NEXT GENERATION FIRST RESPONDER
CASE STUDY
ENHANCED SITUATIONAL AWARENESS

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EXECUTIVE SUMMARY

The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) launched the Next Generation First Responder (NGFR) Apex program to help tomorrow's first responder become better protected, connected and fully aware. DHS S&T has held a series of NGFR Integration Demonstrations to incrementally test and evaluate interoperable technologies currently in development. These demonstrations have evolved from tabletop integrations to field exercises with partner public safety agencies and have involved increasingly complex technology integration.

DHS S&T partnered with Harris County, Texas, and the City of Houston to host the first major urban NGFR Integration Demonstration in December 2018. The NGFR – Harris County Operational Experimentation (OpEx) involved testing a variety of integrated technologies in an operational environment with participating first responders from Harris County, City of Houston, U.S Coast Guard (USCG), SouthEast Texas Regional Advisory Council, Cy-Fair Volunteer Fire Department and the Atascocita Fire Department.

During the OpEx, Harris County, Houston-area responders and federal partners used integrated responder technologies to enhance their mission capabilities in a hazardous materials (HAZMAT) scenario that included a simulated gas leak from a USCG Cutter (USCGC) vessel in the Port of Houston. Together, responders and DHS S&T evaluated how DHS-funded and commercial technologies integrated with existing public safety systems using open standards and how those integrated capabilities enhance emergency communications, increase operational coordination, improve responder safety and augment situational awareness.

The NGFR – Harris County OpEx included 23 different DHS and industry-provided technologies, including six Internet of Things (IoT) sensors, five situational awareness applications and platforms, and live-stream video feeds. Additional OpEx technologies included body-worn cameras, deployable communications systems, and real-time data aggregation and access across multiple agencies.

This case study identifies and explains the situational awareness technologies that were used in the OpEx, and discusses how nationwide public safety agencies could implement situational awareness platforms to enhance operational situational awareness, collaboration and communication.

DHS S&T's technical team, DHS-funded and industry partners provided the sensors and integration work to support the OpEx, incorporating the feeds from multiple sensors to multiple situational awareness applications. The OpEx scenario provided sufficient realistic opportunities to assess the technologies and allowed participating responders to identify gaps and required enhancements to improve the participating technologies.

Figure 1. Participants Conduct Simulated Emergency Response Activities During the NGFR - Harris County OpEx

DHS S&T and partners brought new and enhanced situational awareness capabilities to Houston-area responders during the OpEx. By integrating data from multiple sensor types into unified situational awareness applications, the NGFR Apex program enhanced operational communications, increased operational coordination, improved responder safety and augmented situational awareness. The OpEx demonstrated that the first responders, incident commanders and emergency managers were able to maintain enhanced situational awareness during the scenario by interacting with the various situational awareness platforms provided for the OpEx.

Administrative and Handling Instructions

The title of this document is the "Next Generation First Responder Case Study: Enhanced Situational Awareness." This document provides public safety agencies with an overview of how DHS S&T implemented situational awareness tools during the NGFR – Harris County OpEx and provides some areas that an agency may consider if they choose to implement the capability within their organization. All preparation and documentation for the NGFR – Harris County OpEx is unclassified.

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If you have any questions about this case study, or to request more information about the NGFR – Harris County OpEx, please contact NGFR@hq.dhs.gov. Public release of information is at the discretion of DHS S&T.

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INTRODUCTION

Next Generation First Responder Apex Program

The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) works with America's first responders to ensure they are more effective and safer—regardless of the hazards they face. DHS S&T develops and adapts innovative technologies that help first responders make communities more secure and resilient, because homeland security truly starts with hometown security.

The Next Generation First Responder (NGFR) Apex program is a five-year program that began in January 2015 and is part of a longer-term DHS S&T commitment to envision and assist the responder of the future. The NGFR Apex program works to make responders better protected, connected and fully aware by developing, adopting and integrating cutting-edge first responder technologies using open standards. This complex, multi-disciplinary program consists of a diverse but related portfolio of projects that span from basic research to advanced technology development, and an initiative to define a common set of open standards for technology integration. These open standards enable industry partners to develop standards-based solutions that easily plug-and-play into an interoperable responder ecosystem, including legacy systems. This approach opens doors to industry while lowering costs and increasing choices for public safety organizations, helping them rapidly adapt to changing environments and evolving threats as they secure communities nationwide.

NGFR Integration Demonstrations

Since 2016, DHS S&T has held a series of NGFR Integration Demonstrations to incrementally test and evaluate interoperable technologies currently in development. These demonstrations have evolved from tabletop integrations to field exercises with partner public safety agencies, including the rural 2017 Grant County—DHS S&T NGFR Apex Program Technology Experiment. This case study highlights the efforts, lessons-learned and guidance from the NGFR – Harris County Operational Experimentation (OpEx) that was held in December 2018 in Houston, Texas, to demonstrate the interoperability of DHS S&T and industry-developed responder technology and increase community resilience.

DHS S&T has incorporated the results and responder feedback from the NGFR Integration Demonstrations into the NGFR Integration Handbook, which outlines a standards-based environment that enables commercially-developed technologies to integrate with existing first responder infrastructure. Using the lessons learned and responder feedback from these integration demonstrations, DHS S&T has also produced materials to help public safety agencies implement new technologies that address their operational priorities, such as the NGFR Case Study series, which this document is part of.

