Gunshot Detection System

Operational Field Assessment Report

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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, local, tribal and territorial first responders to address the homeland security mission. The laboratory provides first responders with services, products, and tools necessary 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. The goal is to advance technologies that address mission capability gaps in a rapid time frame, and then promote 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) or technical demonstration of the technology's capabilities and operational suitability to verify and document that project goals were achieved.

NUSTL's publicly released reports are available at www.dhs.gov/publications. Reports deemed sensitive are available on a case-by-case basis and can be requested by contacting NUSTL@hq.dhs.gov.

Visit the DHS S&T website, www.dhs.gov/science-and-technology/first-responder-capability-rd-program-fact-sheets, 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

The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) funded the research and development of a portable outdoor Gunshot Detection System (GDS) with the intention of improving emergency response time and identifying shooter locations. The GDS consists of Guardian outdoor gunshot detection sensors and Guardian Gateway (GW) and situational awareness (SA) applications.

DHS S&T's National Urban Security Technology Laboratory (NUSTL) conducted an Operational Field Assessment (OFA) of the GDS on November 8, 2022, at the Joint Base McGuire-Dix-Lakehurst in New Jersey. Six law enforcement officers from Iowa, New Hampshire, and New York served as evaluators of the GSD. These law enforcement officers participated in operational activities including setting up the outdoor sensors, overlaying maps and sensors using the situational awareness software, observing gunshot detection notifications on a PC and mobile device, and participating in a debrief with NUSTL to gather feedback.

During the OFA, the evaluators were instructed on how to set up the situational awareness interface, how to connect mobile devices and emails to the situational awareness interface, and how to mount and unmount the outdoor sensors. After the familiarization session, evaluators mounted the sensors in the designated locations and returned to the conference room to monitor the situational awareness interface, while a range safety officer and the officer in charge fired weapons to activate the sensors.

The evaluators' consensus was that the GDS would meet their operational needs. Evaluators were satisfied overall with the capabilities, portability, usability and interoperability of the GDS. Evaluators agreed that the system met detection capability requirements and that its setup was intuitive and easy to install. A majority of the evaluators, however, gave neutral ratings to the system's ability to integrate computer-aided dispatch (CAD) drawings, as they found uploading, cutting, pasting, resizing and moving images to be cumbersome. All six evaluators found the gunshot detection sensors accurately detected single and multiple shots and did not indicate a false alert during the false alert test when balloons, a nail gun and a musical clapper were used to try to trigger an alert. Evaluators also offered feedback for enhancing the system, including:

- Adding a strap or handle to the bottom of the sensor to assist with stabilizing the sensor during the installation process
- Offering color options for the sensor to enable/ its blending into environments
- Adding distinct audible alert to indicate when multiple shots are detected

Additionally, throughout the false alert test, evaluators suggested that future false alert testing include fireworks, as evaluators expressed difficulties with differentiating between fireworks and gunshots.

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1.0 INTRODUCTION

When a shooting occurs, first responders generally rely on a nearby person to call 911 and notify them of the incident. However, calls may be delayed, and information shared with dispatchers may not be accurate—common issues in school shootings and in areas of extreme gun violence. Further, in active shooter situations that develop at concerts, parades, concert venues and malls, first responders have indicated that they do not have situational awareness tools to help detect an active shooter due to the location of the event, size of the venue and/or the number of attendees. Responders need a portable, intuitive technology that can be set up quickly and alert them of shooting incidents instantaneously, provide them critical information ahead of their on-scene arrival, such as the number of rounds fired, the number of active shooters, or the type of weapons used (e.g., semi-automatic, automatic, handgun), and record evidence that is usable in court.

Because these capabilities could improve the safety and effectiveness of responders to gun violence incidents, the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) funded Shooter Detection Systems (SDS) to develop a gunshot detection system (GDS) that will alert responders of a shooting incident in real time, provide critical situational information, and record evidence. The objective of the technology is to allow law enforcement officers to respond to shooter incidents quickly, approach the scene with greater awareness, and use recorded data for the apprehension and conviction of suspects. Deploying mobile gunshot detection systems can enable law enforcement to be more responsive to criminal activity and improve their ability to prevent violent criminal activity in high-risk areas. This research effort is being managed by DHS S&T's Office of Mission and Capability Support (MCS).

On November 8, 2022, the National Urban Security Technology Laboratory (NUSTL) conducted an operational field assessment (OFA) to evaluate the portability, interoperability, capability, and usability of the gunshot detection system. Six law enforcement officers from Iowa, New Hampshire, and New York served as evaluators and performed various job-related tasks including system setup and using a SA application also developed by SDS.

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 GDS's capacity to alert responders of a shooting incident in real-time, provide critical situational information and record evidence.

1.2 OBJECTIVE

The OFA evaluated the gunshot detection system against performance objectives pertaining to:

- Portability: System can be transported by only two law enforcement officers and set up in any location.
- Interoperability: System can be integrated with currently existing CAD drawings, blueprints, and geographic information system (GIS) databases used by first responders and must have internet-enabled communication.

- Capability: System can provide accurate notifications and real-time alerts of active shooter detections and also provides flexible power sources and data paths.
- Usability: Sensors can be used in multiple locations where an active shooter scenario may occur and the situational application's setting can be customized as appropriate.

