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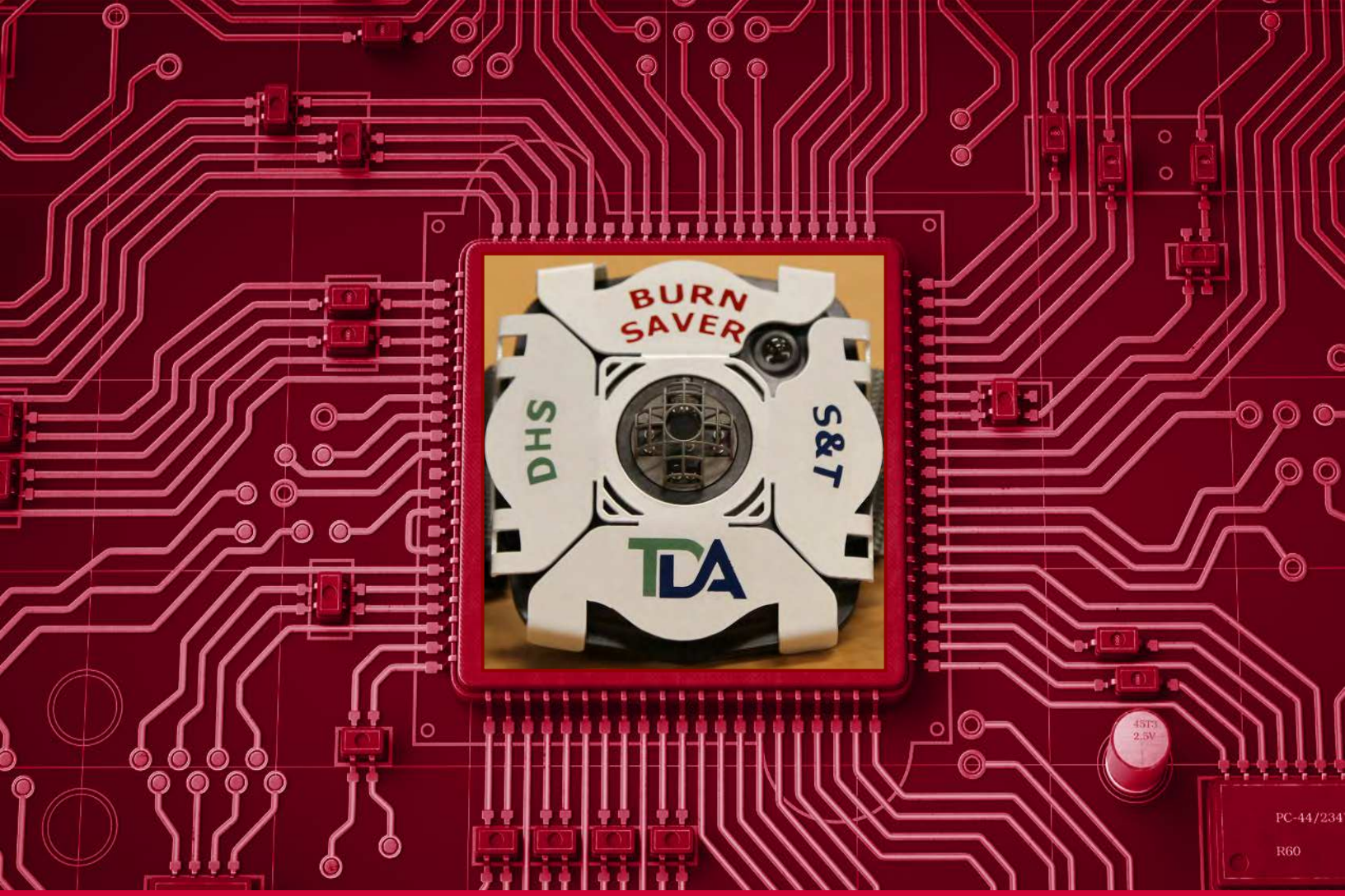

Burn Saver

Operational Field Assessment Report

March 2019

Homeland Security
Science and Technology

NUSTL®
NATIONAL URBAN SECURITY TECHNOLOGY LABORATORY

Approved for Public Release

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FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory organized 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 state and local first responders to address the homeland security mission. The laboratory provides first responders with the necessary services, products, and tools to prevent, protect against, mitigate, respond to, and recover from homeland security threats and events.