NGFR Operational Experimentation in Harris County, Texas

DHS S&T collaborated with public safety agencies from Harris County and the Houston area to host the NGFR – Harris County OpEx from December 4-5, 2018, at the Port of Houston. Participating agencies included Harris County (Fire Marshal's Office, Sheriff's Office Marine Unit, Office of Homeland Security and Emergency Management, Central Technology Services, and Community Emergency Response Team), the City of Houston (Fire Department, Police Department Marine Unit, and Information Technology Services), Port of Houston Authority (Emergency Management, Fire Department, Police Department), SouthEast Texas Regional Advisory Council, Cy-Fair Volunteer Fire Department,

Atascocita Fire Department, U.S. Coast Guard Sector Houston-Galveston, DHS Federal Emergency Management Agency's Integrated Public Alert and Warning System Office, and DHS Cybersecurity and Infrastructure Security Agency's Emergency Communications Division.

The goal of this OpEx was to integrate and demonstrate a variety of cutting-edge responder technologies, assist Houston-area response organizations in incorporating them into their daily operations, gather responder feedback to help improve both individual DHS-funded and industry technologies, and demonstrate the value of the NGFR Apex program. During the OpEx, Houston-area responders and federal partners used integrated responder technologies to enhance their mission capabilities in a HAZMAT and mass casualty incident response scenario in the Houston Ship Channel. Together, responders and DHS S&T evaluated how selected S&T-developed and commercial technologies integrated with existing public safety systems using open standards and how those integrated capabilities enhanced emergency communications, increased operational coordination, improved responder safety and augmented situational awareness.

Purpose of this Case Study

This case study describes how DHS S&T augmented situational awareness during the NGFR – Harris County OpEx, taking real-time data from numerous sensors and displaying it on unified situational awareness applications to give the Incident Commander, command staff and first responders the right information at the right time. It provides an overview of the systems used, the challenges encountered and the solutions implemented for the OpEx, as well as considerations that any public safety agency should think through if they intend to implement situational awareness applications for their organization.

OpEx OVERVIEW

OpEx Objectives

DHS S&T hosted the OpEx to validate and advance the Next Generation First Responder Apex program, as well as benefit Houston-area public safety and technology provider partners. The OpEx integrated NGFR technologies to support an operationally-relevant, mission-based scenario centered on HAZMAT and mass casualty response operations. The goal of this OpEx was to demonstrate the capabilities of new technologies and provide a proof of concept to participating responders to illustrate how the technologies could be incorporated into daily operations and existing systems. By gathering feedback from first responders on the technologies and how they did or did not augment public safety emergency response capabilities, the NGFR Apex program seeks to better ensure new technologies fully meet responder needs.

Figure 2. Atascocita and Cy-Fair Paramedics connect physiological sensors to an OpEx "patient" prior to transport

OpEx Requirements

Initial discussions with Harris County resulted in the identification of the following technology requirements for the OpEx:

- Geo-location of first responder personnel in three dimensions on map displays provided to the Incident Commander, the command staff and on smartphones carried by responders.

- Capability to monitor patients' physiological condition and send the data wirelessly to the Incident Commander and command staff for viewing using a visual "dashboard" on a monitor and/or smartphone.
- Remote monitoring of HAZMAT using body-worn gas sensors transmitting alerts to the Incident Commander and command staff.
- Integration of all sensor feeds into one data feed provided to multiple situational awareness applications, especially the two existing applications in place or planned for use by Harris County and the Port of Houston (Intrepid Response and AVERT C2, respectively).

DHS Core Capabilities Alignment

The NGFR – Harris County OpEx was shaped around critical requirements identified by operational partners from Harris County, the City of Houston, Port of Houston Authority, U.S. Coast Guard, SouthEast Texas Regional Advisory Council, Cy-Fair Volunteer Fire Department and Atascocita Fire Department. These requirements included helping fill gaps identified during the response to Hurricane Harvey in 2017, particularly gaps around information sharing and multi-jurisdictional coordination. The planning process included joint identification of OpEx objectives and targeted DHS Core Capabilities, which included:

- Operational Communications;
- Operational Coordination;
- Environmental Response/Health and Safety;
- Intelligence and Information Sharing;
- Access Control and Identity Verification;
- Mass Search and Rescue Operations;
- On Scene Security, Protection and Law Enforcement;
- First Responder Safety; and
- Situational Awareness.

OpEx technologies were selected to meet these Core Capabilities and the scenario was developed to test the technologies and the associated operational capabilities.

Figure 3. A DHS Data Collector Observes the Harris County HAZMAT Team During the OpEx

OpEx Scenario

The OpEx scenario provided sufficient realistic opportunities to assess the various technologies' utility and integration with existing systems (technical and human). The scenario also provided opportunities for participating first responders to identify gaps and required enhancements to improve the participating technologies. The evaluation team was able to verify that the NGFR system architecture implemented and configured at the Port of Houston was easy to install, easy to use and provided capabilities that were valued by the first responders.

The NGFR – Harris County OpEx consisted of an operational scenario divided into three vignettes:

- **Vignette A**: A HAZMAT spill occurs on USCGC Hatchet and the resulting gas cloud also affects the civilian vessel, the M/V Sam Houston, following in its wake. The vessels moor across Buffalo Bayou and HAZMAT teams are activated from the Port of Houston, Harris County and the City of Houston, as well as emergency medical services (EMS) units from the City of Houston, Atascocita Fire Department and the Cy-Fair Volunteer Fire Department. Harris County and the City of Houston marine units respond, as well as the Port of Houston Fireboat 1 and a USCG Response Boat Small (RB-S). All HAZMAT and marine units arrive on scene at the Sam Houston

Pavilion and the Battalion Chief from the Port of Houston establishes Incident Command to evaluate the situation.