1.3 REQUIREMENTS

Table 1-1 lists the requirements the GDS was expected to meet and the test procedures conducted to evaluate whether the technology meets them. These requirements are from the Needs Notification Form [1] developed by the MCS project manager. Numbers that appear in parentheses in the requirement descriptions represent the requirement's number as listed in the Needs Notification Form. While the table specifies which test method(s) were used to assess a specific given requirement, the individual tests were staged within the context of the NUSTL OFA team's broader data collection and analysis methodology. NUSTL data collectors observed evaluators using the gunshot detection prototypes and collected feedback throughout the simulated scenarios as well as during the end-of-day debriefing.

Table 1-1 Gunshot Detection System Requirements and Activities Matrix

Objective	Requirement (with publication cited)	Test Method
Portability	The proposed solution must have the ability to be moved from location to location by not more than two law enforcement (LE) officers (1)	Evaluators will be timed while setting up the outdoor sensors system at a specified location. One team of evaluators, up to four, will work together during the setup process. Evaluators will be timed while breaking down the system of outdoor sensors at the end of the testing day.
Interoperability	The software and hardware must be able to integrate with existing computer-aided design (CAD) formats (i.e., .dfx and .dwg) and geographic information systems (GIS) (e.g., .shp and geodatabase) utilized by first responders (2)	Evaluators will be asked to integrate existing CAD drawings of the site's buildings, blueprints and GIS shape files into the software. Evaluators will verify that the alerts received overlayed on the drawing and the GIS shape file.
Interoperability	Internet-enabled communication (3)	Evaluators will test the internet connection via wired Ethernet and cellular network (as available).
Interoperability	Outputs of the data must be easily transferable to a mobile device wirelessly in a degraded (or unavailable) internet area via cellular network (4)	Evaluators will be asked to disconnect from wired Ethernet and demonstrate data being transferred via LTE. Data transfer will be demonstrated by "heartbeats" being received from the sensor and the sensor appearing as online within the SA application. The sensor may appear offline in the SA during the network transition but will recover after connecting to the cellular network. Evaluators will then observe if notifications and/or alerts were received. Data collectors will track latency (e.g., for a large file, track if there is significant latency or failure)
Capability	The system must be able to receive and download updates automatically (5)	Feature is not available.

Objective	Requirement (with publication cited)	Test Method
Capability	Provide alerts with a prescribed set of user-defined parameters and triggers (6)	Evaluators will be asked to use the Guardian Gateway (GW) and SA applications to become familiar with the interface and practice customizing settings and parameters as appropriate.
Capability	Ability to transmit alerts and location data in real time (8)	Evaluators will verify that they received alerts after every round fired. Data collectors will quantify the accuracy and latency between the alerts and shots fired. Data collectors will annotate the time of the gunshot heard vs. the alert received by using an Excel file (or another tool) to track latency. Evaluators will also test alerts data based on false alert testing. Different devices and events will be used to create gunshot-like sounds, such as banging noises, balloons popping or nail guns.
Usability	Fault or power failure notification (9)	Evaluators will perform the Communication Failover test by disconnecting the Power over Ethernet (PoE) switch from the external network and then recording the time it takes for the system to switch to an LTE connection. The evaluators will be asked to verify that the sensor returns to an online status and shows "LTE" as the connection alert in the GW application. Evaluators will perform the Power and Battery Failover test by disabling the PoE on the sensor port of the PoE+ managed switch. The evaluators will then witness if the system remains powered by the back-up battery and stays connected to the SA application via the Ethernet connection. Evaluators will record the time it takes for the SA to send out a warning that the sensor is on battery power.
Usability	Battery backup, if hardwired (10)	The backup battery will be tested as part of the Power Failover Test described under the fault or power notification requirement.
Capability	Ability to alert on multiple types of gunshots (11)	Safety officers from Joint Base McGuire-Dix-Lakehurst will use two types of weapons—handguns and long guns of various calibers—to fire shots. Evaluators will observe if they receive an alert on the situational application. Safety officers from Fort Dix will fire multiple weapons at the same time from the same location. Evaluators will observe if they receive an alert for all of the rounds fired. Safety officers from Fort Dix will fire multiple rounds at the same time from different locations. Evaluators will observe if they receive an alert for all of the rounds fired. For all scenarios, data collectors will track the latency between the time a shot was fired and the time an alert was received as well as from which firing location the alert was received.
Capability	Permanent record of activation (12)	Evaluator will retrieve the SA shot log from the test computer. Data analysis will be performed by the evaluators after testing is complete. The data output will be evaluated to determine the performance of the outdoor gunshot detection prototype.

1.4 SYSTEM DESCRIPTION

One prototype of the outdoor gunshot detection system was tested at the OFA. The system is comprised of infrared and acoustic sensors (Figure 1-1), and accompanied by a personal computer (PC) with the GW and SA applications installed, an associated Wi-Fi access point, and technical guides and training materials. Each sensor detects wirelessly within a maximum outdoor range of 145 feet. Each system utilizes 10/100 Ethernet or an LTE-M cellular network to communicate “heartbeat” messages and shot alerts and to log downloads. A heartbeat message, which assures those monitoring the system that the sensor is still functional, is sent every 30 seconds. Example alerts on a computer screen and a mobile device are shown in Figure 1-2; alerts can also appear within computer-aided dispatch and interoperability systems among other types.

