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*Urban Operational Experimentation hosted by the
National Urban Security Technology Laboratory (NUSTL)*

Situational Head Up Display Report

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**Homeland
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Science and Technology

Executive Summary

The National Urban Security Technology Laboratory (NUSTL) conducted an operational experimentation (OpEx) of Avon Protection Systems' Situational Head Up Display (SHUD) on July 30, 2015, at the New York City Police Department's Floyd Bennett Field facility in Brooklyn, New York. Eleven first responders with police, fire or hazmat experience from New York, New Jersey, Virginia, California, Illinois and Maryland participated as evaluators in this experimentation. One Department of Homeland Security (DHS) Science and Technology Directorate (S&T) manager also provided an evaluation of the SHUD.

The SHUD is a micro liquid crystal display (LCD) with magnifying lens for full color widescreen layout that attaches to Avon's face shield, and is powered by a rechargeable lithium ion battery. During the OpEx, it displayed information from an integrated global positioning system (GPS) that provided position and direction information. This technology has the capability to be integrated with additional devices wirelessly to allow other information can be displayed. The device also has the ability to log information displayed into retrievable memory.

The participating responders attended a 30-minute introduction and training presentation on the SHUD that was conducted by an Avon representative. Following the introduction and training, the first responders used the SHUD in a simulated scenario where they viewed the display under three different lighting conditions (interior room lighting, outdoors ambient sunlight and interior darkened room). The Avon representative was also present during the OpEx scenario to give direction as necessary. NUSTL data collectors gathered feedback provided by participants during the entire event and interviewed them following the use of the SHUD. A debrief was held to conclude the experience, discuss the technology and allow participants to provide final feedback.

The feedback on the SHUD was categorized into five topics: information displayed, issues, suggestions, training and summary. With regard to the information displayed, there was a general consensus that the GPS-derived information displayed on the prototype was not useful because it is not typically needed during operations and would not be available for responses in GPS-denied environments that are prevalent in urban settings. The responders proposed 16 types of information that would be useful, and they observed issues with use of the device. It was noted that the desired display information would be dependent on responder specialty and application, so ideally it would be selectable from a set of options. Evaluators encountered challenges upon reading the display under different lighting conditions, due to differences in the wearer's individual eyesight and the small size of the display. Other issues noted were the impact of the SHUD on the user's peripheral vision, proper display of information, proper operation and suspected interference of the SHUD with rifle sights.

The suggested improvements were quite varied and included ways to better display the information, to easily disable and/or remove the SHUD when needed, to add radio communication of information and to design the SHUD to be compatible with other manufacturer's equipment. First responders suggested tests should be conducted at facilities that would provide more operationally realistic conditions, such as smoke chambers, and include operational assessments. Through first responder feedback, this Urban OpEx helped to identify many possible ways the SHUD can be improved to better support their applications.

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1 Introduction

The Situational Head Up Display (SHUD) is a micro liquid crystal display (LCD) with magnifying lens for full color widescreen layout developed by Avon Protection Systems, and it attaches to Avon's face shield. This technology would visually provide essential information to the user, while minimizing the distractions associated with other means of obtaining this information. The hands-free feature of this device has potential benefits in the first responder community.

On July 30, 2015, during the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Urban Operational Experimentation (OpEx) event, hosted by the National Urban Security Technology Laboratory (NUSTL), first responders experimented with the SHUD. New York City Fire Department (FDNY), New York City Emergency Management, New York City Police Department (NYPD), and Port Authority of New York and New Jersey (PANYNJ) subject matter experts selected the technologies and worked with NUSTL scientists to plan the experimentation scenarios and arrange test venues. Eleven first responders from New York, New Jersey, Virginia, California, Illinois and Maryland and one DHS S&T manager experimented with the technologies and provided feedback and observations. Table 1 lists all the technologies included in this event, which were selected with input from local first responder agencies and met capability gaps identified in the Project Responder 4 National Technology Plan for Emergency Response to Catastrophic Incidents (1).

