Battery-Powered Rescue Tools for Vehicle Extrications

Focus Group Report

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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 DAGER Technology, LLC, NUSTL conducted a focus group on commercially available Battery Powered Rescue Tools for Vehicle Extrications. This equipment falls under the AEL reference number 03SR-02-TPHY titled, "Tools, Power, Hydraulic, Pneumatic."

For more information on NUSTL's SAVER Program or to view additional reports on extrication tools or other technologies, visit 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.

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

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EXECUTIVE SUMMARY

Through its System Assessment and Validation for Emergency Responders (SAVER) program, the National Urban Security Technology Laboratory (NUSTL) will conduct a comparative assessment of battery-powered rescue tools for vehicle extrication, specifically spreading, cutting and spreading/cutting combination tools (hereafter, "extrication tools"), to provide emergency responders with information that will assist with making operational and procurement decisions.

As a part of the assessment planning process, NUSTL, in conjunction with DAGER Technology, LLC, (DAGER) convened a focus group of emergency responders in April 2022 to obtain their recommendations for evaluation criteria, product selection criteria, and possible scenarios for an assessment. The focus group consisted of eight emergency responders from Colorado, the District of Columbia, Illinois, New York, Texas, Virginia, and Washington.

Emergency response personnel use extrication tools to cut, spread, and pull sections of vehicle body structures to create space for accessing and removing a person who is trapped and may be injured. Battery-powered spreading, cutting, and spreading/cutting combination tools for vehicle extrication fall under AEL reference number 03SR-02-TPHY, titled "Tools, Power, Hydraulic, Pneumatic."

The focus group identified 25 evaluation criteria by which extrication tools should be assessed. They grouped them into the five SAVER categories and concluded that Capability and Usability were of the most importance, followed by Affordability, Maintainability, and Deployability. The focus group assigned a weight for each criterion's level of importance and identified 13 of the utmost importance, i.e., that the focus group participants would not purchase extrication tools that did not meet their expectations for those features. Those criteria considered of utmost importance were Battery Performance, Battery Operating Time, Durability, NFPA 1936-Certified, NFPA 1936 Performance Rating, Visual Indicators, Ergonomics, Ease of Use, Portability, Compatibility with Personal Protective Equipment, Replacement Battery Cost, Training, and Startup Time. The focus groups outlined four possible operational scenarios for the assessment, including accessing the interior of vehicles in recreated front-end, side-impact, and rollover collisions as well as of an undamaged vehicle. NUSTL and DAGER will use these recommendations to plan a SAVER assessment of extrication tools.

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1.0 INTRODUCTION

Emergency responders use battery-powered spreading, cutting, and spreading/cutting combination tools (hereafter, "extrication tools") to open or remove sections of a damaged vehicle from around a person who is trapped and may be injured. The tools can assist responders in accessing a trapped person when vehicle doors are damaged, nonoperational or blocked, or when the vehicle occupant cannot unlock the vehicle door. This is performed to access the victim as soon as possible and also help minimize any further harm.

Cutting and spreading capabilities are rated according to performance test standards published by the National Fire Protection Association (NFPA) in NFPA 1936: "Standard on Rescue Tools" [1]. Extrication tools compliant with NFPA 1936 bear the mark of an independent, third-party certification organization. Tools may also be rated for operability in potentially explosive environments in compliance with Underwriters Laboratory's (UL) Standard 913 titled "Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations" [2] or other applicable standards for intrinsic safety.

In April 2022, the System Assessment and Validation for Emergency Responders (SAVER) program conducted a focus group of experienced users of such tools to obtain information on their practical experiences relevant to operational and procurement decisions. The information provided by this focus group will be used to plan a future SAVER assessment of extrication tools.

1.1 PARTICIPANT INFORMATION

Eight emergency responders from various jurisdictions and each with at least five years of experience using vehicle extrication tools participated in the focus group.

Table 1-1 Focus Group Participant Information

Practitioner	Years of Experience	State
Fire Services/Engineer	15–20	CO
Fire Services	20–25	IL
Fire Services	20–25	NY
Fire Services	15–20	TX
Fire Services	25–30	TX
Fire Services	20–25	VA
Fire Services	25–30	WA
Emergency Response	5–10	Washington D.C.

