DeepZero Gun Detection Platform

Technology Report

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FOREWORD

The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Urban Operational Experimentation (OpEx) 2022—hosted in July 2022 by the OpEx Program and National Urban Security Technology Laboratory (NUSTL)—provided first responders with the opportunity to experiment with new and emerging technologies in realistic, urban settings. This event combined demonstrations of leading-edge technologies with application-based field assessments staged throughout the New York City metropolitan area.

Urban OpEx 2022 was an important opportunity for DHS S&T to better understand the operational needs and requirements of urban first responders. Additionally, this event enabled first responder agencies to assess new technologies and provide feedback to participating technology vendors. Urban OpEx 2022 included participation from a broad range of federal, state, local, and private sector partners.

As part of the preparation for this event, DHS S&T facilitated discussions with first responder agencies to identify existing capability gaps. In coordination with NUSTL, the OpEx Program used these capability gaps to develop a Request for Information to solicit interest from technology vendors working to address the current gaps, interests, and priorities of first responder organizations. DHS S&T selected technologies, in collaboration with first responder stakeholders, for participation in Urban OpEx 2022. Urban OpEx events enrich the homeland security enterprise by gathering subject matter experts as first responder evaluators to train on and assess emerging technologies.

First responder evaluators provided recommendations and feedback to technology vendors that can inform the refinement of existing technologies. Evaluator recommendations also provided valuable insight for the national first responder community to inform investments in new and emerging technologies.

For more information on Urban OpEx 2022 or to view additional Urban OpEx reports, visit www.dhs.gov/publications-library/science-and-technology.

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EXECUTIVE SUMMARY

On July 20, 2022, the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) as a part of Urban Operational Experimentation (OpEx) 2022, staged an evaluation of DeepZero. An artificial intelligence computer vision technology developed by ZeroEyes, DeepZero automatically detects and classifies weapons through integration with existing security cameras and associated video management systems.

During Urban OpEx 2022, first responder evaluators tested DeepZero in an operational scenario to provide feedback on its features and suitability for urban first responder organizations. Participating responders came from a variety of New York City agencies, including the New York City Police Department (NYPD), Metropolitan Transportation Authority, and New York City Emergency Management, as well as from the DHS S&T First Responder Resource Group[1], including responders from the Lubbock (TX) Fire Rescue, Oswego (NY) Fire Department, and San Diego (CA) Fire and Rescue. ZeroEyes product engineers presented on DeepZero's features and capabilities before test activities were conducted in a mock city block at the NYPD Training Academy. The Urban OpEx Planning Team incorporated first responder input to develop a list of critical tasks to accomplish while testing DeepZero. The Urban OpEx Planning Team also encouraged first responder evaluators to consider other use cases and critical tasks for which the technology could be useful during an actual event or incident.

Evaluators found the DeepZero software intuitive and the interface easy to use. Evaluators were also impressed by DeepZero's ability to notify software operators of a potential firearm detection within seconds of the object appearing on the screen. First responder evaluators encountered a few challenges, however, including DeepZero's color-coding to signal threats and failure to detect multiple people wielding weapons simultaneously. They also faced difficulty with image clarity when using lower-quality security cameras. As a result, some evaluators questioned the utility of DeepZero in emergency response operations. During the debriefing, evaluators discussed that DeepZero might not prevent a mass shooting, but its' faster notification to the facility and responders may reduce the number of casualties. Suggestions for improvements include allowing users to change the indicator colors to align with recognizable warning alert colors already in use, and decreasing the detection time, even if only improving the response time by seconds or fractions of seconds. Evaluators also recommended adding or improving DeepZero's object of interest indicator to include other weapon types, such as knives or bats.

[1] First Responder Resource Group is an all-volunteer working group comprised of 120 experienced emergency response and preparedness professionals (active and retired) that help S&T maintain focus on the top-priority needs of responders in the field, helping to guide its research and development efforts.

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1.0 INTRODUCTION

The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) supports first responders in their mission to protect the public by introducing them to new products and tools that enhance their operational effectiveness. The DHS S&T Operational Experimentation (OpEx) Program partnered with the National Urban Security Technology Laboratory (NUSTL) to plan, conduct, and assess Urban OpEx 2022.