Table 1. Technologies Included in OpEx 2015

Product Name Manufacturer	Description
Situational Head Up Display Avon Protection Systems	Micro LCD display with full color widescreen layout built into face shield
Tridion™-9 PerkinElmer	Portable Gas Chromatography/Mass Spectrometry (GC/MS) system that provides identification of volatile and semi-volatile organic hazards in the field in less than three minutes
BioFlash-E Biological Identifier PathSensors	Portable and rapid aerosol sample collection and identification of up to 16 biological threat agents
Fido B2 IBAC FLIR	Networked array of portable biosensors
Internet of Things for First Responders BAE Systems	Networked sensors that use a long range wireless protocol capable of concrete penetration to send signals through a network aggregator
Knight Robot/HAZPROBE WM Robots	All-terrain robot with a manipulator arm, cameras, and a boring and inspecting device that can drill through walls for bomb tech personnel to inspect suspect abandoned vehicles or objects
RepKnight ADI Technologies	Monitors and analyzes social media with geolocation feature
X-Ray Scanning Rover Smart Imaging Systems	An x-ray scanner integrated into a custom built robot that is designed to rapidly screen suspicious left-behind bags or parcels on the ground

1.1 Purpose

The purpose of the operational experimentation was to consider the suitability of and provide feedback on the SHUD in typical fire, hazmat and tactical police response operations. By bringing together emergency responders and product developers during technology development, design changes can be incorporated early, responders can learn about emerging technologies to enhance mission capabilities, and S&T can gain a better understanding of responder needs and gaps to guide future homeland security investments.

1.2 Objective

This experimentation was designed to allow first responders to experience the use of the SHUD so they could provide feedback and suggestions for the developers, which could enhance the product capabilities and usability for responder operations.

1.3 Responder Capability Need

Project Responder 4 (PR4) describes the need for capabilities that provide multi-sensory communications for situational awareness (1). Devices with these capabilities would include the following features (documented as “Responder Goals” in PR4): integrated into personal protective equipment (PPE); hands-free operation; minimal size, weight and power; ruggedized; waterproof; thermal resistant; intrinsically safe; simple; and not able to be turned off by the user. The SHUD is an emerging technology intended to help address these necessary capabilities in emergency response.

1.4 Prototype Description

The device is a micro LCD display with magnifying lens for full color widescreen layout that attaches to Avon’s face shield. Information displayed on the screen comes from an integrated global positioning system (GPS), which provides position and direction information. In the future, use of this technology could include integration with other devices such as environmental sensors (heat, altitude, and relative humidity), health monitoring sensors (heart rate), equipment (gas detector and self-contained breathing apparatus [SCBA] tank air remaining) and communications. Figure 1 shows the type of information that can be displayed.

During the OpEx, the SHUD was fitted onto Avon’s M53 mask, as seen in Figure 2. The mask can be used with SCBA for firefighter applications or with a variety of filter canisters for particular HAZMAT and law enforcement tactical situations. Bluetooth, Wi-Fi, Near Field Communication (NFC) or radio links are available means for the SHUD to communicate with existing equipment. SHUD is powered by a rechargeable lithium-ion battery. The device has the ability to log information displayed into retrievable memory. Medium- and large-sized masks were available for the OpEx, but only one heads up device was used. The device was quickly (within a couple of minutes) swapped between the two masks by hand (without a need for any tools) as needed to suit each evaluator.



Figure 1 – Image of SHUD Screen

An example of information that can be displayed on the face shield is shown.



Figure 2 – Photograph of Situational Head Up Display Attached to Avon's M53 Mask

The SHUD is the component shown on the right side of the image with the display positioned in the field of view for the wearer's left eye.

2 Experimentation Design

The OpEx Plan for SHUD (2) contains a full description of the experimentation design that was followed for this technology without any significant changes to note. The scenario used in this event was developed with input from New York City first responders and the technology vendor, Avon Protection Systems, so the SHUD could be used in a manner that closely emulated its expected use in a typical operational response.

2.1 Event Design

This event convened a group of first responders experienced with wearing face masks to experiment with this technology under differing light conditions and to provide feedback. The experimentation was conducted inside a room of a trailer and on a small outdoor path (about 15 m) adjacent to the entrance of the trailer. The windows of the trailer were covered with black plastic so the room could be fully darkened with the lights turned off. The responders carried flashlights to illuminate the darkened room. A mask containing the SHUD was placed on participants one at a time, and they each walked through the trailer,

both lighted and darkened, and the outdoor path. Features assessed included attachment to personal protective equipment and use of the SHUD. NUSTL data collectors recorded responder comments during scenario execution, solicited feedback following the use of the system using a questionnaire (see the experimentation plan (2) as a guide) and captured information exchanged in a subsequent group debrief.

2.2 Summary of the Operational Experimentation

This OpEx took place at NYPD's Floyd Bennett Field facility, in Brooklyn, New York, on July 30, 2015. In attendance were first responder representatives from the NYPD, FDNY, Port Authority of New York and New Jersey police, Chesterfield Fire & EMS (Virginia), California Office of Emergency Services, Chicago Fire Department (Illinois) and Rockville Volunteer Fire Department (Maryland).