DHS S&T works closely with the nation's emergency response community to identify and prioritize mission capability gaps, and to facilitate the rapid development of critical solutions to address responders' everyday technology needs. DHS S&T gathers input from local, tribal, territorial, state, and federal first responders, and engages them in all stages of research and development—from building prototypes to operational testing to transitioning tools that enhance safety and performance in the field—with the goal of advancing technologies that address mission capability gaps in a rapid time frame, and then promoting quick transition of these technologies to the commercial marketplace for use by the nation's first responder community.

As projects near completion, NUSTL conducts an operational field assessment (OFA) of the technology's capabilities and operational suitability to verify and document that project goals were achieved. NUSTL's OFA reports are posted on the First Responder Communities of Practice website—a professional networking, collaboration, and communication platform created by DHS S&T to support improved collaboration and information sharing amongst the nation's first responders. This vetted community of members focuses on emergency preparedness, response, recovery and other homeland security issues. To request an account, complete the online form on communities.firstresponder.gov/web/guest/home.

Publicly released OFA reports are available at www.dhs.gov/science-and-technology/frg-publications.

Visit the DHS S&T website, www.dhs.gov/science-and-technology/first-responder-technologies, for information on other projects relevant to first responders.

Visit the NUSTL website, www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory, for more information on NUSTL programs and projects.

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EXECUTIVE SUMMARY

Firefighters are exposed to dangerous thermal conditions, including elevated temperatures, convective heat flux, and radiant heat flux when entering burning buildings during a fire. The self-contained breathing apparatus (SCBA) facepiece lens is often the first component of a firefighter's personal protective equipment (PPE) to fail when exposed to dangerous thermal conditions, a contributing factor in many firefighter injuries and fatalities [1].

To address this issue, the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) funded TDA Research Inc. (TDA) to develop Burn Saver, a sensor and alarm system that can be mounted on an SCBA shoulder strap, and measures the temperature and heat flux of the environment and calculates the length of time until those conditions will damage the SCBA facepiece lens. Specifically, Burn Saver will activate an alarm when it calculates that a firefighter has 45 seconds remaining before the environment begins to damage their SCBA facepiece.

On October 16, 2018, the DHS S&T National Urban Security Technology Laboratory (NUSTL), a testing and evaluation laboratory, conducted an operational field assessment (OFA) of Burn Saver. During this OFA, five firefighters served as evaluators and engaged in operational tests to evaluate Burn Saver's suitability for use by firefighters in field scenarios that simulate conditions they may encounter during the performance of their duties.

The evaluators agreed that Burn Saver could become a valuable sensor for firefighters. It is difficult for firefighters to sense when the temperature within a fire is high enough to damage their facepiece lens. Burn Saver can alert a firefighter to these dangerous thermal conditions. However, the evaluators believed that Burn Saver's alarm mechanisms needed to be improved. They believed the blue light emitting diode on the front of Burn Saver would not be sufficient to alert firefighters during a live fire. The ability for Burn Saver to send the alarm to a heads-up display of an SCBA facemask or to an incident command's personnel accountability software display via digital radio were seen as viable alternatives; however, not all fire departments own the specific SCBA or digital radio model that are compatible with Burn Saver. Lastly, the evaluators believed that a firefighter could wear Burn Saver without it interfering with their ability to perform their job duties. They noted that the Burn Saver was occasionally a minor annoyance while completing the OFA's activities, but it did not cause the evaluators to change their methods for completing tasks.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

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This report describes the OFA activities performed, the results from those activities, and the evaluators' feedback.

1.1 PURPOSE

The purpose of the OFA was to assess the suitability of Burn Saver during firefighter field operations, focusing on the firefighters' mobility and range of motion, and the visibility and clarity of alarm modes.

1.2 OBJECTIVE

The objective of the OFA was to obtain firefighters' feedback on Burn Saver when used during activities that mimic operational conditions.

The OFA assessed:

- Motion restriction
- Visibility and clarity of Burn Saver's alarm modes.

1.3 REQUIREMENTS

Table 1-1 summarizes the requirements Burn Saver was designed to meet. These requirements are drawn from the Burn Saver statement of objectives, the TDA research technical proposal corresponding to Broad Agency Announcement H8HQDC-13-R-00009, and subsequent design review reports.