2.0 FOCUS GROUP METHODOLOGY

The focus group opened with an overview of the SAVER program and battery-powered rescue tools for vehicle extrication. After explaining the focus group goals and objectives, a facilitator led group discussions to elicit four sets of recommendations:

1) Evaluation criteria: specific features that are important to consider when making acquisition or operational decisions
2) Assessment scenario: operational settings and activities in which the products should be assessed to evaluate their performance in those criteria
3) Product selection criteria: specifications, attributes, or characteristics a product should possess to be considered for the assessment
4) Product suggestions: products, manufacturers, and vendors that are relevant to the emergency responder community and should be candidates for inclusion in the comparative assessment

Figure 2-1 highlights the process followed to gather recommendations.

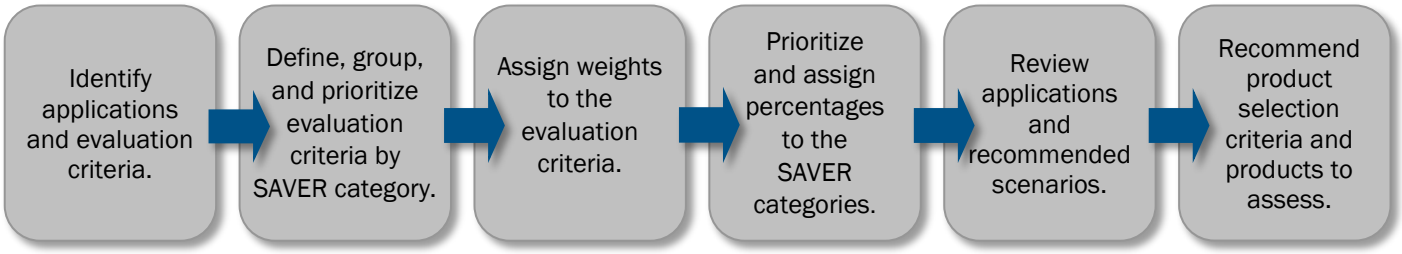

Figure 2-1 Focus Group Process

Focus group participants first identified applications in which extrication tools are commonly used. Next, the focus group participants identified and defined evaluation criteria, which were then grouped and prioritized in the SAVER categories: Affordability, Capability, Deployability, Maintainability, and Usability. The SAVER categories organize criteria in the following manner:

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

Once the evaluation criteria were prioritized within the SAVER categories, focus group participants assigned a weight for each criterion's level of importance on a 1–5 scale, where five is of utmost importance and one is of minor importance. Table 2-1 summarizes the evaluation criteria weighting scale.

Table 2-1 Evaluation Criteria Weighting Scale

Weight	Definition
5	This evaluation criterion is ***of utmost importance:*** "I ***would never*** consider purchasing a product that does not meet my expectations of this criterion or does not have this feature."
4	This evaluation criterion is ***very important***: "I ***would be hesitant*** to purchase a product that does not meet my expectations of this criterion or does not have this feature."
3	This evaluation criterion is ***important***: "Meeting my expectations of this criterion or having this feature ***would strongly influence*** my decision to purchase this product."
2	This evaluation criterion is ***somewhat important:*** "Meeting my expectations of this criterion or having this feature ***would slightly influence*** my decision to purchase this product."
1	This evaluation criterion is ***of minor importance***: "Other things being equal, meeting my expectations of this criterion or having this feature ***may influence*** my decision to purchase this product."

After the evaluation criteria were assigned a weight, the focus group participants recommended whether the criteria should be assessed operationally or evaluated according to vendor-provided specifications.

Figure 2-2 Focus Group Identifying Evaluation Criteria

Next, considering the evaluation criteria in each category, the focus group participants ranked the SAVER categories in order of importance. A percentage was then assigned to each category to represent its level of importance.

After rating the SAVER categories, the participants identified product selection criteria, including performance ratings of NFPA 1936. The focus group identified manufacturers that should be considered for the assessment.

Lastly, the focus group participants reviewed the applications identified at the beginning of the focus group session and recommended operational scenarios for the assessment.

3.0 EVALUATION CRITERIA RECOMMENDATIONS

The focus group identified 25 evaluation criteria and concluded that Capability and Usability were the most important SAVER categories, followed by Affordability, Maintainability, and Deployability, respectively. Table 3–1 presents the category weights, evaluation criteria, and evaluation criteria weights.

