on the physical and electrical aspects of materiel.
510	Sand and Dust	Dust (< 150µm) procedure – evaluate the ability of materiel to resist the effects of dust that may obstruct openings, penetrate into cracks, crevices, bearings, and joints, and to evaluate the effectiveness of filters. Sand (150 to 850µm particle size) procedure – performed to help evaluate the ability of materiel to be stored and operated in blowing sand conditions without degrading performance, effectiveness, reliability, and maintainability due to abrasion (erosion) or clogging effects of large, sharp-edged particles.
511	Explosives Atmosphere	Demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition or demonstrate that an explosive or burning reaction occurring within encased materiel will be contained and will not propagate outside the test item.

Method Number	Title	Purpose ⁱⁱⁱ
512	Immersion	Determine if materiel can withstand immersion or partial immersion in water (e.g., fording), and operate as required during or following immersion.
513	Acceleration	Assure that materiel can structurally withstand the steady state inertia loads that are induced by platform acceleration, deceleration, and maneuver in the service environment, and function without degradation during and following exposure to these forces. Acceleration tests are also used to assure that materiel does not become hazardous after exposure to crash inertia loads.
514	Vibration	Performed to (1) develop materiel to function in and withstand the vibration exposures of a life cycle including synergistic effects of other environmental factors, materiel duty cycle, and maintenance. This method is limited to consideration of one mechanical degree-of-freedom at a time. Refer to Method 527 for further guidance on multiple exciter testing. Combine the guidance of this method with the guidance of Part One and other methods herein to account for environmental synergism. (2) Verify that materiel will function in and withstand the vibration exposures of a life cycle.
515	Acoustic Noise	Determine the adequacy of materiel to resist the specified acoustic environment without unacceptable degradation of its functional performance and/or structural integrity.
516	Shock	Performed to provide a degree of confidence that materiel can physically and functionally withstand the relatively infrequent, non-repetitive shocks encountered in handling, transportation, and service environments. This may include an assessment of the overall materiel system integrity for safety purposes in any one or all of the handling, transportation, and service environments; determine the materiel's fragility level, in order that packaging may be designed to protect the materiel's physical and functional integrity; and test the strength of devices that attach materiel to platforms that can crash.

Method Number	Title	Purpose ⁱⁱⁱ
517	Pyroshock	Performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by the detonation of a pyrotechnic device on a structural configuration to which the materiel is mounted; and experimentally estimate the materiel's fragility level in relation to pyroshock in order that shock mitigation procedures may be employed to protect the materiel's structural and functional integrity.
518	Acidic Atmosphere	Determine the resistance of materials and protective coatings to corrosive atmospheres, and when necessary, to determine its effect on operational capabilities.
519	Gunfire Shock	Performed to provide a degree of confidence that materiel can structurally and functionally withstand the relatively infrequent, short duration, transient, high rate repetitive shock-input encounter in operational environments during the firing of guns.
520	Temperature, Humidity, Vibration, and Altitude	Determine the combined effects of temperature, humidity, vibration, and altitude on airborne electronic and electro-mechanical materiel with regard to safety, integrity, and performance during ground and flight operations. Some portions of this test may apply to ground vehicles, as well. In such cases, references to altitude considerations do not apply.

Method Number	Title	Purpose ⁱⁱⁱ
521	Icing/Freezing Rain	Evaluate the effect of icing on the operational capability of materiel. This method also provides tests for evaluating the effectiveness of de-icing equipment and techniques, including prescribed means to be used in the field.
522	Ballistic Shock	This method includes a set of ballistic shock tests generally involving momentum exchange between two or more bodies, or momentum exchange between a liquid or gas and a solid, performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by high levels of momentum exchange on a structural configuration to which the materiel is mounted; and experimentally estimate the materiel's fragility level relative to ballistic shock in order that shock-mitigation procedures may be employed to protect the materiel's structural and functional integrity.
523	Vibro-Acoustic/Temperature	Performed to determine the synergistic effects of vibration, acoustic noise, and temperature on externally carried aircraft stores during captive carry flight. Such determination may be useful for, but not restricted to, the following purposes: (1) To reveal and correct design weaknesses (Test, Analyze, and Fix (TAAF) test); (2) To determine whether a design meets a specified reliability requirement (Reliability Demonstration test); (3) To reveal workmanship or component defects before a production unit leaves the place of assembly (Screening test); (4) To estimate the Mean Time Between Failure (MTBF) of a lot of units based upon the test item's time to failure of a small sample of the units (Lot Acceptance test); and (5) To determine the relative reliability among units based upon the test item's time to failure of a small sample of the units (Source Comparison test).
524	Freeze-Thaw	Determine the ability of materiel to withstand the effects of moisture phase changes between liquid and solid, in or on materiel, as the ambient temperature cycles through the freeze point; and the effects of moisture induced by transfer from a cold-to-warm or warm-to-cold environment.

Method Number	Title	Purpose ⁱⁱⁱ
525	Time Waveform Replication	Performed to provide a degree of confidence that the materiel can structurally and functionally withstand the measured or analytically specified test time trace(s) to which the materiel is likely to be exposed in the operational field environment; and experimentally estimate the materiel's fragility level in relation to form, level, duration, or repeated application of the test time trace(s).
526	Rail Impact	Replicate the railroad car impact conditions that occur during the life of transport of systems, subsystems, and units, hereafter called materiel, and the tiedown arrangements during the specified logistic conditions.
527	Multi-Exciter Testing	Performed to provide a degree of confidence that the materiel can structurally and functionally withstand a specified environment, e.g., stationary, non-stationary, or of a shock nature, that must be replicated on the test item in the laboratory with more than one motion degree-of-freedom consideration.
528	Mechanical Vibrations of Shipboard Materials	Specifies procedures and establishes requirements for environmental and internally excited vibration testing of naval shipboard equipment installed on ships.