Table 1-1 Burn Saver Requirements Matrix

Category	Requirement	Test Method

Ergonomic Design	• Lightweight:
	  ○ Threshold <1 pound
	  ○ Objective <10.6 ounces
	• Not interfere with normal operations
	• Simple, durable, and rugged
		• OFA activities to assess interference with arm motion:
		  ○ Hose drag
		  ○ Forcible entry
		  ○ Rescue
		  ○ Ceiling breach
		• And ruggedness of attachment:
		  ○ Search (crawling)
		  ○ Stair climb (vertical jostling)
		  ○ Ladder raise and climb

Sensors	• Accurately measures convective heat (ambient air temperature) • Accurately measures radiative (infrared) heat flux: ○ Thermal sensor must respond to all mechanisms of heat transfer	• Controlled laboratory tests reported by developer

Alarm Activation and Detection	• Alarms within 10 seconds to changes in infrared radiation
	• Alarms within approximately 30 seconds to changes in ambient air temperature
	• Audible and/or visual alarms simultaneously activated:
	  ○ On the Burn Saver
	  ○ In the command center
	  ○ On the heads-up display (HUD) in the SCBA facemask
		• Controlled laboratory tests reported by developer
		• OFA live burn demonstration camera feed observation to assess visibility of the blue light emitting diode (LED) alerts through smoke:
		  ○ LED and command center alert remotely manually activated during the ceiling breach and search activities
		  ○ HUD will be demonstrated in classroom setting only

Power	• Battery powered	• Manufacturer report, pre-check inspection
Construction	• Housing should not deform if front face begins to soften • Silicone shoulder straps withstand short exposures to high temperatures • Burn Saver unit, power source, and associated electronics able to withstand high temperatures and high pressure water sources	• Manufacturer presentation of test reports at OFA

1.4 Compliance

The DHS S&T Compliance Assurance Program Office and the New England Independent Review Board reviewed and approved the Burn Saver OFA test protocol and found it compliant with all relevant human subjects research statutes, regulations, and directives [2], [3]. In addition, the DHS Privacy Office approved the collection and storing of personally identifiable information from participants [4].

1.5 Burn Saver Description

Burn Saver is a small, lightweight, battery-powered device contained in a thermoplastic case, and designed to be mounted on the straps of a firefighter's SCBA. The Burn Saver Generation 4 prototype, which was used in this OFA, is 3.6 inches in height, 3.5 inches wide, 1.8 inches deep, and weighs 7.8 ounces. The device aims to serve as an early detection system for radiant and convective heat sources that can cause firefighters' SCBA facepiece lenses to fail.

Figure 1-1 Burn Saver Generation 4 Prototype

In a National Institute of Standards and Technology (NIST) study of SCBA facepiece lenses, two of the tested lenses started to show signs of degradation when exposed to a heat flux of five kilowatts per square meter (kW/m^2). All of the tested facepiece lenses showed signs of degradation after 3.9 minutes when exposed to a heat flux of 15 kW/m^2 [1]. Using an algorithm created by TDA, Burn Saver calculates how much time the wearer has before the SCBA facepiece lens begins to fail. When Burn Saver calculates that the wearer has 45 seconds before equipment failure, a blue light emitting diode (LED) on the front of the Burn Saver device will illuminate. When 15 seconds remain, the blue LED will blink.

Burn Saver can also use a Bluetooth signal to activate an alarm on other devices. It is capable of activating an alarm on the heads-up display (HUD) of the G1 model SCBA facemask made by MSA Safety Inc. The G1 SCBA has four unused lights on its HUD, and TDA has created a software update for the G1 SCBA that causes one of the lights to blink when a paired Burn Saver alarms. It can also use the Bluetooth signal to communicate with an incident command post via a Motorola Inc. APX model digital radio carried by a firefighter. If a Burn Saver is paired with a Motorola APX radio carried by a firefighter, the radio will transmit the Burn Saver sensor's current temperature and alarm state to the incident commander and display this information on Motorola's personnel accountability software. The display of the personnel accountability software can be seen in Figure 1-2. TDA can program Burn Saver to send an alarm to any Bluetooth enabled device, but there is not a standard for sending alarms over Bluetooth to SCBA HUDs or digital radios. Burn Saver's compatibility is currently limited to the MSA G1 SCBA and Motorola's personnel accountability software.

Figure 1-2 A screenshot of Motorola's Personnel Accountability Software

Picture provided by TDA Research Inc.

2.0 OPERATIONAL FIELD ASSESSMENT DESIGN

2.1 EVENT DESIGN

The OFA venue was the Federal Emergency Management Agency's National Fire Academy (NFA) in Emmitsburg, Maryland. The NFA provided the props and structures necessary to mirror the physical motions and activities that firefighters typically engage in during a real-world response.