Figure 1-1 Outdoor sensor equipped with a set of infrared sensors as well as a set of acoustic sensors positioned just below
Image credit: Shooter Detection Systems

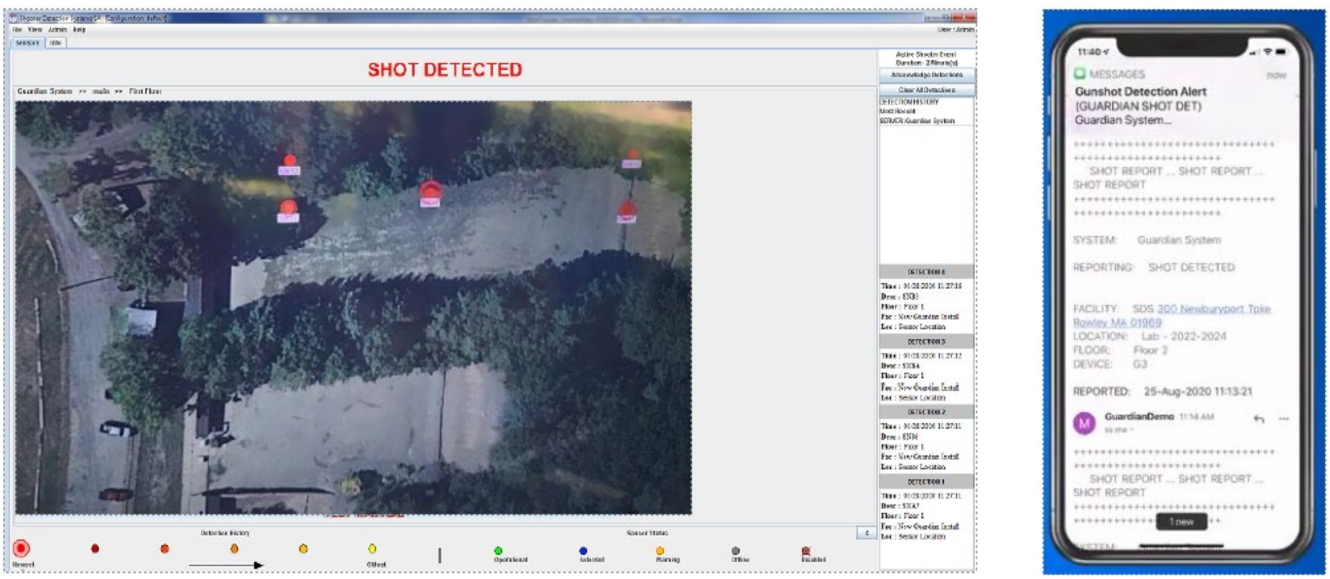

Figure 1-2 Shot detected alerts via PC (left) and mobile device (right)
Image credit: Shooter Detection Systems

The system’s dual-mode (infrared and acoustic) sensors can distinguish between low and high caliber rounds and subsonic rounds. The GDS sensors can be mounted on a ladder or on a wall or ceiling by using a ¼ inch-20 threaded post with an angle bracket adapter. The GDS sensors can also be attached to poles and/or small trees through a banning mechanism. The systems also have GPS capability and offers expanded data recording and storage capabilities.

The primary power source of the sensor is a Power over Ethernet switch (PoE+), a technology that delivers data and power to devices. However, each system can also be powered by a 12-volt battery pack or an external direct current (DC) power source of 12VDC. The battery pack may operate as a primary or a redundant power source.

2.0 OPERATIONAL FIELD ASSESSMENT DESIGN

2.1 EVENT DETAILS

This OFA was designed as a one-day event bringing together six law enforcement personnel, to set up the gunshot detection sensors and use the situational awareness tool, in simulated operational field scenarios to provide feedback. The evaluators were encouraged to test the system usability based on their field experiences and typical or expected operations.

The test venue was the Joint Base McGuire-Dix-Lakehurst in Pemberton, New Jersey. Operational scenarios were set up in two outdoor ranges, where the sensors were set up by the six evaluators. The situational awareness tool was set up within a building on the range. The U.S. Army Combat Capabilities Development Command (DEVCOM) provided ammunition as well as a Range Safety Officer (RSO) and an Officer in Charge (OIC) to ensure the safety of all participants and observers.

2.2 PARTICIPANTS

Six law enforcement personnel from Iowa, New Hampshire, and New York served as evaluators to test and provide feedback on the gunshot detection system. Table 2-1 lists the evaluators and other OFA participants by their roles and organizational affiliations.

Table 2-1 Participants

Role	Organization
Evaluator	New York City Police Department
Evaluator	New York City Police Department
Evaluator	Schenectady Police Department (NY)
Evaluator	Story County Sheriff's Office (IA)
Evaluator	Troy Police Department (NY)
Evaluator	University of New Hampshire
Program Manager	DHS S&T MCS
OFA Director and Data Collectors	DHS NUSTL
OIC	The 254th Regiment, New Jersey National Guard
RSO	The 254th Regiment, New Jersey National Guard
Technology Developer	Shooter Detection Systems, LLC
DHS Observers	S&T MCS, S&T Test and Evaluation Division
Venue Host	U.S. Army
Venue Coordinator	DEVCOM

2.3 SCOPE AND LIMITATIONS

The assessment consisted of four scenarios that incorporated different tasks to test if the GDS met its objectives requirements (summarized in Table 2-2).[1]

Evaluators worked as teams throughout the OFA, and each team of evaluators was paired with a NUSTL data collector. While evaluators conducted the OFA test activities, data collectors recorded their observations and candid comments. Data collectors also administered a questionnaire after each activity station to elicit evaluator feedback on the GDS.