To identify technologies with the highest utility for emergency response personnel, urban first responders from the New York City Fire Department (FDNY), Metropolitan Transportation Authority (MTA), New York City Emergency Management (NYCEM), and New York City Police Department (NYPD) identified capability gaps in their work and technology areas to help mitigate those gaps.

Using this input, the Urban OpEx Planning Team identified technology areas to address the first responders' capability gaps. DHS S&T then developed and disseminated a Request for Information (RFI) to solicit responses from vendors who offer products in those technology areas. The Urban OpEx Planning Team surveyed technology vendors whose products could enhance operations for urban first responders. Table 1 highlights Urban OpEx 2022 technology areas included in the event.

Table 1: Urban OpEx Technology Areas

Topic Area	Description
Fixed, On-body or Handheld Sensors	Fixed, on-body, or handheld technology solutions that can send and receive sensor data to support and enhance first responders' mission effectiveness.
Unmanned Aircraft Systems (UAS)	UAS technology solutions that provide the capability to survey and model urban environments.
Situational Awareness Platforms	Situational awareness technology solutions that provide necessary information to first responders to enhance disaster and emergency preparedness and response capabilities.
Deployable Robotics	Technology solutions that provide deployable robotics capabilities to support or enhance first responders' mission effectiveness.
Deployable Communications Systems	Technology solutions that provide deployable communications capabilities for use during an emergency or disaster, restoring failed communications systems or augmenting existing ones to increase capacity for emergency response functions.
Video Content Analysis and Video Analytics	Mobile and deployable technology solutions that aid law enforcement in threat detection, including but not limited to anomaly detection (e.g., bags left behind), behavior threat detection (e.g., crimes in progress, people in need of assistance), and facial recognition.

DHS S&T used the technology areas to guide the selection processes in consultation with subject matter experts (SMEs) from within S&T, leading to the Urban OpEx Planning Team selecting seven technologies out of more than 50 RFI responses. The Urban OpEx Planning Team then worked with first responders, emergency response personnel, and technology developers to create scenarios and select venues for experimentation.

In addition to scenario development, the Urban OpEx Planning Team created an Experimentation Plan (ExPlan) to guide the event. The ExPlan included information about logistics, safety, roles and responsibilities, experiment design and scope, and evaluation guidance. Hosted by the OpEx Program and NUSTL, from July 19 to 22, 2022, New York City first responder agencies and members of the DHS S&T First Responder Resource Group (FRRG) experimented with the technologies and provided feedback and observations to inform technology development.

On July 20, 2022, nine first responder evaluators experimented with DeepZero, an artificial intelligence (AI) computer vision technology for weapon detection developed by ZeroEyes as a part of Urban OpEx 2022. SMEs from MTA, NYCEM, NYPD, and FRRG participated as evaluators to assess DeepZero's utility for their respective agencies. ZeroEyes participated under a Cooperative Research and Development Agreement (CRADA) with DHS S&T. Additionally, July 20, 2022, served as an Observer Day, where the Urban OpEx Planning Team hosted leadership from federal, state, and local agencies to attend the event, including the Port Authority of New York and New Jersey (PANYNJ). The Experiment Director provided New York City public safety leaders with an overview of the Urban OpEx 2022 event and the DeepZero technology prior to initiating the experiment.

1.1 PURPOSE

The Urban OpEx Planning Team designed the DeepZero operational experiment to provide first responders and emergency response personnel with an opportunity to learn about the capabilities and limitations of DeepZero, gain hands on knowledge in a representative operational environment, and provide feedback about DeepZero's application for first responders and emergency response personnel. First responder evaluators gave feedback that could be used by ZeroEyes to improve its DeepZero Platform. Likewise, the feedback provided S&T program managers with a better understanding of first responder and emergency response personnel needs to guide future S&T investments.

1.2 OBJECTIVE

Urban OpEx 2022 will introduce new technologies and assess their ability to address first responder mission capability needs.