Table 3-1 Evaluation Criteria

SAVER CATEGORIES				
Capability	**Usability**	**Affordability**	**Maintainability**	**Deployability**
Overall Weight 30%	Overall Weight 30%	Overall Weight 20%	Overall Weight 15%	Overall Weight 5%
Evaluation Criteria				
Battery Performance Weight: 5	**Ergonomics** Weight: 5	**Replacement Battery Cost** Weight: 5	**Training** Weight: 5	**Startup Time** Weight: 5
Battery Operating Time Weight: 5	**Ease of Use** Weight:5	**Initial List Price** Weight: 4	**Customer Service** Weight: 4	**Mounting Options** Weight: 2
Durability Weight: 5	**Portability** Weight: 5	**Warranty and Service Plans** Weight: 4	**In-House Maintenance** Weight: 3	**Storage Conditions** Weight: 2
NFPA 1936-Certified Weight: 5	**Compatibility with PPE** Weight: 5			
NFPA 1936 Performance Rating Weight: 5	**Cutter Placement*** Weight: 4			
Visual Indicators Weight: 5	**Intrinsic Safety** Weight: 1			
Battery Operating Conditions Weight: 4				
Accessories Weight: 2				

Anti-Jam Release Weight: 1				
LED Lights Weight: 1				
Notes * indicates a criterion is applicable only to combination tools				

3.1 CAPABILITY

The focus group identified and defined 10 capability criteria. They are listed below in descending order of importance, as ranked by the focus group.

Battery Performance refers to the battery performance and longevity as provided by the manufacturer and includes battery charge time.

Battery Operating Time refers to the run time while the tool is in use, built-in power saving features such as auto shut-off and standby mode, and the run time while the tool is in standby mode (where appliable).

Durability refers to the extrication tool's ability to withstand a variety of environmental conditions. This includes water, shock, and drop resistance. Military specifications (MIL-SPEC), military standards (MIL-STD), and ingress protection (IP) ratings can serve to evaluate extrication tools for durability.

NFPA 1936-Certified refers to tools that meet the minimum requirements for design, performance, testing, and certification in accordance with the National Fire Protection Association (NFPA) 1936 "Standard on Rescue Tools," 2020 edition.

NFPA 1936 Performance Rating refers to the results of various tool performance characteristics when tested by a third-party, independent laboratory in accordance with standards set forth in NFPA 1936 (2020). NFPA 1936 standardized tests applicable to battery-powered cutters and combination tools include an alphanumeric cutting performance levels for various material categories expressed as A#/B#/C#/D#/E#. This cutting performance level is based on the ability of a cutter to cut specific grades and thicknesses of formed steel stock. An optional F# test was added for manufacturers who claim the ability of their tool to cut high-strength materials.

Visual Indicators refers to character or graphical displays of features such as battery status, power status, or force exertion.

Battery Operating Conditions refers to environmental conditions that a battery can withstand (e.g., extreme temperatures).

Accessories refers to additional components that can be used with an extrication tool to enhance its capabilities.

Anti-Jam Release refers to the ability of the device's blades or arms to decompress or depressurize should the battery die during operation.

LED Lights are light emitting diodes that are incorporated into the exterior of the extrication tools to aid the operator's visibility when using the device.

3.2 USABILITY

The focus group identified and defined six usability criteria. They are listed below in descending order of importance, as ranked by the focus group.

Ergonomics refers to the design of the tool for physical ease of use, which includes maneuverability, balanced handle (e.g., thumb levers, activated throttles, twist grips), and battery placement.

Ease of Use refers to the intuitiveness of using the tool and making configuration adjustments including navigating through menus.

Portability refers to the ease with which the tool can be moved from one location to another, which includes the weight of the device including battery.

Compatibility with PPE refers to the ease with which the tool can be used with personal protective equipment (PPE) such as gloves.

Cutter Placement refers to the location of the cutter blades on the interior of the arms of a spreader/cutter combination tool (e.g., blades along the full length of the arms, only near the tips of the arms, or only near the base of the arms). Blade placement may dictate the ability of the tool to be used for cutting materials in confined spaces. *This criterion applies only to combination tools.*

Intrinsic Safety refers to the ability of the device and any accessories to be operated in potentially explosive environments in compliance with the Underwriters Laboratory (UL) Standard 913 titled "Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations" [2] or other applicable standards for intrinsic safety.