- **Vignette B**: The Harris County HAZMAT crew sets up a decontamination station at the Sam Houston pavilion, boards the M/V Sam Houston, and starts evaluating the passengers and crew. HAZMAT crews from the Port of Houston and City of Houston board Fireboat 1 and are transported across the bayou to USCGC Hatchet. They board the vessel to evaluate the crew and identify the source and nature of the HAZMAT spill. They also note that one of the crewmembers is unaccounted and is assumed to have fallen overboard prior to mooring.
- **Vignette C**: Victims from civilian vessel M/V Sam Houston undergo technical decontamination, triage and treatment, and are prepared for transport. Victims from USCGC Hatchet undergo gross decontamination and are then transported by Fireboat 1 over to the pavilion, where they undergo technical decontamination, triage and treatment. The USCG crew and a helicopter search for and find the missing crewman in the bayou, the RB-S crew retrieves him and returns him to the pavilion for decontamination, triage and treatment.

OpEx Technologies

DHS S&T worked with federal, industry and on-contract performers to provide 23 technologies, many of which were integrated to increase information sharing and situational awareness during the OpEx. DHS S&T and partners used data and alert standards to facilitate technology integration, including the Sensor Things server running their Open Geospatial Consortium (OGC) standard Application Program Interface (API), and Message Queuing Telemetry Transport (MQTT). Full descriptions of all OpEx technologies are available in the NGFR – Harris County OpEx Playbook and After Action Report listed in the References and Recommended Reading section. Note that the following descriptions were current as of the NGFR – Harris County OpEx in December 2018, and that throughout this document, technologies are frequently referred to by the name of the company rather than the name of the technology. OpEx technologies relevant to this case study include:

Ardent Management Consulting, Inc.

Vortex Router with the Esri Ops Dashboard

The Esri Ops Dashboard is an Esri-based situational dashboard which uses Esri Portal and ArcGIS awareness to display and help visualize the data collected in the Vortex Router from both personnel and vehicles for use in emergency situations. The Vortex Router aggregates and translates messages encoded with the Emergency Data Exchange Language (EDXL) Distribution Element (DE) standards and uses a REST API to allow for easy third-party integration and to encourage interoperability. Ardent Management Consulting, Inc. (Ardent MC) was funded by DHS S&T for this technology.

ARES Security Corp.

AVERT C2

AVERT C2 is an intelligent command and control platform that provides collaborative situational awareness by allowing each user to view and share the information sources and layers they need to understand and manage events as they unfold. AVERT C2 ingests and visualizes data from virtually any sensor—including chemical sensors, biometric sensors, cameras, radar, access control and alarm systems—to manage all security and response information through a single user interface.

Centrex Solutions LLC

Nightjar

The Nightjar Platform connects devices with systems and people, over a variety of long-range, low-power wireless technologies, allowing connectivity beyond cellular coverage areas. During the OpEx, first responders used Nightjar handheld, wearable and vehicle-mounted flammable gas sensors.

Haystax, a Fishtech Group Company

Haystax Constellation

Haystax Constellation for safety and security helps first responders prepare and respond with confidence, using a cloud-based platform for early threat detection, situational awareness and information sharing. Haystax Constellation gives first responders advanced analytics to automatically score the highest-priority threat signals and rapidly deliver them to the right people at the right time, and provides a tightly-integrated ecosystem of web and mobile apps that enables users to manage their critical assets and respond effectively to incidents and natural hazards.

Integrated Solutions for Systems, Inc. (IS4S)

Communication Hub

The Communication Hub (CommsHub) is a body-worn, smart router that interconnects multiple communications systems (e.g., land mobile radio [LMR], long-term evolution [LTE], FirstNet) with the variety of sensors and electronics (e.g., location, vitals) worn or carried by the user. It intelligently, efficiently, securely and resiliently routes data between first responders and commanders using the best available communication link, removing the burden of handling increasing amounts of data, so first responders can focus on the task at hand. IS4S was funded by DHS S&T under the Small Business Innovation Research (SBIR) program for this technology.

Zephyr™ Performance Systems

IS4S brought this commercial-off-the-shelf product, which is produced by Medtronic, to the OpEx to test out additional physiological monitoring capabilities. The Zephyr physiological monitoring sensor is attached to the responder via a strap around the chest, which can monitor core body temperature, body positioning and stress levels.

Intrepid Networks, LLC

Intrepid Response

Intrepid Response is a mobile application that enables enhanced situational awareness by providing live responder locations and static locations of interest with a simple user interface. Open API architecture provides integration capability for higher level command and control tools or other platforms.

Intrepid Connect (Moxtra)

Moxtra, powered by Intrepid Networks, provides robust team collaboration with rich multimedia sharing, whiteboarding, task management and secure text communication.

Keys Net LLC

Keys Internet of Things (IoT) Watch App

With the Keys IoT Watch App, first responders can leverage the devices they already own to provide location, heart rate and other sensor data into their current operational systems, as well as receive incident alerts (visual/audio/vibration), select sensor data and view an incident/team map from their smart watch. Keys IoT Watch App is a software-based solution that utilizes mass-market consumer wearables (such as

the Apple Watch) to both send and receive location, sensor data and alert notifications. Keys Net LLC was previously funded by DHS S&T for this technology.

N5 Sensors, Inc.

Compact Multi-Gas and Particulate Matter Detector

A compact, low-cost gas and particulate detector leveraging N5's patented chip-scale nanoengineered gas sensor technology. It provides real-time detection of multiple toxic and fire gases along with particulate matter counts in a wide range of environmental conditions. N5 Sensors, Inc. was funded by DHS S&T under the SBIR program for this technology.

National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory

AUDREY – Assistant for Understanding Data through Reasoning, Extraction and Synthesis

AUDREY is a state-of-the-art human-like Artificial Intelligence (AI) system designed to assist first responders in reducing their data overload problems and providing life-saving actionable intelligence by automatically analyzing relevant sensor data and synthesizing high-level situational awareness information while at the scene of an emergency.

WAMS – Wearable Alert and Monitoring Systems

WAMS provides front-end processing for AUDREY, enabling AUDREY agents to efficiently receive personalized sensor data, alerts and events and supporting voice-to-text conversion. NASA Jet Propulsion Laboratory was funded by DHS S&T for these technologies.