- Objective 1: Share end-user feedback on DeepZero with the national first responder community to inform their decision-making
- Objective 2: Share first responder feedback with ZeroEyes to improve their products

1.3 RESPONDER CAPABILITY NEED

First responder SMEs who advised the Urban OpEx Planning Team on capability gaps indicated that video analytics technology could enhance their ability to detect weapons to support and enhance first responders' mission effectiveness during a critical incident and when securing critical infrastructure and soft targets. ZeroEye's technology meets that gap by augmenting responders' ability to proactively detect threats and by streamlining communication between first responders and DeepZero clients during an active shooter emergency.[2]

1.4 SCOPE

Due to time constraints and scenario limitations, evaluators and the Urban OpEx Planning Team could not experience all of the features, capabilities, and configurations of DeepZero at Urban OpEx 2022. Technology training was limited to one hour of virtual training offered before Urban OpEx, and one hour of in-person training at the event, which may have constrained how the evaluators interacted with the technology.

1.5 PRODUCT DESCRIPTION

DeepZero (see Figure 1) is an AI computer vision technology that automatically detects and classifies weapons. The DeepZero software platform integrates with existing security cameras and associated video management systems. DeepZero ingests video directly from security cameras or a video management system and analyzes keyframe[3] images to detect brandished weapons. Once a weapon is detected, a still image is sent to a trained human who is in the loop to validate or reject the classification. This validation or rejection of a detection is achieved at a 24/7 watch command center managed by ZeroEyes. At the watch command center, trained ZeroEyes personnel review each alert, determine if the alert is credible, and send dispatch information directly to local law enforcement and their clients within three to five seconds.

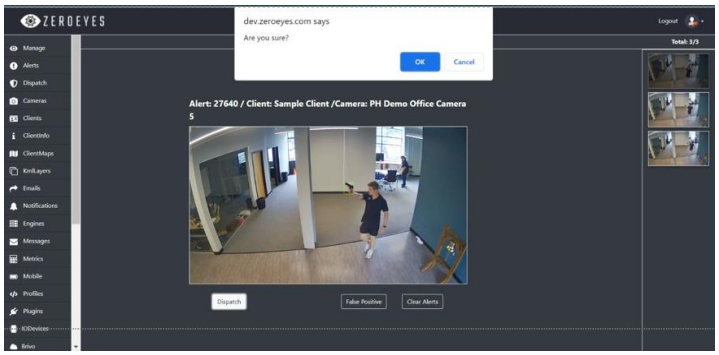

Figure 1: DeepZero Web Platform
Image Credit: ZeroEyes

[2] ZeroEyes defines clients as site staff at a location where DeepZero is being used, such as school resource officers and facility security services.
[3] The key frame means the part of the video that can represent a visual summary and meaningful information about the video sequence. The key frame can be useful in many applications such as video scene analysis, browsing, searching, information retrieval, and indexing. https://www.intechopen.com/chapters/71081.

The DeepZero Platform integrates directly with fixed and mobile cameras, such as those found on UAS and unmanned ground vehicle (UGV) applications, to create a visual network that enables automated threat detection classification and alerting. While the system does not store any video feed data long-term, positive detections of a threat are stored according to the ZeroEyes' and client's data retention policies. The DeepZero platform uses a trial-and-error process that involves testing the technology with a comprehensive dataset of thousands of images and videos (Figure 2) to continuously train the platform's AI weapons detection.

Figure 2: DeepZero Positive Pistol Detection Examples
Image credit: ZeroEyes

2.0 EXPERIMENT DESIGN

The Urban OpEx Planning Team designed scenarios to allow first responders the flexibility to experiment with features most relevant to their unique missions. Input from first responders, emergency response personnel, the technology vendor, the OpEx Program, and NUSTL's Urban OpEx Experiment Director informed the test scenario developed to evaluate DeepZero's operation, functionality, reliability, accuracy, and speed (see Figure 3 and Figure 4).