3.3 AFFORDABILITY

The focus group identified and defined three affordability criteria. They are listed below in descending order of importance, as ranked by the focus group.

Replacement Battery Cost refers to the expense incurred when the battery needs to be replaced. It also includes whether the battery is commercial-off-the-shelf or proprietary.

Initial List Price refers to the manufacturer's suggested retail price. This does not include bulk discounts.

Warranty and Service Plan refers to the period of time and terms of coverage in which a vendor will replace or repair equipment that is not functioning properly.

3.4 MAINTAINABILITY

The focus group identified and defined three maintainability criteria. They are listed below in descending order of importance, as ranked by the focus group.

Training refers to the content and format of resources included with initial purchase.

Customer Service/Vendor Accessibility refers to the resources and technical support provided by vendors, including a loaner policy, manuals, reference materials, and hours of vendor availability either by phone or online.

In-House Maintenance refers to inspections and component replacements that can be performed by technicians within the user's agency or department, rather than having to be returned to the vendor or other approved service provider for maintenance.

3.5 DEPLOYABILITY

The focus group identified and defined three deployability criteria. They are listed below in descending order of importance, as ranked by the focus group.

Startup Time refers to the amount of time needed after powering on, or exiting standby mode, until the tool becomes usable.

Mounting Options refers to the ability for the extrication tool to be affixed to various platforms, such as in-vehicle brackets.

Storage Conditions refers to how the tool must be stored to maintain its efficacy (e.g., temperature-controlled environment, case durability, docking stations).

4.0 EVALUATION CRITERIA ASSESSMENT RECOMMENDATIONS

The focus group made recommendations on whether the evaluation criteria should be assessed operationally or by review of information from vendor-provided specifications. At the assessment, evaluators will assess operationally focused criteria based on hands-on experience using (or by inspecting the features of) the product. They will evaluate other specifications, based on product information provided by the vendor, including reports from third-party testing labs. Some criteria may be assessed by both methods.

Table 4-1 presents the focus group's assessment recommendations for the evaluation criteria.

Table 4-1 Evaluation Criteria Assessment Recommendations

Category	Criteria	Operational	Specification
Capability	Battery Performance		✓
	Battery Operating Time	✓	✓
	Durability		✓
	NFPA 1936-Certified		✓
	NFPA 1936 Performance Rating		✓
	Visual Indicators	✓	
	Battery Operating Conditions		✓
	Accessories		✓
	Anti-Jam Release		✓
	LED Lights	✓	
Usability	Ergonomics	✓	
	Ease of Use	✓	
	Portability	✓	✓
	Compatibility with PPE	✓	
	Cutter Placement*	✓	
	Intrinsic Safety		✓
Affordability	Replacement Battery Cost		✓
	Initial List Price		✓
	Warranty and Service Plans		✓
Maintainability	Training		✓
	Customer Service		✓
	In-House Maintenance		✓
Deployability	Startup Time	✓	
	Mounting Options	✓	✓
	Storage Conditions	✓	✓
*Only applies to spreader/cutter combination tools			

5.0 ASSESSMENT SCENARIO RECOMMENDATIONS

The focus group identified undamaged vehicles, as well as front-end impact collision, side-impact collision, and rollover collision vehicles as use cases for battery-powered extrication tools. Based on these applications, the focus group recommended five operational scenarios to access mannequins in vehicles, as described in sections 5.2 to 5.5. Focus group participants also suggested activities such as vehicles leaning over an overpass, or stuck upright or between trees, and those in underride crashes to evaluate the complications of confined space entrapment. The project team will evaluate the feasibility of creating a confined-space scenario based on logistics and safety at the assessment venue. The assessment will also include an equipment familiarization and deployment operations scenario, described in section 5.1.

All scenarios will take place at a venue that has a conference room as well as the ability to accommodate safe placement and destruction of vehicles. Vehicles needed for use during this assessment will be coordinated between NUSTL, DAGER, and the venue. The assessment team will seek a variety of vehicle types (e.g., sedans, sport utility vehicles, vans) and attempt to secure sets of similar vehicles for use during each scenario.