Pacific Northwest National Laboratory (PNNL)

VitalTag

VitalTag is a small, disposable suite of sensors that securely detects and communicates vital sign data in real-time to first responders. This information helps first responders more effectively triage, treat and transmit patients during a mass casualty event. PNNL was funded by DHS S&T for this technology.

SensorUp, Inc.

SensorThings

SensorUp provides the Internet of Things platform for customers who rely on geospatial in their IoT Implementations. SensorUp helps make sense of data, combining all different sensors into one easily-managed visualizer and get the bigger picture. SensorThings technology rapidly aggregates and coordinates disparate sensors and IoT systems transforming them into actionable insights. SensorThings provides the primary sensor integration platform for the OpEx by connecting and aggregating various sensors and providing that actionable information to situational awareness tools. SensorUp, Inc. was funded by DHS S&T through a subcontract for this technology.

TRX Systems, Inc.

NEON® Personnel Tracker and NEON® Command

NEON Personnel Tracker delivers ubiquitous location indoors and out, improving operational efficiency, command effectiveness and safety for security, public safety and industrial applications. NEON Personnel Tracker is an Android application tightly integrated with the NEON Location Service where a suite of patented algorithms fuse inertial sensor data. NEON Command is a PC based visualizer used to view location data remotely in real-time. TRX Systems, Inc. was previously funded by DHS S&T for indoor tracking solutions under the Firefighter Accountability and Proximity Systems project.

OpEx Constraints and Limitations

DHS S&T identified the following constraints and limitations for the OpEx:

- Most of the technology providers were identified through a Request for Information process and worked under Cooperative Research and Development Agreements (CRADAs) with DHS S&T, which did not include funding. This constrained the scope of their participation.
- DHS S&T could not interface with existing Computer Aided Dispatch (CAD) systems for the City of Houston, Port of Houston or Harris County, so the sensor feeds had to be aggregated, normalized and sent to situational awareness applications entirely outside of the local CAD systems.
- The primary situational awareness solutions used—AVERT C2, Intrepid Response and Haystax Constellation—were selected because they were already in use (or planned for use) by Harris County and the Port of Houston.
- Standards for data payloads, alerting messages and SensorUp-to-situational awareness platforms had to be developed and implemented for the integration solution to work.

OpEx Communications Architecture

Based upon site visits, a baseline technology assessment of all participating agencies and ongoing collaboration with Harris County and other participants, DHS S&T developed a notional communications architecture. This established the foundation for the OpEx architecture, as well as ensured consistency with the expectations and needs of participating public safety organizations, as shown in Figure 4.

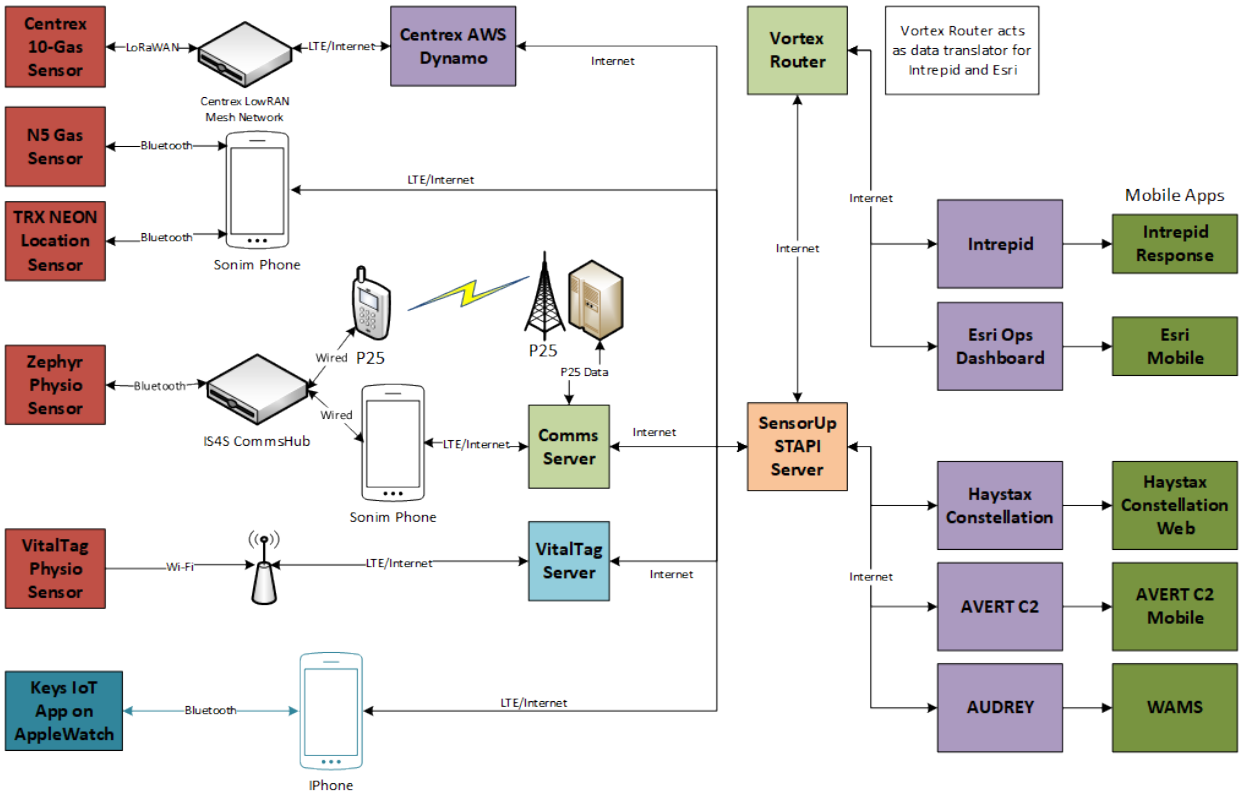

Figure 4. OpEx Communications Architecture with Central SensorUp Data Integration Point

Implementing Enhanced Situational Awareness Solutions

It is crucial for public safety agencies to maintain effective real-time situational awareness in the execution of their various law enforcement, emergency medical care and fire safety missions. Part of situational

awareness is knowing the location of first responders, their physical condition and if there are any environmental hazards nearby. This awareness helps command staff make informed decisions that both protect first responders and improve their effectiveness in serving their communities.