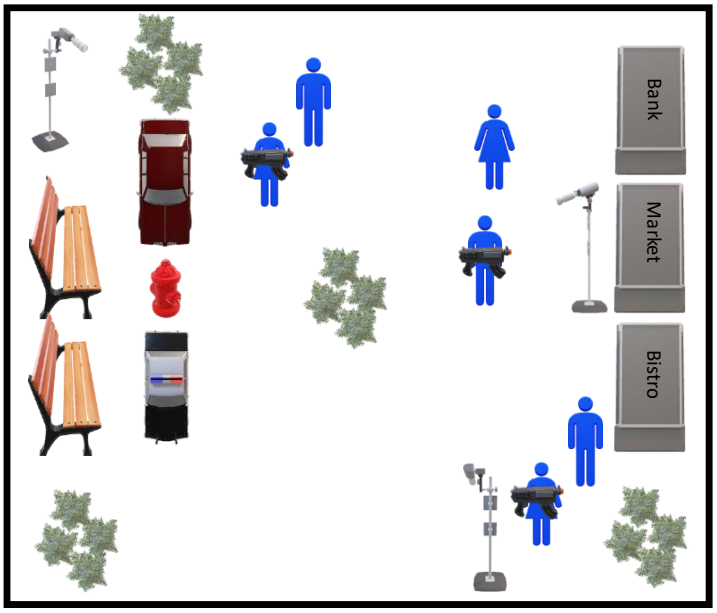

Figure 3: Diagram of Testing Area and Locations of Three ZeroEyes Cameras

Scenario:

Overwatch operators observe multiple individuals in public areas with what appear to be firearms. Critical tasks for the experiment included evaluators:

- Verifying the platform identifies specific weapons systems being carried by armed subject(s)
- Verifying the platform clearly distinguishes between armed and unarmed subject(s)
- Verifying automated alerts are sent to first responders

After the test scenario, evaluators were asked to consider how this technology would affect their current standard operating procedures and whether DeepZero could be used to augment their response capabilities.

2.1 SUMMARY OF THE OPERATIONAL EXPERIMENT

Evaluators from MTA, NYPD, NYCEM, and FRRG convened at the NYPD Training Academy (Figure 4) in Queens, New York, to participate in Urban OpEx 2022's demonstration and assessment of DeepZero (Table 2). Before OpEx convened, evaluators had the opportunity to participate in virtual technology training with technology vendors, allowing them to gain familiarity with the technology ahead of the live event.

Figure 4: DeepZero Testing Area at NYPD Training Academy

Activities began in a classroom with a presentation by personnel from the OpEx Program, NUSTL, and NYPD, to provide an overview of Urban OpEx and its purpose. The Experiment Director provided NYC public safety leaders with an overview of the Urban OpEx 2022 event prior to initiating the experiment. ZeroEyes technology vendors provided an overview and training for evaluators on the operation and capabilities of DeepZero (Figure 5). The Experiment Facilitator then provided additional opening remarks and a safety briefing. After hands-on training with evaluators for approximately 30 minutes, the experiment began with evaluators testing DeepZero in a mock city block within the NYPD Training Academy.

Nine evaluators tested DeepZero. The Urban OpEx Planning Team paired each evaluator with at least one data collector who recorded experiment observations and real-time evaluator feedback. A TV monitor was available for attendees not engaged in hands-on testing to observe DeepZero detections and dispatch notification procedures.

Table 2: First Responder Evaluators for DeepZero

First Responder Agency	Number of Evaluators
Lubbock (TX) Fire Rescue	1
MTA	2
NYPD Counterterrorism	3
NYCEM	1
Oswego (NY) Fire Department	1
San Diego (CA) Fire-Rescue	1

Figure 5: ZeroEyes Developer Training Evaluators

Table 3 summarizes the equipment used for this experiment.

Table 3: Equipment Used During Experiment

Equipment	Description
MSI brand Laptop	Runs DeepZero Software
1080P Axis Cameras x 4	Used by DeepZero for Video Input
Port Power over Ethernet (PoE) Network Switch	PoE switch, which supplies power and data to powered devices (P.D.s) via Ethernet cables to enable network connectivity
Prop Firearm	Mock Glock Pistol Variant
Prop Firearm	Mock AR-15 Rifle
Prop Firearm	Mock M4 Rifles
TV Monitor	Displays for ZeroEyes Visual Interface