During this OFA, five experienced firefighters served as evaluators to assess Burn Saver in simulated field activities using their own standard turnout gear. The evaluators wore the Burn Saver on the SCBA right shoulder strap while participating in eight operational activities adapted from the Candidate Physical Ability Test (CPAT) to provide opportunities to test if the Burn Saver prototype would interfere with the performance of typical firefighter tasks. During two of the activities (search and ceiling breach), the LED light was activated remotely using an app created by the developer. This allowed the evaluators to assess the visibility of the Burn Saver alarms in applicable scenarios without putting them in a high temperature environment. The activities performed are summarized in Table 2-1 and shown in Figures 2-1 through 2-9.

Following the operational activities were two demonstrations of Burn Saver's capabilities that could not be explored during the operational activities. The first demonstration was of the HUD capability; it was conducted in the classroom with the specific brand and SCBA model that is needed for this capability. A Burn Saver unit was connected to an MSA G1 SCBA via Bluetooth and a TDA representative remotely activated the Burn Saver alarm. The evaluators observed the alarm displayed as a flashing light on the HUD in the SCBA facemask.

In the second demonstration, a Burn Saver device was positioned in a burn cell configured with flammable furnishings and a remote-controlled video camera focused on the device's warning light. An NFA instructor conducted a controlled burn that generated smoke and dynamic temperature fluctuations inside a burn room. While standing a safe distance away, the evaluators observed the Burn Saver alarm through the doorway of the burn room and by viewing the video feed. The live burn was repeated by placing the Burn Saver in the doorway of a different burn cell configuration where the evaluators could simultaneously view the Burn Saver and the command post user interface. The HUD and live fire demonstrations are shown in Figure 2-9 and Figure 2-10, respectively.

Table 2-1 Summary of the Operational Field Assessment Activities

Activity	Task
Stair Climb	Ascend and descend a 50-foot staircase.
Hose Drag	Carry a high rise pack 75 feet, turn around and return to the starting point, then drag a 100-foot fire hose by the nozzle 75 feet, make 90-degree turn, and drag another 25 feet.
Forcible Entry	Swing a sledgehammer at a wooden pallet.
Ladder Carry and Raise	Carry a 16-foot extension ladder 20 feet, then raise it against a wall and climb.
Ceiling Breach and Pull *with remote alarm activation*	Use a pike pole to breach the ceiling and walls of a previously burned structure.
Search *with remote alarm activation*	Crawl on hands and knees through a previously burned structure containing debris, soot, and ash.
Rescue	Carry a rescue mannequin 10 feet, make a 90 degree turn, walk 10 feet, then return to starting point.
Command Center	Monitor Motorola's personnel accountability software on a laptop while a burn saver alarm is manually activated.

Figure 2-1 Hose Drag by Nozzle (left) and High Rise Pack (right)

Figure 2-2 Stair Climb

Figure 2-3 Forcible Entry

Figure 2-4 Ladder Carry and Raise

Figure 2-5 Ceiling Breach and Pull

Figure 2-6 Search

Figure 2-7 Rescue

Figure 2-8 Command Center
TDA Representative Explaining the Personnel Accountability Software's User Interface

Figure 2-9 MSA G1 HUD Demonstration

Figure 2-10 Live Burn Demonstration
The Blue LED Alarm (Circled) is Activated

2.2 PARTICIPANTS

Table 2-2 lists the Burn Saver OFA participants.

Table 2-2 Burn Saver OFA Participants

Role	Organization
Evaluator	Montgomery County Fire & Rescue
Evaluator	Fairmount Fire Department
Evaluator	Rockville Fire Department
Evaluator	Colorado Department of Public Safety
Evaluator	Golden Gate Fire Protection District
Subject Matter Expert Observer	International Association of Fire Chiefs
Venue Host and Observers	Federal Emergency Management Agency National Fire Academy
Program Managers and Support Staff	U.S. Department Homeland Security (DHS) Science and Technology Directorate (S&T)
OFA Director and Data Collectors	DHS S&T National Urban Security Technology Laboratory
Technology Developers	TDA Research Inc.
Observers	DHS S&T Communications and Outreach Division (COD)
Photographer/Videographer	DHS S&T COD

2.3 SCOPE

The OFA consisted of four main components:

- **Classroom Presentations and Technology Familiarization:** The OFA began with an introductory session providing the evaluators with overviews of DHS S&T, the Burn Saver OFA Plan, and a site safety briefing. This was followed by an overview of Burn Saver by TDA. The evaluators were then trained on how to use Burn Saver during the operational scenarios.
- **Operational Assessment Scenarios:** After the evaluators gained an understanding of the assessment plan and Burn Saver, they worked in teams of 2 or 3 to perform the operational assessment scenarios described in Table 2-1.
- **Technology Demonstrations:** After the operational assessment scenarios were completed, the HUD alarm capability was demonstrated in the classroom and a live fire demonstration was conducted at the burn range.
- **Evaluator Survey and Discussion:** After each activity, the evaluators answered activity-specific questions read to them by NUSTL data collectors. After all of the activities and demonstrations were completed, each evaluator answered additional survey questions about their overall experience with and impressions of Burn Saver. After the survey was completed, the OFA test director led a group discussion. NUSTL data collectors documented responses and additional comments made by evaluators regarding the prototype and the overall concept of the technology.

2.4 LIMITATIONS

The OFA scenarios did not include live use of SCBA. Evaluators would have to use their own department-issued SCBA facemask at the OFA, but most of the evaluators do not use the SCBA brand and model compatible with the Burn Saver HUD capability. As such, it was not possible to test the HUD during the operational activities. Each evaluator had the opportunity to see a classroom demonstration of the Burn Saver alarm inside an SCBA HUD.

After completing the operational activities, a few of the evaluators commented that the ladder and hose used in the activities were smaller and lighter than those they normally use. The corresponding feedback is described in detail in section 3.1, Motion Restriction during Operational Activities.

3.0 RESULTS

After each operational activity and demonstration, the evaluators were surveyed about the comfort of wearing a Burn Saver prototype, and where applicable, about the visibility of the Burn Saver alarm. After the completion of all of the activities and demonstrations, the evaluators were surveyed on their overall experience with the Burn Saver. For each survey question, the evaluators were asked if they "strongly agree," "agree," "disagree," or "strongly disagree" with the given statement. Their responses are summarized in table format, with the number of evaluators selecting each response shown (from 0 to 5) and additional comments and observations on each topic are discussed in each section.

3.1 Motion Restriction During Operational Activities

All of the evaluators completed all of the OFA activities without the Burn Saver restricting their motion. Table 3-1 shows how the evaluators responded to the survey question "Burn Saver did not restrict my motion or interfere with my ability to complete this activity." While they noted that it was bothersome in some cases, the evaluators believed they could slightly adjust the way they completed these tasks to ensure Burn Saver did not get in the way. For example, during the hose drag activity, one of the evaluators felt the hose snag on the Burn Saver. To avoid this snag, the evaluator carried the hose over their other shoulder to avoid contacting the Burn Saver. While watching the evaluators perform the hose drag activity, the subject matter expert (SME) observer from the International Association of Fire Chiefs noted they saw the hose shift outward during the activity. The SME also observed the high rise pack shifting out and away from the evaluator's body while being carried on the same side as the Burn Saver. A few evaluators also noted the ladder and fire hose used during the OFA were smaller and lighter than those typically used, and heavier, larger equipment may have an increased possibility of getting caught on Burn Saver, potentially breaking it. However, they did not believe that the Burn Saver would physically prevent a firefighter from performing their job activities. The only negative response to the survey came after the completion of the ladder carry and raise activity—an evaluator commented that they responded negatively because they believed a heavier ladder would get caught on the Burn Saver.

Table 3-1 Motion Restriction Survey Results

Survey Statement	Evaluator Responses			
Burn Saver did not restrict my motion or interfere with my ability to complete this activity.	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
Stair climb	5	0	0	0
Hose drag	4	1	0	0
Ladder carry and raise	3	1	1	0
Forcible entry	4	1	0	0
Ceiling breach and pull	4	1	0	0
Search	4	1	0	0
Rescue	5	0	0	0

3.2 Alarm Visibility and Clarity

After each activity or demonstration that included the activation of a Burn Saver alarm, the evaluators were surveyed about the visibility and clarity of the alarm as shown in Table 3-2. Their additional comments about the blue LED alarm, HUD alarm, and the personnel accountability software alarm are summarized in following subsections.