An Avon representative provided an introduction and brief training for the first responder evaluators and observers in a classroom setting. Following the training, 11 first responders participated in the experiment and wore the SHUD in the scenario (see Figure 3). The vendor representative attached the SHUD to an appropriately sized mask for each user and powered on the device. The first responder participant wore the SHUD while walking under different lighting conditions: through the trailer with lights on; through the trailer with lights off while carrying a flashlight; and outside in ambient daylight. There was a short staircase (with four steps) near the entrance of the trailer that the responder had to navigate while wearing the mask outside. The duration of the experimentation was not timed, but each participant wore the SHUD for a few minutes under each condition. The NUSTL data collectors were present to record comments and other relevant information during the experimentation. Once a responder completed the experimentation, they met with a data collector to discuss the experience and provide feedback.

At the completion of the experimentation, the group reconvened for a debriefing led by the experimentation director. This allowed for more frank discussions of the features of the technology and its potential for incorporation into emergency response. This information was also captured by data collectors and was documented, along with all other information collected prior to this, as described below.



Figure 3 – First Responder Wearing the SHUD Mounted on a Face Mask During the OpEx

3 Results

Feedback from the first responders is summarized in the section below and is provided in tabular form in Appendix A. This information is based on comments made during the OpEx.

3.1 User Feedback

The feedback provided by first responder participants is categorized into five topics: information displayed, issues, suggestions, training and summary. There are some comments that apply to multiple topics, but they are only listed in the most appropriate topic.

3.1.1 Information Displayed

There were many comments about the information that was displayed on the SHUD, as well as desired information that could be included. There was limited information featured on the SHUD; the information included date, time, latitude, longitude, heading and battery life. Nearly all the responders made remarks that the GPS-provided information displayed was of little value or would be unavailable to them in typical operations in an urban setting, especially inside buildings and other GPS-denied locations. One responder mentioned the compass was useful and another the date and time. Several first responders observed the compass heading displayed was for the SHUD and not the direction the wearer was facing. The compass heading displayed should be adjusted to indicate the direction the wearer is headed. The suggestions for information to include in the display are listed in Table 2. There are many possible items to display, and what is desired will likely be highly dependent on the responder's mission. A suggestion was offered that the device be set up to display multiple types of information, but allow the user to select the information and the position on the display from a menu of options.

Table 2. First Responder Suggestions of Information to Include in SHUD Display

Thermal imaging	Night vision	Positional breadcrumbs
Travel directions	Distance into buildings	Uploadable structural diagrams
Entry time	Elapsed time	Exposure time
Air tank pressure	External oxygen value	4-gas levels ¹
External temperature	Passive alarm	Warning indicators
Commands to user		

3.1.2 Issues

Another set of comments addressed the challenges with using the SHUD that were identified during the OpEx. Users found the display was more difficult to read outdoors in bright light than indoors under florescent lighting. One user reported the display was also too bright to read in darkness and noted the display should have an automated dimming feature to adjust the brightness based on the external lighting condition. Another statement made by multiple users was the display was too small and required too much time and concentration to read than would be possible in a tactical situation. There were comments that indicated that when the mask is first put on, the device is distracting; but after a short while, the wearer focuses their eyes better and learns how to use it. Some did not seem to ever get comfortable

¹ 4-gas levels are those displayed on a commonly used detector type that analyzes for the concentrations of oxygen, carbon monoxide, hydrogen sulfide and combustible gasses in the air.

having the device on their mask. One user who has a need for glasses found the display to be blurry. Another wearer had received Lasik surgery previously and found discrepancies between the vision in his two eyes (one “long” eye and one “short”²), which resulted in difficulty reading the display when there was light present and it became unreadable when used in the dark.

Other comments concerned the position of the SHUD on the mask. It was felt that there should be a means to adjust the position of the SHUD, including which side it is on, based on the user’s preference and dominant eye. Several first responders reported the SHUD reduced their peripheral vision. This raised concerns about having this device on during a shooting scenario or when clearing a room of dangerous suspects, where any visual obstruction, including a reduction in peripheral vision, is particularly dangerous. At least one responder felt training with the SHUD would alleviate the issue. One reported it made it more difficult to walk down stairs. The feedback indicates there are some situations where having the SHUD in view, even if powered off, would be an issue because it can obstruct vision; as such, the responders believed it should be able to be completely removed from view or taken off the mask. However, a few of the first responders believed the position of the SHUD was satisfactory and did not think it would interfere with typical operations. There was also a comment that the focal distance should be adjustable to suit individual users. One user reported an edge of the display was cut off. Another responder noted if the mask moved, the display went off alignment. There was a concern pointed out by one responder that the SHUD would interfere with the optics used for sighting with rifles. The SHUD device timed-out during a period when one first responder was wearing it. This was the only noticeable time when the technology was not working as intended during the OpEx.