2.1.1 CONDUCTING EXPERIMENTATION ACTIVITIES

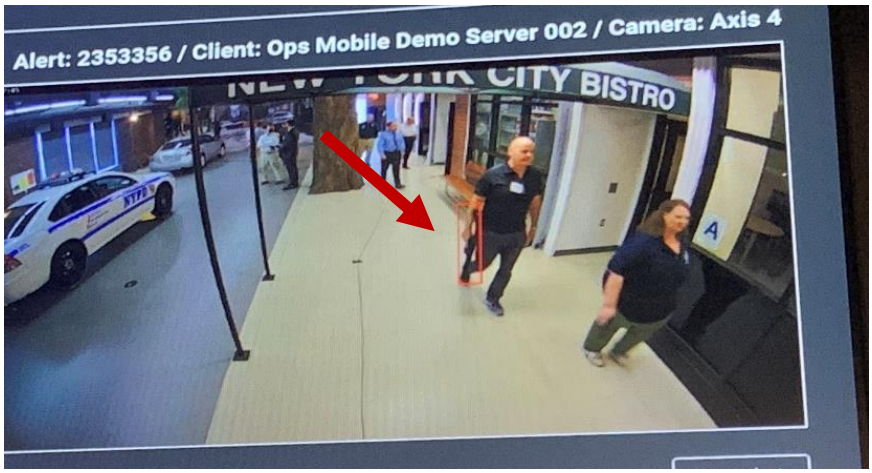

Figure 6: Screenshot of Detected Weapon

The operational scenario was planned as two vignettes focused on using DeepZero to identify brandished and semi-concealed weapons in an active shooter setting. However, ZeroEyes instructed evaluators to only conduct the vignette with an actor brandishing a firearm, as DeepZero does not detect partially concealed firearms. This allowed evaluators to experiment with identifying brandished weapons while also understanding DeepZero's limitations. Replica firearms were used for experimentation purposes.

First responder evaluators used DeepZero to identify replica firearms brandished by Urban OpEx actors walking through a mock New York City block (see Figure 6). Actors appeared in different locations throughout the mock city block carrying replica firearms and other objects like smartphones, which were present to test for false positives. Using the platform's display, evaluators located in a different room, verified whether DeepZero accurately detected a brandished firearm.

The hands-on experiment with DeepZero continued until each evaluator had an opportunity to test the platform in the scenario. In one classroom, evaluators tested and observed the human-in-the-loop process typically performed by ZeroEyes staff (see Figure 7), while in another classroom, evaluators and observers could watch via a monitor as the scenario unfolded.

ZeroEyes representatives were available to answer questions and provide technical assistance as requested by first responder evaluators during hands-on experimentation. Otherwise, technology vendors remained hands-off, allowing for uninterrupted assessment of the technology.

Figure 7: DeepZero Monitor Platform

2.2 DATA COLLECTION

Throughout the experiment, the Urban OpEx Planning Team encouraged evaluators to voice their opinions to assigned data collectors. The Urban OpEx Planning Team obtained feedback from the evaluators in several ways:

- During the test activities, at least one data collector worked with each evaluator to record comments, concerns, and challenges
- After participating in the scenarios, evaluators completed a questionnaire that captured their opinions on the suitability of DeepZero for first responders and emergency response agencies
- Finally, the Experiment Director led a technology debriefing during which evaluators provided additional comments and feedback that data collectors recorded. The discussion included the following questions:
  - In what applications do you anticipate using this technology?
  - What did you like about this technology?
  - What did you dislike about this technology?
  - What changes would you recommend? Why?
  - Is this technology something that you would actively use if it was available to you?
  - How do you think this technology would affect your ability to complete your duties?

3.0 RESULTS

The results of the DeepZero evaluation are made up of three types of feedback: questionnaire feedback, data collector notes, and technology debriefing notes.

These results are intended to help first responder agencies understand whether DeepZero may be suitable for their operations and to provide ZeroEyes with information on strengths and opportunities for improvement of their technology. Each of the evaluators come from different regions, disciplines, and levels of experience (see Table 2). This diversity of experience yielded user feedback that at times may appear contradictory.