5.1 EQUIPMENT FAMILIARIZATION/DEPLOYMENT PREPARATION

In a conference room setting, evaluators will begin the assessment of each extrication tool in a familiarization session that includes an overview of features and specifications by the technology vendor or, in their absence, a subject matter expert trainer. Specifically, instructional overviews of the tool, assembly procedures, attachment connection procedures, deployment techniques, power source management, control operations, target placement, and functioning processes will be covered.

Following the overview, evaluators will don PPE and handle the extrication tools, actively manipulating the controls and preparing them for deployment – including customizing settings or adding accessories as available.

Evaluation criteria scored during this scenario will include: Battery Performance, Durability, NFPA 1936-Certified, NFPA 1936 Performance Rating, Battery Operating Conditions, Accessories, Anti-Jam Release, Portability, Intrinsic Safety, Replacement Battery Cost, Initial List Price, Warranty and Service Plans, Training, Customer Service, In-House Maintenance, Mounting Options, and Storage Conditions.

5.2 UNDAMAGED VEHICLES

Evaluators will respond to a simulated medical incident with a simulated unconscious, physically impaired individual (mannequin) locked inside an undamaged vehicle and requires immediate extrication and medical attention. During the scenario, the responders will use cutting tools to gain access to the vehicle and then spreading tools to expand the vehicle components (e.g., doors, trunk, roof) surrounding the victim. This will allow evaluators to access the victim. The activities will also be conducted with the combination tool.

Evaluation criteria scored during this scenario will include: Battery Operating Time, Visual Indicators, LED Lights, Ergonomics, Ease of Use, Portability, Compatibility with PPE, Cutter Placement (combination tool only), Startup Time, Mounting Options, and Storage Conditions.

5.3 FRONT-END IMPACT COLLISION

Evaluators will respond to a vehicle with heavy front-end impact damage and simulated multiple victims (mannequins) trapped inside the vehicle. Evaluators may encounter airbag deployment, undeployed airbags, seatbelt attachments with active pretensioners, and front-end damage to the reinforced wheel and engine deflection system, including the bulkhead/firewall, crumple zone locations, shifted side-impact bars, and/or reinforced dashboard areas. Extrication techniques may include side door removal, B-pillar removal, or roof top removal with reinforced pillar structures containing high strength low-alloy (HSLA) or ultra-high strength low alloy (UHSLA) steel.

Evaluation criteria scored during this scenario will include: Battery Performance, Visual Indicators, LED Lights, Ergonomics, Ease of Use, Portability, Compatibility with PPE, Cutter Placement (combination tool only), Startup Time, Mounting Options, and Storage Conditions.

5.4 SIDE-IMPACT COLLISION

Evaluators will respond to a side-impact vehicle collision simulating driver and passenger (both mannequins) entrapment. Evaluators may have limited space to work on the driver's side due to impact blockage of the driver's side doors and distorted vehicle structure. Crash impact may make patient care and extrication more difficult due to a shifted vehicle dashboard, distorted high strength micro-alloy and boron steel supports, steering wheel misalignment, reinforced door structures wedged into the vehicle's frame, and active seat belt pretensioners and undeployed airbags presenting a safety hazard.

Evaluation criteria scored during this scenario will include: Battery Performance, Visual Indicators, LED Lights, Ergonomics, Ease of Use, Portability, Compatibility with PPE, Cutter Placement (combination tool only), Startup Time, Mounting Options, and Storage Conditions.

5.5 ROLLOVER COLLISION

Evaluators will respond to a rollover collision with the vehicle occupants (mannequins) in the upside-down position, suspended by seatbelt restraining devices. The vehicle will have experienced a passenger side-impact collision, causing the vehicle to roll over and come to rest on its roof and potentially causing airbag deployment. Damage to the vehicle may include jammed doors, side-impact bars collapsing into the passenger compartment, passenger-side dashboard damage, and weakened and damaged A, B, C, and D pillars and roof rails, requiring the implementation of careful stabilization and extrication techniques. Figure 5-1 illustrates a vehicle with four roof pillars and their associated (A, B, C, and D) nomenclature.