Table 2-2 Summary of Activities Performed During the OFA

Activity	Locations	Task
Developer Presentation	Conference Room	Overview of system design and operation

[1] NUSTL's Gunshot Detection System OFA Test Plan contains the complete details of the OFA design.

Activity	Locations	Task
GW and SA Application Configuration	Conference Room	System setup, integration of CAD and GIS files, internet communication, GW and SA applications customization
Timed Sensor Setup and Breakdown Activity	Outdoor Range (Lanes 1 and 2)	Conduct a timed sensor setup and breakdown by two evaluators or less
Timed Sensor Setup and Breakdown at Second Location	Outdoor Range (Lanes 2 and 3)	Conduct a timed sensor setup and breakdown by two evaluators or less
Outdoor Gunshot Test and False Alert Test	Outdoor range (OIC, RSO, NUSTL delegate) and Conference room	Single shot test, rapid fire test, multi-shot test, false alert test
Communication Failover/Power Failover/Battery Test	Conference Room and Outdoor Range	Communication failover, power failover, battery test
Detection Performance Analysis	Conference Room and Outdoor Range	Correct detection, detection position accuracy, time to detect
Group Discussion and Wrap Up	Conference Room	Gather overall feedback from evaluators

The OFA began in a conference room, where a representative of SDS presented the gunshot detection system, covering the system's design and basic operation as well as training the evaluators to use the GW and SA software. After those introductory presentations, a group of evaluators performed a timed setup of the outdoor sensors at a specified location. This included affixing a sensor atop a 12-foot-tall ladder at each of three locations: up range, mid-range and down range. Meanwhile in the conference room, another group of evaluators began to integrate existing CAD drawings of the site's building blueprints and GIS shape files. The evaluators working indoors then tested the internet connection via wired Ethernet and started to use the SA application to become familiar with the interface. They practiced customizing settings as appropriate for the gunshot detection evaluation as well as configuring other customizable parameters.

The RSO and OIC then executed live fire exercises in various locations on the outdoor range and in different directions relative to the sensor system. Weapons of diverse caliber were used for each exercise.

During the live fire testing, one designated NUSTL team member remained outdoors near the live fire with the RSO and OIC. This NUSTL team member documented the times and the number of shots fired. All evaluators, other NUSTL data collectors, and observers remained inside the conference room to monitor the SA application.

During the first activity, the single shot test, the OIC fired one round within the 145-foot detection radius of each sensor. Evaluators then determined if the alerts were received, and if the sensors marked the gunshots within the SA application in the order that they were fired.

For the second activity, the rapid-fire test, the OIC fired multiple rounds within the 145-foot detection radius of each sensor. The evaluators then determined if the alerts were received, and if the sensors marked the gunshots within the SA application in the order that they were fired.

For the third activity, the multi-shot test, the OIC was located near the first sensor and the RSO was located near the second sensor. Both the OIC and the RSO fired from their designated positions at the same time. The evaluators determined if the alerts were received, and if the correct sensors were indicated in/by the SA application.

For the final activity, false alert testing, the OIC used a variety of tools to trigger possible false alarms. The OIC used a clapper, popping balloons, a nail gun and a starter pistol to trigger the sensors. The evaluators determined if false alerts were received on the SA application for any of the items used.

At the end of the outdoor gunshot detection exercises SDS provided a log of all detections, including range direction information, to the NUSTL team for post-test data analysis.

After the outdoor gunshot detection tests were completed, the evaluator and/or NUSTL data collector performed the communication failover test by disconnecting the PoE+ switch from the external network and then recording the time it took for the system to switch to an LTE connection. The evaluators were asked to verify that the sensor returned to an online status and showed "LTE" as the connection alert in the GW application.

The evaluator and/or NUSTL data collector performed the Power and Battery Failover test by disabling the PoE power on the sensor port of the PoE+ managed switch. The evaluators witnessed if the system remained powered by the back-up battery and stayed connected to the SA application via the Ethernet connection. Evaluators recorded the time it took for the SA to send out a warning that the sensor was on battery power.

Data analysis was performed by the evaluators after testing was complete. The data output was evaluated to determine the performance of the outdoor gunshot detection prototype. Data transfer was tested by sending the data via wired Ethernet and over a cellular network. NUSTL data collectors tracked the latency of the data transfer for each collection method.

2.4 DEVIATIONS FROM THE TEST PLAN

The OFA was conducted with six evaluators, instead of the eight identified in the OFA plan [5]. This did not impact the OFA's test activities' design.

Due to the remote location of the test site, cellular coverage was limited. This resulted in the inability of the Guardian outdoor gunshot detection sensors to communicate with the GW and SA applications over LTE-M.[2]

As such, a deployable network was setup by NUSTL which allowed the sensors to communicate via Wi-Fi in order to successfully execute the OFA. Near the end of the OFA, an attempt was made to transition from Wi-Fi to LTE-M to assess the communication failover capability of the system. No transmissions of data occurred via LTE-M.