3.1 QUESTIONNAIRE FEEDBACK

Each evaluator completed a questionnaire on technology suitability, ease of use, and most useful features. Part one of the questionnaire asked evaluators to respond to a series of statements about DeepZero's suitability for incident management missions and ease of use. Table 4 provides these questions and a breakdown of the evaluators' responses. The number in each cell represents the total number of evaluators who selected Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree, or Unable to Determine when completing their evaluation.

All evaluators agreed that DeepZero could help fulfill their agency's mission. Most evaluators indicated that DeepZero was an improvement over their current technology and the group unanimously agreed that the user interface was intuitive and easy to engage with and understand (see Figure 8). The majority of evaluators also indicated that because DeepZero transmits real-time video to incident commanders, the technology would improve their ability to communicate, share information, and coordinate with other agencies or groups during a multi-agency active shooter response.

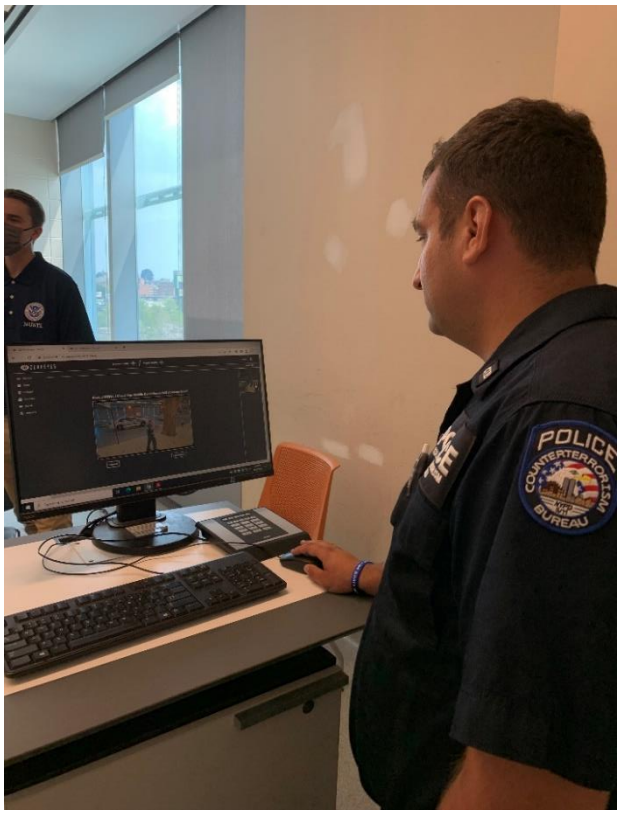

Figure 8: Evaluator Uses DeepZero Platform to Identify a Brandished Weapon

Part two of the questionnaire asked participants open-ended questions about what features they found most and least useful. Evaluators expanded upon these answers by also describing potential solutions to their challenges operating DeepZero. Most evaluators believed that DeepZero could be an asset to their organization, but others expressed concern that an alert for an already brandished weapon may still be too late to prevent violence.

During the event, data collectors recorded evaluators' comments on positive attributes and challenges they experienced while operating DeepZero. Data collectors documented capability limitations while noting evaluators' concerns about the user interface, which were minor. After testing, the Experiment Director led a debriefing to solicit additional comments and feedback from the evaluators and observers

Table 4: Evaluators' Responses Regarding Suitability and Ease of Use

Equipment	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Unable to Determine
This technology can help urban first responders' missions.	0	0	1	5	1	0
This technology is an improvement on the technology urban first responders currently use.	0	0	0	4	2	1
This technology performed all capabilities outlined by vendor	0	0	0	2	5	0
Responders are able to easily use this technology in conjunction with their required personal protective gear, if applicable to the scenario.	0	0	0	0	2	5
The computer/mobile device user interface was intuitive and easy to both understand and engage with.	0	0	0	2	5	0
The technology was easy to use with little to no interference from vendor during testing.	0	0	0	2	5	0
This technology increases urban first responders' ability to communicate and disseminate information during an event or incident.	0	1	0	3	2	1
This technology can improve first responders' ability to communicate and coordinate with other agencies and groups.	0	1	0	2	2	2
This technology can improve my ability to review and report information back to my leadership.	0	2	0	1	3	1
This technology should be recommended to other urban first responders.	0	2	0	4	1	0

Table 5 summarizes evaluator responses captured by data collectors during the experiment and remarks from the technology debriefing session. The feedback falls under one category, remarking on the DeepZero software interface.