Table 3-2 Alarm Survey Results

Survey Statement	Evaluator Responses			
	Strongly Agree	Agree	Disagree	Strongly Disagree
I was easily able to see Burn Saver's blue LED alarm during the ceiling breach and pull activity.	1	1	0	3
I was easily able to see Burn Saver's blue LED alarm during the search activity.	1	1	1	2
Burn Saver's blue LED would be visible by Burn Saver's wearer or by a partner of the wearer in a smoke filled room.	3	0	0	2
The Burn Saver alarm light on the HUD of the SCBA facemask was clear and easy to notice during the demonstration.	3	2	0	0
The Burn Saver alarm shown on the screen of Motorola's personnel accountability software was clear and easy to notice.	5	0	0	0
The information presented on screen of Motorola's personnel accountability software is enough information for a command center to determine if firefighters need to evacuate.	3	1	1	0

3.2.1 Blue LED Alarm

All of the evaluators reported during the OFA discussion that they did not notice the LED alarm on their own Burn Saver. Additionally, the evaluators believed that wearing an SCBA facemask would obstruct their view of the LED alarm. A TDA representative explained their plan for the blue LED alarm was not for the wearer to view their own LED directly, but rather to see their light reflect off their arm or a surface in front of them, or for them to see their partner's alarm. One of the evaluators believed that moving the LED lower on the front face of Burn Saver or rotating the Burn Saver upside down to change the position of the LED would increase the chances of them seeing the alarm in their peripheral vision.

The two evaluators who responded positively to the survey questions on the alarm's visibility during the ceiling breach and pull and search activities explained they could easily see the alarm on their *partner's* (not their own) Burn Saver; however, they noted they would not be looking at their partner during actual firefighting operations. They described how specific assigned roles would prevent them from seeing their partner's alarm. For example those working on the hose line are facing front-to-back with the nearest firefighter, and the most senior squad that goes inside burning structures without a hose line (and therefore at the greatest risk and would benefit most from burn saver) typically operate with the most autonomy and would need to be able to receive their own alarm.

In such scenarios, the evaluators described a chaotic environment inside a burning building, where intense light from flames and dense smoke may prevent them from being able to see their hand in front of their face; when combined with sounds of burning and collapsing material, firefighters must focus on the threats in front of them. In such a setting, they felt they should not have to change their habits to check for an alarm, and if they have 45 seconds until their facepiece lens fails, the alarm should be able to interrupt everything else. One suggestion made by an evaluator to make the LED alarm more interruptive is to increase the LED blinking speed, similar to a rapid strobe light.

3.2.2 SCBA Facemask HUD Alarm

All of the evaluators believed the alarm light on the SCBA facemask HUD was easier to see than the blue LED on the Burn Saver. Two of the evaluators were concerned the alarm on the HUD was too similar to the other alarms on the HUD. They suggested using a color other than red, yellow, or green because these colors are common on HUDs. The evaluators also suggested increasing the speed at which the alarm light blinked to make the alarm more noticeable.

3.2.3 Personnel Accountability Software Alarm

All of the evaluators agreed the information displayed on the Motorola APX personnel accountability software screen was clear and easy to understand. However, a few of the evaluators commented the audible alarm used by the software was similar to other audible alarms they use, as such they recommended changing the alarms sounds to avoid confusion. As shown in Table 3-2, most of the evaluators were confident in using the information provided on the personnel accountability software display to make decisions, but they also noted they would prefer to have more information displayed in addition to the current temperature and a binary state for the alarm (either alarming or not alarming). One evaluator recommended adding different levels of alarms, such as one to indicate high temperature and another to indicate immediate danger. Other suggestions for additional information to be displayed were the predicted time the firefighter has remaining before the failure of their facepiece lens and the remaining battery life of the Burn Saver.

3.3 Additional First Responder Feedback

After the completion of all of the activities and demonstrations, each evaluator was asked a series of survey questions about their experiences with Burn Saver throughout the OFA. Data collectors recorded the evaluators' responses to the survey questions and feedback provided by the evaluators while responding to the survey questions. The responses to the survey questions are provided in Table 3-3 below, and their additional comments are organized by topic in subsequent subsections.