Enhanced Situational Awareness Requirements

To effectively develop and implement a first responder enhanced situational awareness solution, DHS S&T and participating public safety agencies assessed their mission needs for the situational awareness systems and arrived at the following requirements:

- The situational awareness system shall include AVERT C2 (for the Port of Houston) and both Intrepid Response and Haystax Constellation (for Harris County).
- The situational awareness system shall incorporate and display the sensor data from gas sensors, physiological sensors, location sensors, and video analysis and alerting.
- The situational awareness system shall associate the sensor data with the corresponding responder and display any alerts for sensor readings that exceed configurable parameters.

Baseline Assessment of Existing Capabilities

Participating public safety agencies did not have baseline situational awareness capabilities nor an existing environment capable of passing sensor data on to their situational awareness applications without additional development. The following applications and architecture were in place at the time of the OpEx:

- Harris County used Intrepid Response for their legacy situational awareness application, but only for special operations and not routine events;
- Port of Houston had purchased AVERT C2 for their legacy situational awareness application, but it has not yet been installed; and
- Harris County also had Haystax Constellation as a data sharing application, so it was integrated into the overall architecture.

OpEx Situational Awareness Architecture

Once the participating public safety agencies determined their sensor integration requirements, NGFR and agency personnel evaluated the existing technologies and identified an architecture that would fulfill the necessary requirements.

The sensor feeds integrated for the OpEx included:

- *Gas sensors*:
  - Compact Multi-gas and Particulate Matter Detector, N5 Sensors
  - Nightjar, Centrex Solutions
- *Physiological sensors*:
  - VitalTag, PNNL
  - Zephyr, Medtronic via IS4S
  - AppleWatch, Keys Net
- *Location sensors*:
  - NEON Personnel Tracker, TRX Systems
  - Communication Hub, IS4S
- *Video analysis and alerting*:
  - AUDREY, NASA Jet Propulsion Lab

The situational awareness systems to which the sensor and alert data was sent included:

- AVERT C2, ARES Security Corp.
- Intrepid Response, Intrepid Networks

- Haystax Constellation, Haystax
- NEON Command, TRX Systems
- Esri Ops Dashboard, Esri via Ardent MC, and Vortex Router, Ardent MC

The intermediate system that integrated the data between the sensors and the situational awareness systems was the SensorUp Sensor Things server running their Open Geospatial Consortium (OGC) standard Application Program Interface (STAPI). By the time of the OpEx, there were actually six instances of the STAPI server, each collecting data from sensors in a specific format, with all six of the STAPI feeds integrated into one STAPI server providing feeds to the four situational awareness applications. This was the only way that multiple sensor data for each responder could be associated with that responder's identity and sent to the situational awareness applications. This integration at the server required the development of a very structured assignment matrix that linked the various sensor feeds to the individual responders. The data associations were made at the SensorUp server level.

Data Processing and Presentation

Situational awareness vendors faced numerous challenges regarding the sensor and alert data being sent to them. Their systems had different methods of handling incoming data from external sources, and therefore displayed the information in vastly different ways.

The primary challenge for the various situational awareness platforms was how to input the sensor data coming from the devices carried by the responders. Because there is no sensor payload standard, the OpEx team of industry partners and NGFR staff worked to develop documented payload standards for use by the sensor providers and SensorUp in transmitting sensor data and alerts to the situational awareness platforms. These topics are explored further in the Harris County Case Studies, "NGFR Case Study: Data and Alerting Standards" and "NGFR Case Study: Data Integration." For more information, see the References and Recommended Reading section of this document.

A second challenge was how to display the sensor and alert data once received by the situational awareness platforms. The data for display included:

- Responder identification
- Responder location (latitude/longitude/altitude [where available])
- Responder physiological information, including some or all of the following:
  - Skin temperature,
  - Respiration Rate,
  - Heart Rate, and
  - Alerts for reading(s) outside set parameters.
- Patient location (latitude/longitude)
- Patient vital signs, including:
  - Systolic blood pressure,
  - Heart rate,
  - Shock index,
  - Dissolved O2,
  - ECG,
  - Respiration rate, and
  - Alerts for reading(s) outside set parameters.
- Gas sensor data, including some or all of the following:
  - Gas identification,
  - Gas concentration, and
  - Alerts for reading(s) outside set parameters.

- AUDREY video analysis alerts and associated data

Some situational awareness applications were able to display the responder's ID at the appropriate location, but did not initially have the capability to display the other sensor data associated with that responder. There were both development and configuration changes that the situational awareness performers made to display the sensor and alert data to the users, but unfortunately no display standard was identified or implemented across the multiple situational awareness platforms.

Using Situational Awareness Platforms During the OpEx

AVERT C2, ARES Security Corp

For the OpEx, the AVERT C2 server received sensor and alerting data via a feed from the SensorUp SensorThings API server. AVERT C2 modified their graphical user interface (GUI) icons to associate the responder data with corresponding icons. The icons, shown in Figure 5, include:

- Red cross icon for EMS personnel;
- Blue boat icon for marine unit law enforcement and fireboat personnel;
- Yellow bio-hazard icon for HAZMAT fire personnel;
- Red shield for fire (non-HAZMAT) personnel;
- Blue shield for law enforcement (non-marine unit) personnel; and
- Yellow person icon for mass casualty victims.