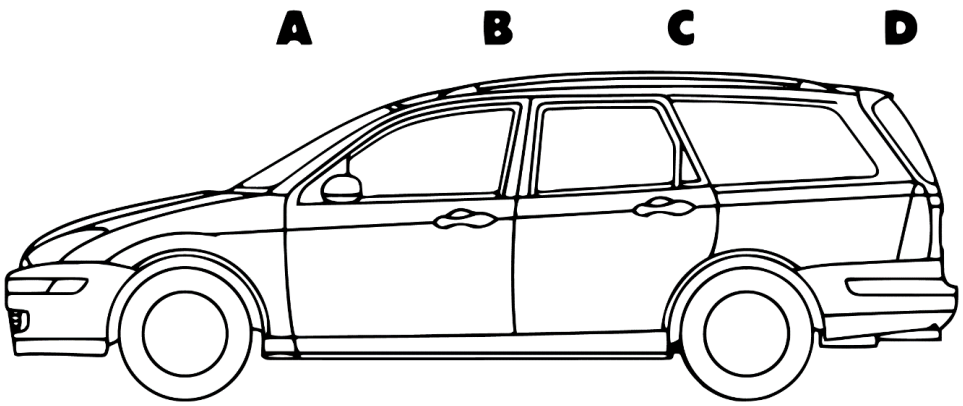

Figure 5-1 Example Vehicle with Four Roof Pillars Labeled A, B, C, and D

Image Credit: Wikimedia Commons

Evaluation criteria scored during this scenario will include: Battery Performance, Visual Indicators, LED Lights, Ergonomics, Ease of Use, Portability, Compatibility with PPE, Cutter Placement (combination tool only), Startup Time, Mounting Options, and Storage Conditions.

6.0 PRODUCT SELECTION RECOMMENDATIONS

The focus group discussed three types of tools that are commonly used during emergency vehicle extrication: spreaders, cutters, and combination spreader/cutters. Up to one tool per manufacturer per product type (e.g., the product that is determined to be the best match against the selection criteria) may be selected for use. Product selection criteria are captured in Table 6-1. Cutters and combination tools that have been rated for high-strength material cutting in accordance with NFPA 1936 ratings, by an independent, accredited third-party testing laboratory will be assessed.

Table 6-1 Product Selection Criteria

Product Type	Product Selection Criteria	Notes
Spreader	28-inch spread	If more than one spreader per manufacturer is available, priority will be given to the product with a 28-inch opening.
Cutter	High-Strength Materials Cut and Level Performance Rating (F) NFPA-1936 Rating	This test was designed to mimic materials used in some modern vehicle roof pillars. This is identified by an alphanumeric rating ranging from F1–F9.
	Lowest weight	If more than one cutter per manufacturer has an F cut rating, priority will be given to the product with the lowest weight.
Spreader/Cutter Combination Tool	High-Strength Materials Cut and Level Performance Rating (F) NFPA-1936 Rating	This test was designed to mimic materials used in some modern vehicle roof pillars. This is identified by an alphanumeric rating ranging from F1–F9.
	14–15-inch spreader range	If more than one combination tool per manufacturer has an F cut rating, priority will be given to the product with a spreader range of between 14–15 inches.

The focus group did not recommend specific products to assess, but stated they had used extrication tools that should be considered for the assessment from the following vendors:

- Genesis
- Holmatro
- Hurst
- Ogura
- PowerHawk
- TNT Rescue

7.0 FUTURE ACTIONS

The focus group's recommendations will be used to guide the development of a Battery-Powered Rescue Tool for Vehicle Extrication Assessment Plan and the selection of products to evaluate. Once the assessment is complete, the results will be available in the SAVER Document Library found at www.dhs.gov/science-and-technology/saver-documents-library.

8.0 REFERENCES

[1] National Fire Protection Association (NFPA), "NFPA 1936: Standard on Rescue Tools, 2020 Edition," 2020.

[2] UL, LLC. (formerly Underwriters Laboratories), "UL 913: Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations," 2022.

9.0 ACKNOWLEDGEMENTS

NUSTL thanks the focus group participants for their valuable time and expertise. Their insights and recommendations will guide the planning and execution of the assessment as well as future SAVER projects. Appreciation is also extended to the home jurisdictions of the participants for allowing them to participate in the focus group.