Table 3-3 Overall Survey Results

Survey Statement	Evaluator Responses			
	Strongly Agree	Agree	Disagree	Strongly Disagree
I was satisfied with the way Burn Saver mounted on the SCBA shoulder strap (i.e., the mount was secure and rugged enough to hold in place during activities).	2	3	0	0
I was satisfied with the size and weight of Burn Saver.	4	1	0	0
I was satisfied with the length of time Burn Saver can function on one AA battery as quoted by the developer.	3	2	0	0
I was satisfied with the process used to replace the battery in Burn Saver.	3	2	0	0
The Burn Saver would not restrict my motion or interfere with my ability to complete my mission.	3	2	0	0
I was satisfied with the visibility of Burn Saver's blue LED alarm.	0	2	1	2
I was easily able to distinguish between the steady blue LED alarm signifying 45 seconds remaining from the blinking blue LED alarm signifying 15 seconds remaining until the SCBA facepiece lens will fail.	0	1	3	1
I was satisfied with the visibility of the Burn Saver alarm on the HUD.	2	3	0	0
I was satisfied with the visibility of the Burn Saver alarm on Motorola's personal accountability software.	5	0	0	0

3.3.1 Burn Saver Attachment

Burn Saver attaches to the SCBA shoulder strap with a standard plastic strap and buckle. The evaluators questioned if exposure to heat would cause the strap to loosen. They also questioned if the buckles would remain sturdy after exposure to heat, or break if the buckle gets snagged. One of the evaluators believed the mount was rugged and secure but the buckle should be made out of metal to prevent it from melting. A TDA representative explained that while wearing Burn Saver, the strap and buckle are behind the SCBA shoulder strap and shielded from the heat, which prevents the condition of the strap and buckle from deteriorating with use.

Additionally, one of the evaluators was concerned about the location on the shoulder strap where Burn Saver is mounted. They believed the Burn Saver could obstruct their view of their instrument gauges.

Figure 3-1 Burn Saver Being Attached to an MSA G1 SCBA Shoulder Strap

One of the evaluators found the Burn Saver SCBA strap attachment to be too wide for the smaller shoulder harness strap of the particular SCBA model used by their department. The TDA representative explained the attachment was based on the MSA G1 SCBA pack and that TDA could modify their attachment for smaller shoulder straps. Figure 3-1 shows how a Burn Saver attaches to an MSA G1 SCBA shoulder strap and displays how the width of the outer case of the Burn Saver is the same with of the G1 SCBA shoulder strap.

3.3.2 Battery Life and Replacement

Burn Saver can operate on one AA battery, which the evaluators found sufficient for operations. They also found Burn Saver's ability to automatically enter sleep mode when not in use to be beneficial as this helps conserve battery life. Burn Saver's LED flashes red when the battery is low; the evaluators found this to be insufficient. They recommended altering the Burn Saver to specify the actual remaining battery life. One evaluator predicted his department's policy would likely be to replace the battery with every use to alleviate this issue.

The evaluators were pleased to learn that replacing the battery was easy; the battery compartment in Burn Saver is sealed by a single screw, which can be removed by a standard flathead screwdriver.

3.3.3 Alarm Timing and Conditions

Four of the five evaluators had trouble distinguishing between the blinking LED alarm (indicating 45 seconds until facepiece lens failure) and the solid LED alarm. Two of the evaluators did not realize that a blinking LED and a solid LED were two different alarms until the live burn demonstration. One of the evaluators could distinguish between the different LED alarms in the beginning of the live burn demonstration, but after the smoke thickened, the evaluator was no longer able to distinguish between the alarms.

The first Burn Saver alarm activates when the Burn Saver algorithm determines that a firefighter has 45 seconds remaining before their facepiece lens begins to fail. The evaluators found this to be an acceptable amount of time for the first alarm. If it was a longer period of time, the evaluators believed they could run the risk of ignoring the alarm to complete their mission. If it were shorter, they believed they might not have enough time to get to safety. One evaluator wanted to see a different alarm for rapidly changing conditions. The evaluator envisioned a situation where a door or window is opened in a burning building, increasing airflow and rapidly creating dangerous conditions. In such a situation, the firefighter may have less time to get to safety than indicated by the Burn Saver. A TDA representative responded that they could update their algorithm to better account for these situations.

According to the SME observer, the National Fire Protection Association standard for SCBA facepiece lenses could change in the near future to require the lenses to be made out of glass instead of polycarbonate. The SME stated that a glass facepiece lens would be able to last longer before showing signs of degradation than their polycarbonate counterparts.

A TDA representative confirmed that TDA could adjust their algorithm to account for improved facepiece lenses. An evaluator noted that an older facepiece lens will degrade faster than current facepiece lenses. A TDA representative explained that they tested a wide variety of different facepiece lenses and designed their alarm algorithm around the facepiece lenses that degraded the fastest. The algorithm could be adjusted to alarm sooner if a fire department was using equipment that would degrade faster than the facepiece lenses tested by TDA.