Figure 5. AVERT C2 Screenshot Showing Asset Icons from Various Data Feeds

AVERT C2 organized the assets by role and appropriate organization within collections to filter the dashboard as needed. Clicking on an icon within AVERT C2 allowed the user to access any relevant data for that asset in a sidebar, as illustrated in Figure 6.

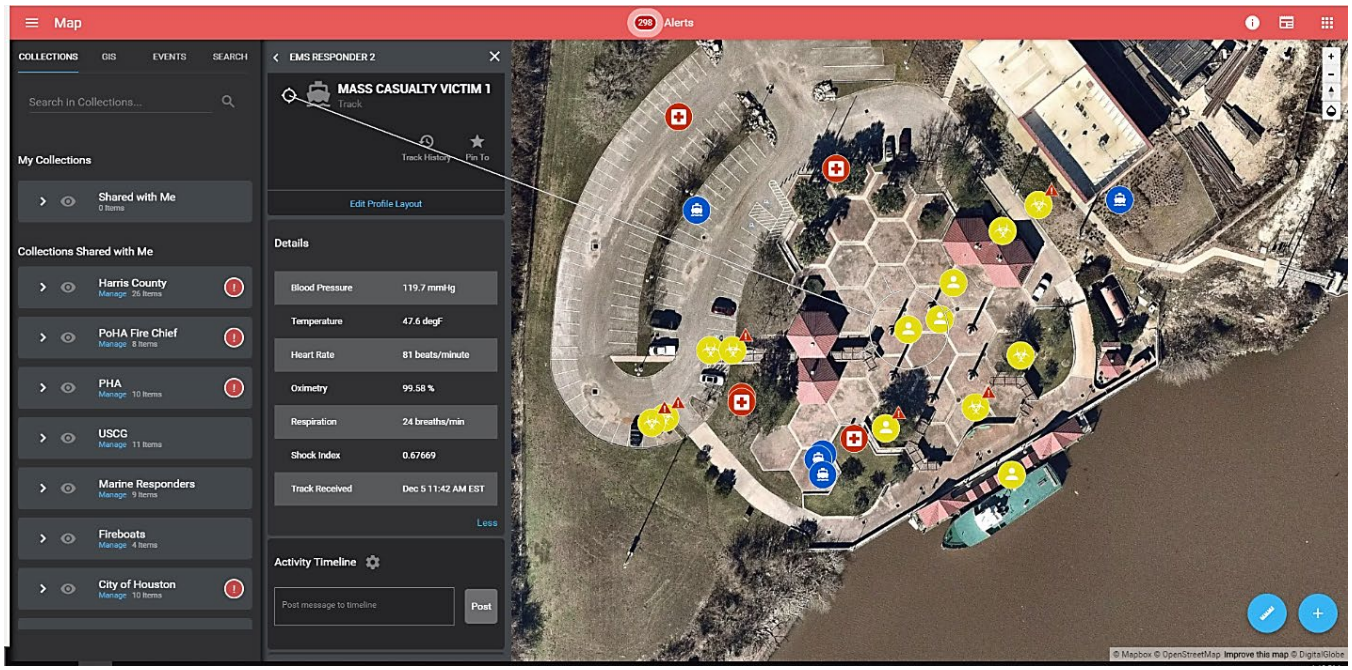

Figure 6. AVERT C2 Screenshot Showing Collections and Sidebar Information

When alerts were received, AVERT C2 showed a notification in a red bar at the top of the screen, showed the sensor and alert data in a sidebar, and placed a red "flag" (a red triangle with an "!" in it) on top of the corresponding responder's icon to signify which responder had an alert associated with him/her. This is shown in Figure 7.