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[2] "LTE-M" is a type of LTE technology that focuses on Machine-to-Machine communication." This category of LTE is "a low power wide area technology which supports IoT through lower device complexity and provides extended coverage, while allowing the reuse of the LTE installed base." GSMA. "Internet of Things: Long Term Evolution for Machines: LTE-M," www.gsma.com/iot/long-term-evolution-machine-type-communication-lte-mtc-cat-m1/.

DEVCOM had ammunition remaining following the completion of planned operational activities, so NUSTL polled the evaluators for additional scenarios that would be beneficial to assessing the technology. As a result, the OFA also included a "multiple shooters, rapid fire scenario" in which two shooters positioned themselves at approximately 145 feet from the sensors in each of their lanes and moved simultaneously down the lane while rapidly firing their assigned weapons (an M9 pistol and M16 rifle) at the same time while moving towards and beyond the sensors. The scenario ended when both shooters reached the base of the ladder where the sensors were mounted, having fired approximately one magazine per weapon (approximately 15 rounds from the M9 and 30 rounds from the M16). This scenario was repeated two more times (three iterations total).

Evaluators did not break down and package the sensors at the end of the operational activities. Based on the ease of deployment and installation, they determined this was not necessary.

3.0 RESULTS

This section contains feedback from the evaluators' questionnaires and group discussions. Questionnaire responses related directly to the portability, interoperability, capability, and usability requirements listed in Table 1-3. The group discussion allowed evaluators to provide generalized feedback on the sensors as well as the situational awareness platform and to elaborate on any feedback given in the questionnaire.

3.1 PORTABILITY REQUIREMENTS

All evaluators found the sensors easily transportable by one or two people, noting that they were lightweight and could be carried singlehandedly (Figure 3-1). Additionally, all evaluators found the transportation case sufficient for their operational needs. Evaluators suggested that a durable padded case should come standard but that SDS might also offer an additional deployable option, such as a backpack, to assist with mobility and installation in small spaces or where multiple flights of stairs may be encountered.

Figure 3-1 Evaluators transporting sensors for installation

3.2 INTEROPERABILITY REQUIREMENTS

Figure 3-2 lists responses regarding interoperability from the questionnaire that NUSTL administered during the OFA. The subsections that follow provide a summary of specific feedback given during the interoperability test activities of the OFA.

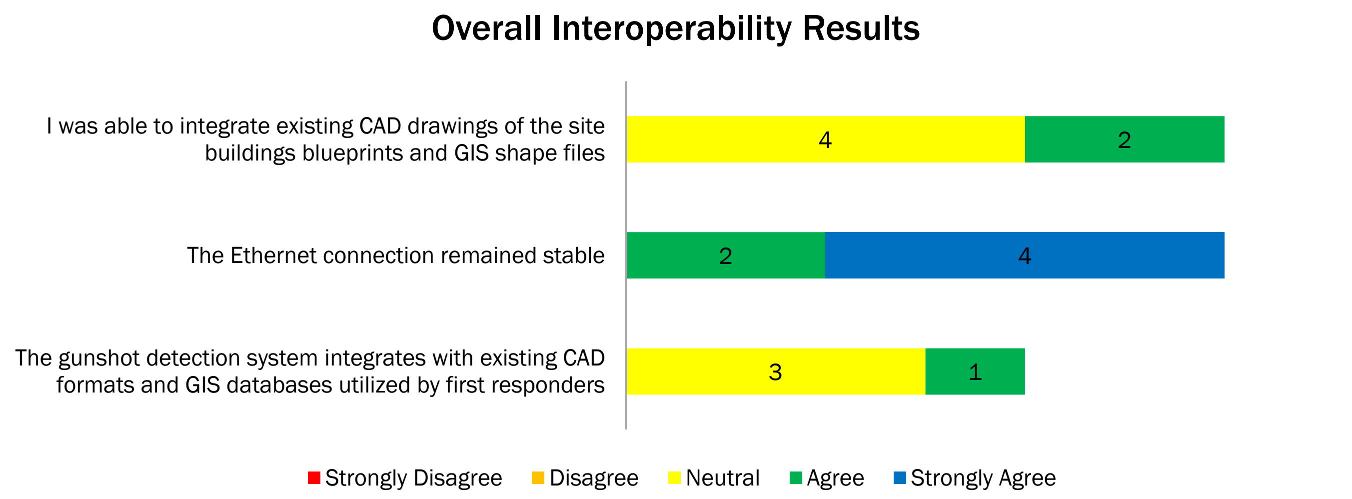

Figure 3-2 OFA Questionnaire Results: Overall Interoperability

3.2.1 CAD DRAWINGS INTEGRATION

Two evaluators agreed that they were able to integrate existing CAD drawings of the site building's blueprints and GIS shape files with relative ease. Four were neutral, one of whom noted that integration depended on the user's previous knowledge and skills related to computer mapping. Evaluators stated that the integration of CAD drawings and file manipulation was cumbersome as it required cutting, pasting, resizing and moving images from screen to screen. Two evaluators expressed concern about the amount of time this would take in a situation when time is of the essence. Evaluators recommended that the developer incorporate automatic map updates for situations when the shooters are in continuous movement and that they add automatic map resizing capabilities to the system.

When asked if the gunshot detection system integrates with existing CAD formats and GIS databases utilized by first responders, all evaluators were neutral as this was not explored or demonstrated during the OFA, although the developer indicated that integration is possible.