3.3.4 Ideas for New Alarms

During OFA discussion, the evaluators discussed ideas for new alarms that would be more noticeable than the blue LED on Burn Saver. One of the evaluators recommended attaching a cable to Burn Saver that ran down the SCBA strap and had an LED at the end of it. The evaluator thought this would increase the chance of putting the LED within their field of view. All of the evaluators believed the best location for a visual alarm is on the HUD in their SCBA facemask. The TDA representative explained they are exploring ways to create an attachment that could hang on the side of a SCBA facemask; however, a second component would increase the cost of Burn Saver and there are difficulties making this component compatible with different mask models.

The evaluators also recommended adding an audible alarm, but a TDA representative responded that an audible alarm would require a significantly larger power source, which would not fit within Burn Saver's current casing. TDA has looked into having Burn Saver emit a radio signal that could make any radio produce an alarm sound, but this signal is different for different radio makes and models. One of the evaluators mentioned that an audible alarm coming from a radio would need to be different from the emergency broadcast tone, which is activated by the orange button on the top of most radios. A TDA representative also discussed that some radios cannot emit sound from two different sources. If Burn Saver is emitting an alarm signal at the same time another firefighter is trying to communicate over the radio, the firefighter with the alarming Burn Saver will only hear one of those transmissions.

3.3.5 Effect of Water on Burn Saver

At the end of the live burn demonstration, when the NFA representative started using water to extinguish the fire, the temperature reported by the Burn Saver rapidly dropped. The TDA representative explained that Burn Saver needs to stay dry to accurately report temperature, but humidity will not affect its ability to accurately report temperature. TDA explained that any modification to Burn Saver to shield it from water would also shield it from heat and cause Burn Saver to incorrectly report the temperature. However, the TDA representative did not believe this should be an issue because if the firefighter is close enough to water that it would splash onto the Burn Saver then the firefighter can use the water to protect themselves from the dangerous thermal conditions.

4.0 CONCLUSIONS

All of the evaluators agreed that Burn Saver could become a valuable sensor for firefighters because they believed the use of improved turnout gear has increased thermal protection but has also made it more difficult to sense dangerous thermal conditions. Burn Saver can detect when dangerous thermal conditions will cause a facepiece lens to degrade; however, the evaluators believed that Burn Saver's alarm mechanisms needed improvement. During the OFA activities, the evaluators did not notice the blue LED on the Burn Saver device they were wearing. While in some of the activities they noticed the LED alarm on their partner, they stated that in a live fire environment their duties would not allow them to look at their partner's Burn Saver and therefore they would not be able to observe the blue LED.

Additionally, the evaluators thought the blue LED on the front of Burn Saver would be ineffective while in a fire because it would not be in their line of sight while wearing an SCBA facemask, and the reflection of the blue LED off of walls or other surfaces would be lost in all of the distractions created by a live fire. The ability for Burn Saver to send the alarm to a HUD of an SCBA facemask or to an incident command's personnel accountability software display via digital radio were proposed as viable alternatives. However, this would require a fire department to own the specific SCBA or digital radio model that is compatible with this capability. TDA has explored ways to make Burn Saver compatible with more SCBA facemask HUDs and radios and noted that each make and model has unique characteristics that do not easily allow for the universal integration of Burn Saver.

All of the evaluators believed that a firefighter could wear a Burn Saver device without it physically interfering with their ability to perform their job. They noted that the device was occasionally a minor annoyance while completing the OFA activities, but it did not prevent the evaluators from completing the activities. It was necessary for the evaluators, in some cases, to adjust the manner in which they approached an OFA activity, but it did not prevent them from completing the activity.

5.0 REFERENCES

[1] A. Putorti Jr., A. Mensch, N. Bryner and G. Braga, "Thermal Performance of Self-Contained Breathing Apparatus Facepiece Lenses Exposed to Radiant Heat Flux," National Institute of Standards and Technology, 2013.

[2] DHS S&T Compliance Assurance Program Office, "DHS S&T Regulatory Compliance Assessment: (HSR-18-011) Operational Field Assessment of Burn Saver," 2018.

[3] New England Independent Review Board, "Approval Notification Form, IRB#: 120180228, Operational Field Assessment of Burn Saver," 2018.

[4] DHS Privacy Office, "Privacy Threshold Assessment, Operational Field Assessment of Burn Saver," 2018.