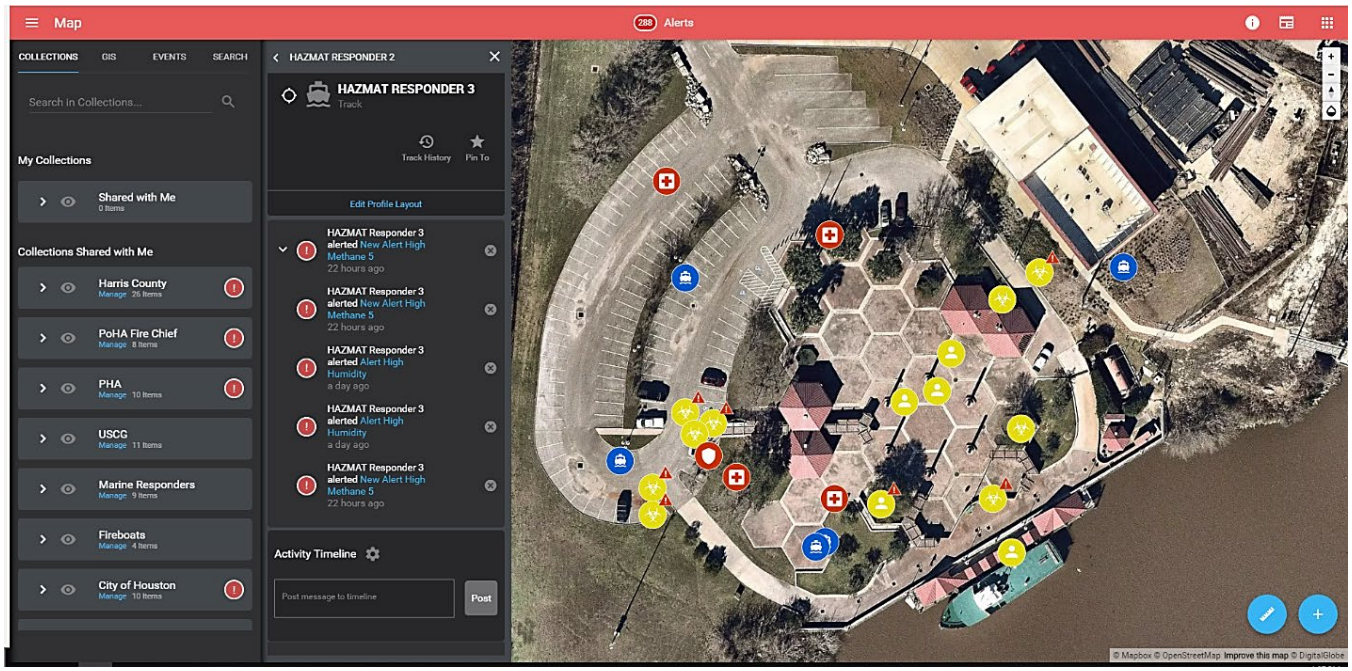

Figure 7. AVERT C2 Screenshot Showing Responder Alert Information

Intrepid Response, Intrepid Networks

The Intrepid Response situational awareness system was different from AVERT C2 in that the sensor data fed to it was passed via the ArdentMC Vortex Router, which converted the SensorUp data into the EDXL DE format. This conversion reduced the development requirements for Intrepid Networks (but increased the development efforts for SensorUp) and enabled them to get responder data displaying on the application.

The Intrepid Response display showed the identification of each responder in a "tag" at the responder's location using their assigned ID number—the "PXXX" number, shown in Figure 8, primarily displays the HAZMAT victim VitalTag data. As can be seen in Figure 8, Figure 9, Figure 10 and Figure 11, the tags differentiate among the types of responders, which are:

- A grey tag with a star indicates a HAZMAT victim or a firefighter;
- A pink tag with the biohazard symbol indicates a HAZMAT responder;
- A pink tag with a medical bag with a "+" sign indicates an EMT;
- A pink tag with a shield indicates a police officer; and
- A pink tag with a "medal" indicates a responder supervisor.

Following the Responder ID, the tags contain differing sensor data, depending upon the sensor. The abbreviations are:

Abbreviation	Item
HR	Heart Rate
PO	Pulse Oximetry
BT	Body Temperature
RR	Respiration Rate
SI	Stain Index
AT	Air Temperature
Hu	Humidity
AP	Air Pressure
Ac	Acid
Am	Ammonia
CD	Carbon Dioxide
CM	Carbon Monoxide
CI	Chlorine
Di	Diborane
HC	Hydrogen Cyanide
HF	Hydrogen Fluoride
HS	Hydrogen Sulfide
Hy	Hydrogen
Io	Iodine
Me	Methane
ND	Nitrogen Dioxide
Ox	Oxygen
Pg	Phosgene
Ph	Phosphine
SD	Sulfur Dioxide