Table 5: Evaluators' Responses to Software Features

Most Useful Features	Least Useful Features/Problems	Recommended Changes
▪ Easy to use and intuitive ▪ Requires minimal training ▪ Works with both interior and exterior cameras ▪ No delay between the initial alert on the screen and the detection ▪ Display clearly shows the movement of the person of interest ▪ Returns a clear image of the actor holding the gun ▪ Identifies a gun with only the tip showing ▪ Easy for human to identify and detect software-generated false positives ▪ Displays diagram of a specific space – created from either a PDF or geographic information system (GIS) data – on the dispatch page ▪ Sends pictures to first responders ▪ Offers applications for mobile devices ▪ Integrates with other map services ▪ Uses Google maps overlays ▪ Saves and shares images externally ▪ Internally saves only confirmed weapon alerts to the ZeroEyes cloud; deletes all other data after 30 days ▪ Customizable time frame for deleting non-alert data	▪ Image clarity depends on the quality of the already existing security cameras ▪ Does not detect concealed weapons ▪ May fail to detect a single handgun, or multiple guns, that are not brandished in a threat's hands ▪ Has difficulty identifying guns of different colors (e.g., blue) ▪ Accuracy percentage (i.e., percent of false positives) not available from vendor ▪ Use of colors to signal threats is not intuitive (may hinder user's quickness to react to the system's alert ▪ May be difficult for an individual with color vision deficiency to operate/use ▪ Unclear how well DeepZero may integrate with existing systems, because installation is individualized each security system and each system is set up different ▪ Takes three to five seconds from operation center personnel dispatching the alert notification to local response agencies and the DeepZero client receiving the alert	▪ Add multisensory integration to improve the detection of concealed weapons ▪ Change the colors used to signal threats ▪ Fully automate software to remove the ZeroEyes monitoring center "human-in-the-loop" (i.e., send directly to 911 response) * ▪ Integrate with other technologies so everything could appear on a single situational awareness display ▪ Implement multiple technology integrations ▪ Add capability to ingest and identify different objects, types of weapons, person of interest descriptions (e.g., clothing †) ▪ Add the ability to detect semi-concealed weapons ▪ Lower the number of frames analyzed by DeepZero from the frame per second (FPS) rate of the camera (e.g., 24, 30, 60) to one FPS

Most Useful Features	Least Useful Features/Problems	Recommended Changes
▪ Collects and uses false positives to improve detection (with client approval) ▪ Requires minimal data capacity and memory ▪ Works well as an add-on for organizations with existing security camera systems ▪ Adoption of ZeroEyes would have a positive impact on dispatch protocols		

*ZeroEyes addressed questions about fully automating the DeepZero software. ZeroEyes considers having a human in the loop part of the ethics of its AI

†ZeroEyes explicitly addressed evaluators feedback to expand DeepZero's platform to ingest and identify different objects, types of weapons, and persons of interest descriptions. ZeroEyes has considered expanding its detection capabilities and has intentionally focused their software on gun detection as a means of a faster and more accurate algorithm. They only do guns because only doing guns means their algorithm is faster and more accurate.

4.0 CONCLUSION

Evaluators' feedback on DeepZero was generally positive. Throughout their questionnaire responses and debriefing remarks, evaluators reiterated that DeepZero's intuitive design and simple interface are positive attributes that would make them more likely to use the platform. Evaluators found that DeepZero's ability to provide live locations of possible threats back to incident command would increase situational awareness during missions and enable responders and people at the site of the detection alarm to make more informed decisions. Most evaluators agreed that it was better than the technology their agency currently has in place.

While the system does not store any video data feed long-term, positive threat detections are stored according to ZeroEyes' and their client's data retention policies. This allows the company to build a comprehensive dataset with thousands of images and videos for continuously training the platform's AI weapons detection.