3.2.2 ETHERNET STABILITY

The Ethernet connection remained stable throughout testing. One evaluator recommended a direct Ethernet wired connection be incorporated to prevent overload. LTE was not tested due to the remote nature testing location, but four evaluators said having an LTE connection is desirable.

3.3 CAPABILITY REQUIREMENTS

Figure 3-3 lists responses related to the overall system capability from the questionnaire that was administered during the OFA. The subsections that follow provide a summary of specific feedback given during the OFA.

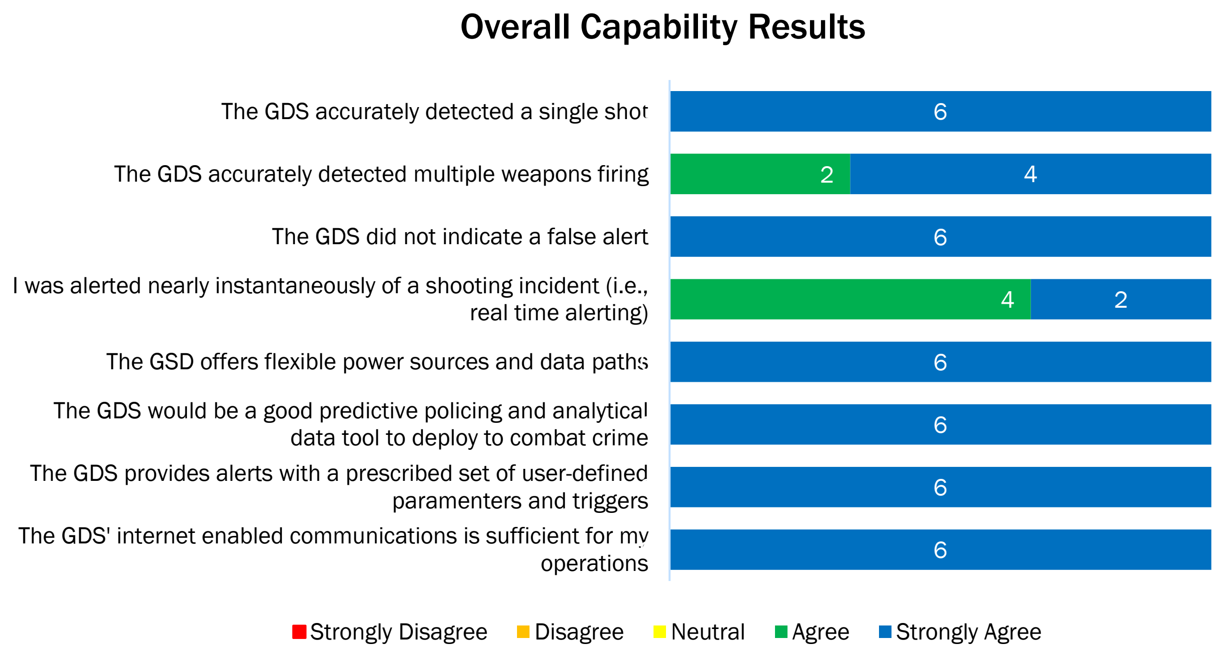

Figure 3-4 OFA Questionnaire Results: Overall Capability

3.3.1 ACCURATE DETECTION

Members of the 254th Regiment, New Jersey National Guard fired M9 pistols and M16 rifles from predetermined locations to test the detection capabilities (Figure 3-4). All evaluators strongly agreed that the GDS accurately detected a single shot. When asked about the accurate detection of multiple weapons firing, four evaluators strongly agreed and two agreed. Evaluators noted that accurate detection of multiple weapons being fired is crucial for response operations.

Figure 3-3 Members of the 254th Regiment, New Jersey National Guard firing weapons while approaching a sensor

3.3.2 FALSE ALERTS

At the conclusion of live firing, false alert testing was conducted with balloons, a nail gun and a musical clapper, as described in Section 2.1 (Figure 3-5). There were no instances of false alerts detected by the system. Evaluators requested that additional false detection testing be conducted by the developer with fireworks and car backfires, as the ability for the system to distinguish between them and gunshots in environments such as civil unrest would be beneficial to law enforcement operations.

Figure 3-5 A representative from SDS using a nail gun during false alert testing

3.3.3 REAL-TIME ALERTING

All evaluators either agreed or strongly agreed that the GDS detected a single shot in real-time. Two evaluators who agreed noted a delay of approximately four to five seconds but explained that it was still faster than waiting for a 911 call and would be sufficient for their operational needs. Alerting is depicted by color-coding and haloing around the sensors on the SA platform (Figure 3-6). The red ring around SN16 (lower left) is a real-time detection and the red circle for SN15 (lower right) is a previous detection. The yellow circle for SN17 indicates that it is the oldest detection of the three. (A full key to the variety of icons used by the SA platform appears in Section 3.4.3 as Figure 3-8.)

Figure 3-6 An image of the user interface for the SA platform displaying detected gunshots

3.3.4 ANALYTICAL DATA TOOL

All evaluators strongly agreed that the GDS would be a good predictive policing and analytical tool for their use cases. Two evaluators noted a use case for this system could be predictive policing or monitoring based on history of activities detected. Two evaluators noted that the system could assist with validating actual shootings, as opposed to fireworks or vehicles backfiring.