3.1.3 Suggestions

There were a number of ideas suggested by first responders to make the SHUD more usable that were not already mentioned in the preceding paragraphs. There were comments made that the SHUD would be a more affordable product if the device could be used on a range of masks from different manufacturers or if at least the vendor’s masks could be adaptable to other commonly purchased air supplies. It was suggested that many first responder agencies have made large purchases for air supply equipment from other companies and cannot afford to replace all this gear just for the benefit of having the SHUD.

Several commented on how to display information. In general, it was to simplify the information, make it intuitive and stick to what is necessary (see Table 2 for a list of recommended information to display). One responder recommended adding a grid on the display to make it easier to read. Another said the most important information should appear on the top left, where the battery life is currently displayed. A few first responders thought it would be appropriate to use a flashing feature to emphasize information that is most critical. A couple of responders called for color coding information to indicate levels of importance or response needed rather than displaying values. Comments were made to have a way to shut off the display on demand. This would be to ensure more covertness since the light emitted by the display may be seen by an adversary in darkness, to minimize distractions and fatigue associated with use, or to conserve use for when it is most needed. Responders noted that this should not involve touching the

² “Long” eye and “short” eye mentioned by the wearer refers to long-sightedness and short-sightedness respectively. In this case, the wearer has one long-sighted eye and one short-sighted eye.

mask while being worn since that could compromise the seal.

One comment was made to secure the battery better. The SHUD prototype used during the OpEx had a battery that was tethered and unsecure. This is not the final design, and the vendor indicated they would find a suitable location for the battery. Some responder comments addressed the SHUD's potential support of radio communications. In such a capacity, it could have a panic feature that would send a message to the command. It could also connect to the command and network to other units to share any desired information.

A few first responders made a comment of the need for additional evaluations before they could fully gauge the suitability of the SHUD. One indicated that Floyd Bennet Field was not an appropriate setting to consider the functionality since it limited the type of operational conditions. Another noted they would want the device evaluated under smoke conditions and in actual operations. A third thought the SHUD should be studied for potential effects on binocular vision and depth perception.

3.1.4 Training

First responder training is a key aspect when using any device. Two first responders noted the need for training on the SHUD before the initial use. The training provided during the OpEx was very brief due to time constraints and would certainly need to be expanded upon before fielding the device.

3.1.5 Summary

As can be seen throughout this section, the first responders' comments were quite substantive and varied. There were a couple of comments specifically mentioned that, despite the need for improvement, this is a promising technology, and the vendor is off to a good start. The feedback provided by first responders provided many possible ways the SHUD can be improved to better support first responder applications.

2 Citations and Bibliography

1. **U.S. Department of Homeland Security.** [*Project Responder 4- 2014 National Technology Plan for Emergency Response to Catastrophic Incident. DHS Science and Technology*](#), July 2014.
2. **NUSTL.** *Urban Operational Experimentation Plan Situational Head Up Display*, OpEx-T-PL-4. July, 2015.

3 Acronym List

DHS	-	Department of Homeland Security
FRRG	-	First Responder Resource Group
GPS	-	Global Positioning System
NFC	-	Near Field Communication
OpEx	-	Operational Experimentation
PPE	-	Personal Protective Equipment
PR4	-	Project Responder 4 (Cited Report)
R-Tech	-	First Responders Technology Program
S&T	-	Science and Technology Directorate
SCBA	-	Self-Contained Breathing Apparatus
SHUD	-	Situational Head Up Display

Appendix

Table A-1 summarizes first responders' feedback on the Urban OpEx with the SHUD, with comments grouped by the most appropriate topic.