A majority of evaluators noted several shortcomings while testing DeepZero. The software's color scheme to signal threats was not intuitive and could hinder user reaction time to alerts. An individual with color vision deficiency might have difficulty using this system due to the spectrum of colors in use. Evaluators also noted other systems for firearm detection have existed for several years. Many wanted to see the capability of DeepZero extended to detecting holstered, semi-concealed, and concealed weapons.

ZeroEyes is not a facial or acoustic recognition technology but relies solely on AI for object detection. ZeroEyes also has controlled access to the network. A few evaluators questioned whether this configuration would be an improvement over a person watching a camera feed or a bystander calling 911 after seeing an individual with a gun.

Some evaluators noted that while DeepZero can alert first responders within seconds of a brandished weapon, it does not guarantee threat prevention. ZeroEyes gets the first alert notification and initiates the dispatch, if necessary, but takes three to five seconds to notify first responders of the incident. Evaluators wonder if these critical seconds before ZeroEyes alerts first responders may result in the system taking too long to be as effective in detection and alerting. ZeroEyes developers point out, however, that there is a trade-off between timeliness and their false positive rate: they cite the additional review by a human as crucial to low false positives.

ZeroEyes prefers maintaining control of system monitoring, the "human-in-the-loop" part of the process. This allows ZeroEyes to hire and train staff specifically for the task of confirming detections. Still, they can work with clients who wish to keep that operation in-house. One evaluator noted that DeepZero may be better as a post-incident investigatory tool as it would reduce the need for investigators to comb through hours of footage from multiple cameras or different businesses.

Some recommendations sought to extend DeepZero's capabilities by integrating the software with other technologies or tools used by first responders:

- Integrate with acoustic detection and alerting technologies (e.g., gunshot audio detection) and add a feature of displaying everything on a single situational awareness display
- Add multisensory fusion to detect concealed weapons

Other feedback imagined that more fundamental changes to the system might yield higher system performance or increased value for system users:

- Fully automating the software and removing the ZeroEyes-staffed human-in-the-loop by sending the alert directly to 911 response and not through ZeroEyes monitoring center
- Adding the capability to digest and ingest different images, objects, and other types of weapons (e.g., knives, bats)

Urban OpEx 2022 experiments were conducted in a half-day timeframe. They were driven by a tailored set of scenarios that limited the evaluator's exposure to a typical training program, broader technology configurations outside the planned scenario, and additional features/configurations of the technology not applicable to the scenario. Given these constraints, it is possible that some first responder evaluator feedback or suggestions for improvement could be addressed by users completing the entire technology provider-recommended training program or having more experience using the system. ZeroEyes representatives addressed feedback on eliminating human review of the AI's positive detections and on expanding the types of weapons detected during the debriefing event. The developer cites the presence of a human as an ethical strength of its deployment of AI and its singular focus on firearms as key to the platform's accuracy.

In conclusion, many evaluators found DeepZero has potential uses across most response agencies. The feedback from evaluators may enable DeepZero technology developers to continue improving the product and/or expand the number of use cases in which DeepZero could support first responders' work.

5.0 ACRONYM LIST

Acronym	Definition
1080P	1920×1080 progressively displayed Pixels
AI	Artificial Intelligence
AR-15	ArmaLite Rifle 15
CRADA	Cooperative Research and Development Agreement
DHS	Department of Homeland Security
FDNY	New York City Fire Department
FPS	Frames per Second
FRRG	First Responder Resource Group
GIS	Geographic Information System
IC	Incident Command
M4	Model 4 rifle (military)
MTA	Metropolitan Transportation Authority
NYCEM	New York City Emergency Management
NYPD	New York City Police Department
NUSTL	National Urban Security Technology Laboratory
OpEx	Operational Experimentation
PANYNJ	Port Authority of New York and New Jersey
PD	Powered Device (e.g., wireless access points, VoIP phones, and I.P. cameras)
PDF	Portable Document Format
PoE	Power over Ethernet (provides electric power and data simultaneously over ethernet cables)
RFI	Request For Information
SME	Subject Matter Expert
S&T	Science and Technology Directorate
UAS	Unmanned Aircraft Systems
UGV	Unmanned Ground Vehicle