3.4 USABILITY REQUIREMENTS

Figure 3-7 lists responses related to usability from the questionnaire that was administered during the OFA. The following subsections provide a summary of specific feedback given during the OFA with respect to the usability requirements listed in Table 1-1.

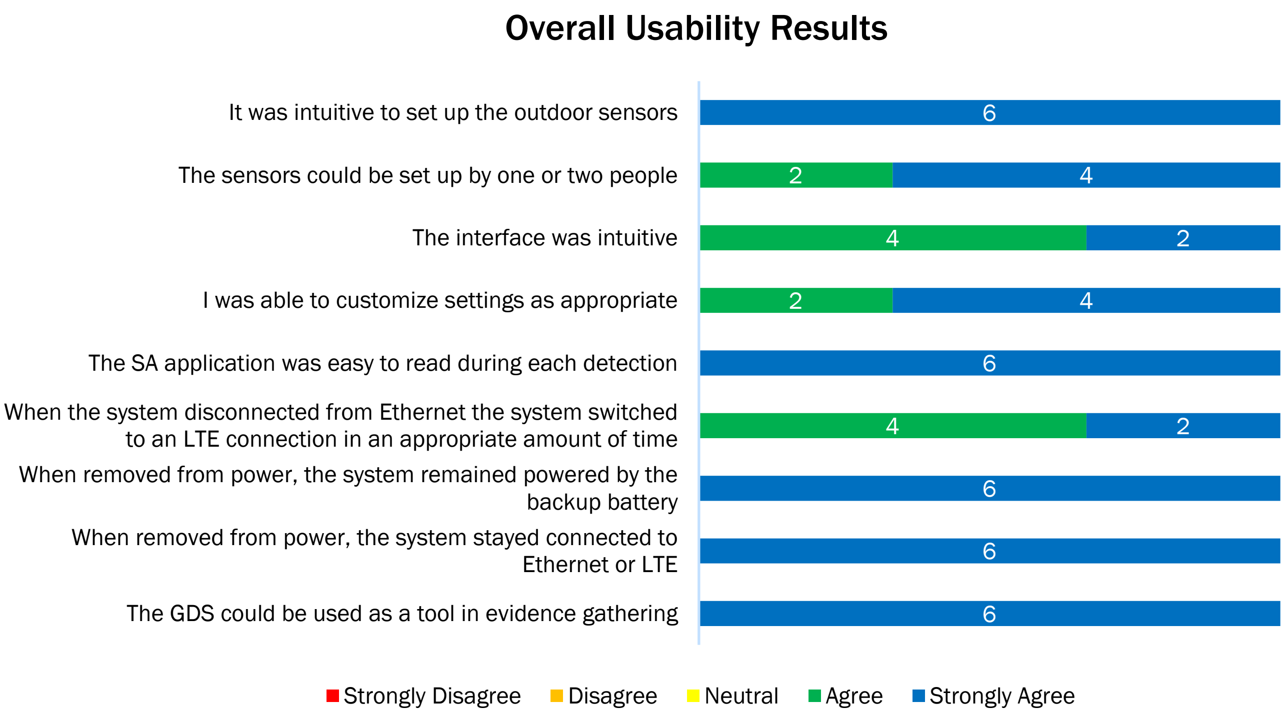

Figure 3-7 OFA Questionnaire Results: Overall Usability

3.4.1 SITUATIONAL AWARENESS APPLICATION CUSTOMIZATION

Four evaluators strongly agreed and two agreed that the SA application is appropriately customizable. Two evaluators had suggestions such as adding a GPS location of the shots, inserting live images of the map where shots were fired, and including a link to the live images on the SMS notifications.

According to two of the evaluators, the number of shots detected is crucial for the next steps in an officer's response. They noted that adding this element to the interface would enhance response operations by helping determine the support level required for the incident.

3.4.2 COMMUNICATIONS FAILOVER

The evaluators agreed that the system switched from an Ethernet connection to an LTE-M connection in an appropriate amount of time. The switch took approximately six minutes as stated in the vendors specifications. One evaluator highlighted that the system indicated the communication method was shifting to LTE-M, which they found useful for situational awareness. Evaluators noted that cell service in the test area was degraded and could have negatively impacted the time it took to connect to the LTE network—which, once connected, was found to be unstable.

3.4.3 SITUATIONAL AWARENESS APPLICATION INTERFACE

All evaluators strongly agreed that the SA application interface was intuitive and user friendly with clearly labeled symbols, as shown in Figure 3-8, and alerts. One evaluator remarked that a mobile application could be useful.

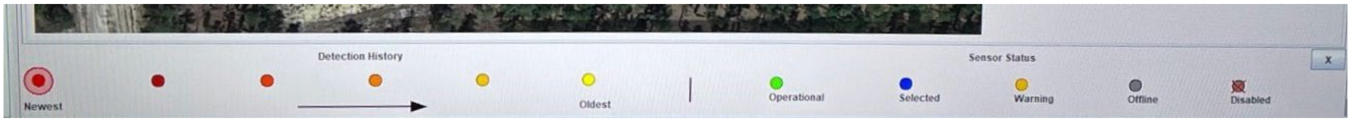

Figure 3-8 Situational Awareness Interface Labels

3.4.4 BATTERY TEST

All evaluators strongly agreed that the system remained powered by the backup battery when removed from external power.

3.4.5 POWER FAILOVER

All evaluators strongly agreed that the system stayed connected to Ethernet when removed from external power.