Table A-1 Consolidated Data Collection Notes

Topic	Responder Comments
Information Displayed	<ul style="list-style-type: none"> • GPS-provided information displayed was of little value or would be unavailable in typical operations in an urban setting: <ul style="list-style-type: none"> ◦ Inside buildings and other GPS-denied locations. ◦ One responder mentioned the compass and another the date and time was useful. • Observed compass heading was based on the orientation of the SHUD and not on the direction the wearer faced. <ul style="list-style-type: none"> ◦ Noted SHUD should correctly indicate direction the wearer is headed. • Suggestions for information to display: thermal imaging, night vision, positional breadcrumbs, travel directions, distance into buildings, uploadable structural diagrams, entry time, elapsed time, exposure time, air tank pressure, external oxygen level, 4-gas levels³, external temperature, passive alarms, warning indicators and commands to user. <ul style="list-style-type: none"> ◦ Recommend user selectable option of information to display and position on display.
Issues	<ul style="list-style-type: none"> • Display more difficult to read outdoors in bright light than indoors under florescent lighting. • Display too bright to read in darkness for one user. <ul style="list-style-type: none"> ◦ Noted SHUD should have an automated dimming feature to adjust the brightness based on the external lighting condition. • Display too small and requires too much time and concentration to read than would be possible in a tactical situation. • SHUD is initially distracting: <ul style="list-style-type: none"> ◦ After a short while, the wearer focuses their eyes better and learns how to use it. ◦ Some users did not seem to get comfortable having the SHUD on their mask. • User with a need for glasses found the display to be blurry. • User that had Lasik surgery found discrepancies between the vision in his two eyes (one "long" eye and one "short") caused difficulty reading the display when there was light present, and it became unreadable when used in the dark. • Felt display should be able to be moved to either side of the mask and have a means to adjust its position based on the user's preference and dominant eye. • Recommended SHUD have adjustable focal distance to suit an individual user. • SHUD reduced peripheral vision-- noted by several first responders. <ul style="list-style-type: none"> ◦ Concerns about having SHUD on mask in a shooting scenario where any visual obstruction, including peripheral, is particularly dangerous. ◦ One responder felt that training with the SHUD could alleviate issue. • Reported as more difficult to walk down stairs with SHUD on by one user.

³ 4-gas levels are those displayed on a commonly used detector type that analyzes for the concentrations of oxygen, carbon monoxide, hydrogen sulfide and combustible gasses in the air.

Topic	Responder Comments
	<ul style="list-style-type: none"> • Many responders recommend the SHUD be removable for situations where complete field of view is necessary. <ul style="list-style-type: none"> ◦ Some first responders believed the position of the display was sufficient and did not think it would interfere with typical operations. • Edge of the display cut off for one user. • Movement of mask causes display to go out of alignment, as reported by one user. • SHUD would interfere with rifle sighting optics indicated by one user. • The SHUD device timed-out once: <ul style="list-style-type: none"> ◦ Only noticeable time when the technology did not working as intended.
Suggestions	<ul style="list-style-type: none"> • Simplify the information displayed, make it intuitive and stick to that which is necessary. • Add a grid on the display to make it easier to read, as suggested by one user. • Most important information should appear on the top left rather than battery life, as suggested by one user. • Use flashing feature to alert on most critical information, as recommended by a few first responders. • Color coding of information rather than displaying values, as suggested by a couple of the users. • Add way to shut off the display on demand. <ul style="list-style-type: none"> ◦ Ensures a more covert action since the light emitted by the display may be seen by an adversary in darkness. ◦ Minimize distractions and fatigue associated with use. ◦ Conserve use for when it is most needed. ◦ Should not involve touching mask while being worn since that could compromise the seal. • Secure the battery better, as noted by one user. <ul style="list-style-type: none"> ◦ SHUD prototype has a tethered battery. ◦ Vendor mentioned they will find a suitable location for the battery. • Radio communications application, as suggested by first responders. <ul style="list-style-type: none"> ◦ Panic feature that would send a message to command. ◦ Connect to command and other units to share information. • Make the SHUD compatible with other manufacturer's masks and products. <ul style="list-style-type: none"> ◦ Impacts affordability, since many agencies will have large purchases of other masks and products. • Perform additional evaluations and formal testing. <ul style="list-style-type: none"> ◦ Floyd Bennet Field was not an appropriate setting to consider the functionality, since it limited the type of operational conditions, as noted by one first responder. ◦ Evaluate under smoke conditions and in actual operations. ◦ Study SHUD for potential effects on binocular vision and depth perception.
Training	<ul style="list-style-type: none"> • Need for training on the SHUD before the initial use, as noted by two users. <ul style="list-style-type: none"> ◦ Training during the OpEx was very brief due to time constraints of the event. ◦ Needs to be incorporated before fielding the device.
Summary	<ul style="list-style-type: none"> • SHUD is a promising technology, and vendor is off to a good start, as noted by a couple of first responders.