3.5 GROUP DISCUSSION

This section covers the evaluators’ overall assessment of the gunshot detection system, including suggestions for improvements as recorded by NUSTL’s team during the group discussion at the end of the OFA.

3.5.1 OVERALL PERFORMANCE

Overall, evaluators saw value in the GDS as a resource for law enforcement operational activities; they were satisfied with the capabilities, portability, usability, and interoperability of the system. Evaluators agreed that the detection capability requirements were met and that the system was intuitive, lightweight and easy to install.

They expressed concerns, however, regarding the durability and performance of sensors in harsh conditions such as extreme temperatures, varying noise levels and light exposure.

Evaluators suggested functional testing be conducted in these conditions and the developer consider enhancing the sensor housing to meet Ingress Protection ratings.[3]

Evaluators also questioned the ability of the system to perform should it become physically degraded. Evaluators asked how a sensor might perform if, for example, two of its component acoustic sensors are damaged. The developers indicated that the sensors have a built-in redundancy based on the configuration of the individual acoustic sensors, so the sensor would remain functional, but detection capability could potentially be decreased.

[3] Ingress Protection (IP) ratings indicate the level of protection an electrical instrument’s enclosure provides against intrusion by solid objects and water, as determined by test methods set forth in International Electrotechnical Commission (IEC) standard IEC 60529 “Degrees of Protection Provided by Enclosures (IP Code).” Alternatively, the National Electrical Manufacturer’s Association standard NEMA 250 “Enclosures for Electrical Equipment (1,000 V Maximum)” also provides means of testing and rating enclosure effectiveness.

Evaluators also strongly suggested that additional false alert testing be conducted using sounds known to mimic that of a gunshot, specifically fireworks and vehicle backfires, for reassurance that the system can reliably detect true gunshots. Additionally, based on the sensor's use of dual-mode detection (infrared and acoustic), evaluators suggested conducting false alert detection that would include exposing the sensor to lightning. Evaluators stated that additional false alert testing would be critical for the adoption of the technology.

Evaluators expressed concern about the potential number of sensor that would be needed to provide a desired level of coverage for an area, noting that the number of sensors would likely drive costs and would, therefore, affect system adoption.

3.5.2 OPPORTUNITIES FOR IMPROVEMENT

Evaluators made the following suggestions to improve the GDS sensors:

- Offering color options for the sensor to assist with blending into various environments, so that it won't stand out as an item of interest
- Adding a strap or handle to the bottom of the sensor to assist with stability during the installation process
- Creating a supplemental mount to hold battery packs in lieu of them being stored on the ground
- Creating multiple mounting options, such as mounts for vehicles or a twist-and-pull method (similar to that of a light bulb)
- Creating durable cases, such as a padded backpack, for easy deployment in small spaces or places with multiple flights of stairs
- Add the capability to detect weapon caliber information and number of shots fired

Evaluators made the following suggestions to improve the SA platform:

- Enhance audible alerts to indicate when multiple shots are detected with a distinct sound
- Display the number of shots detected with the alerts; evaluators offered potential options, such as displaying a digit under the sensor name or overlayed on the sensor icon
- Enhance SMS notifications to users to include a clickable link to a map of the actual location of the shot detected
- Automate map resizing when CAD or GIS layers are added
- Include GPS location data of individual sensors to assist with tracking the shooter's location
- Add GPS capability to provide live, automatically updating mapping of the area where shots are detected

4.0 CONCLUSIONS

On November 8, 2022, NUSTL conducted an OFA on an outdoor gunshot detection system. The OFA was conducted at the Joint Base McGuire-Dix-Lakehurst facility in New Jersey and consisted of six law enforcement evaluators who evaluated the portability, interoperability, capability, and usability of the outdoor gunshot detection system while performing various job-related tasks including using a situational awareness application and deploying sensors.

Overall, evaluators were satisfied with the capabilities, portability, usability, and interoperability of the system. They agreed that the detection capability requirements were met, and that the sensors were lightweight and easy to install, and that the SA was intuitive to use. They did, however, also offer suggestions to improve the technology, such as increasing the durability of the sensors to protect against extreme weather; protecting the sensors from possible tampering by providing additional color options; adding GPS tracking to sensors to assist with tracking the shooter's location; and enhancing the SA application's alerts and displays to better signal instances when multiple shots are detected.

Evaluators saw value in SDS's Gunshot Detection System as a resource for law enforcement operational activities but noted that adoption of the system would be dependent on the results of additional false detection testing (i.e., with fireworks, vehicle backfires and lightning) and the overall cost of the system. Specifically, evaluators were concerned with the number of sensors that would be needed based on the desired coverage area.

5.0 REFERENCES

[1] Office of Mission and Capability Support, DHS Science and Technology Directorate, “Needs Notification Form [Gunshot Detection System],” 2022.

[2] Shooter Detection Systems, “Guardian, Outdoor Gunshot Detection Sensor Combined Test Plan,” 2022.

[3] Compliance Assurance Program Office, Department of Homeland Security, *DHS Regulatory Compliance Assessment: First Responder Technology (R-Tech) Study, 2014.*

[4] DHS S&T, “Statement of Work for Gunshot Detection System,” 2020.

[5] B. Velasco-Lopez, K. Dooley, H. Posner and M. Norman, *Gunshot Detection System Operational Field Assessment Plan, 2022.*