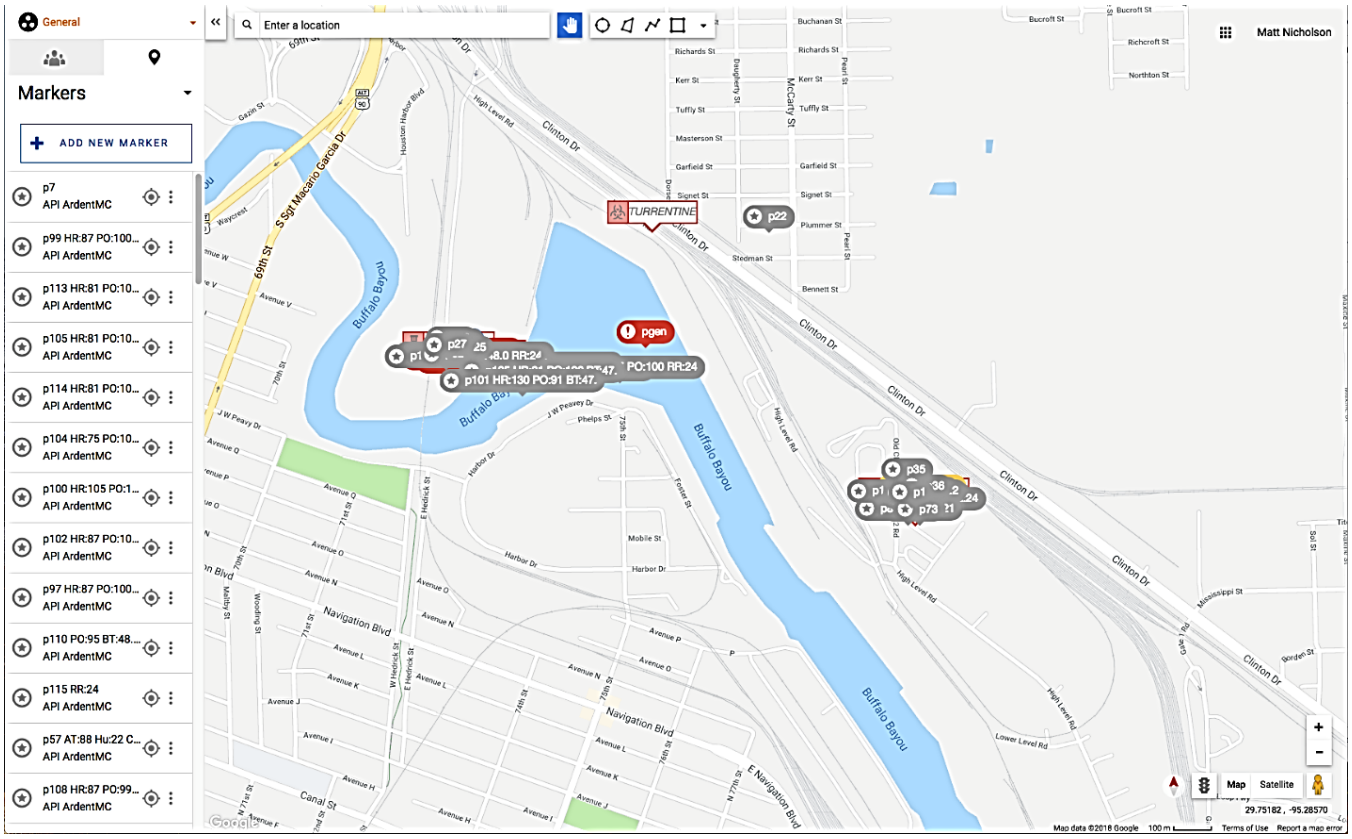

Figure 8. Intrepid Response Display of Patient Sensor Data

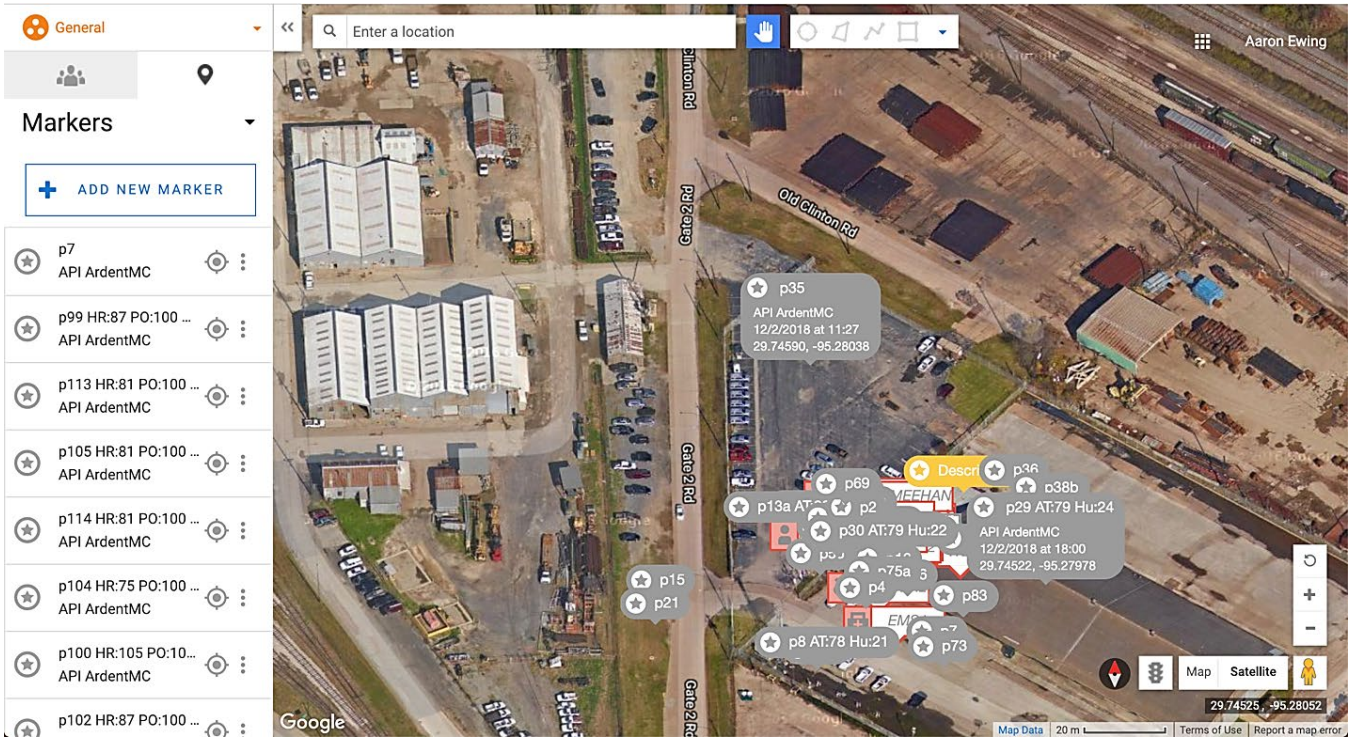

Figure 9. Intrepid Response Display of Responder Sensor Data

Intrepid also allowed the user to manually display text in a tag at a geographical location on the screen, as shown in Figure 10 ("Command Post" and "M/V Sam Houston") and Figure 11 ("COTP Order").

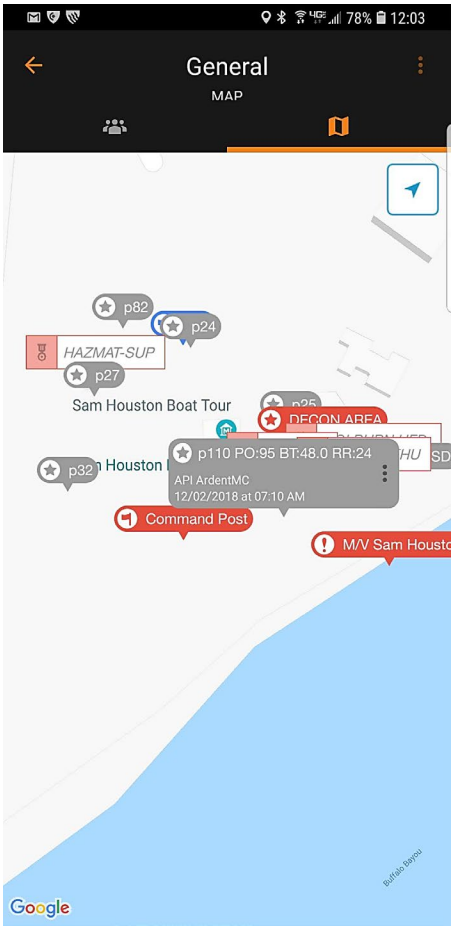

Figure 10. Intrepid Response Manually-Entered Locations

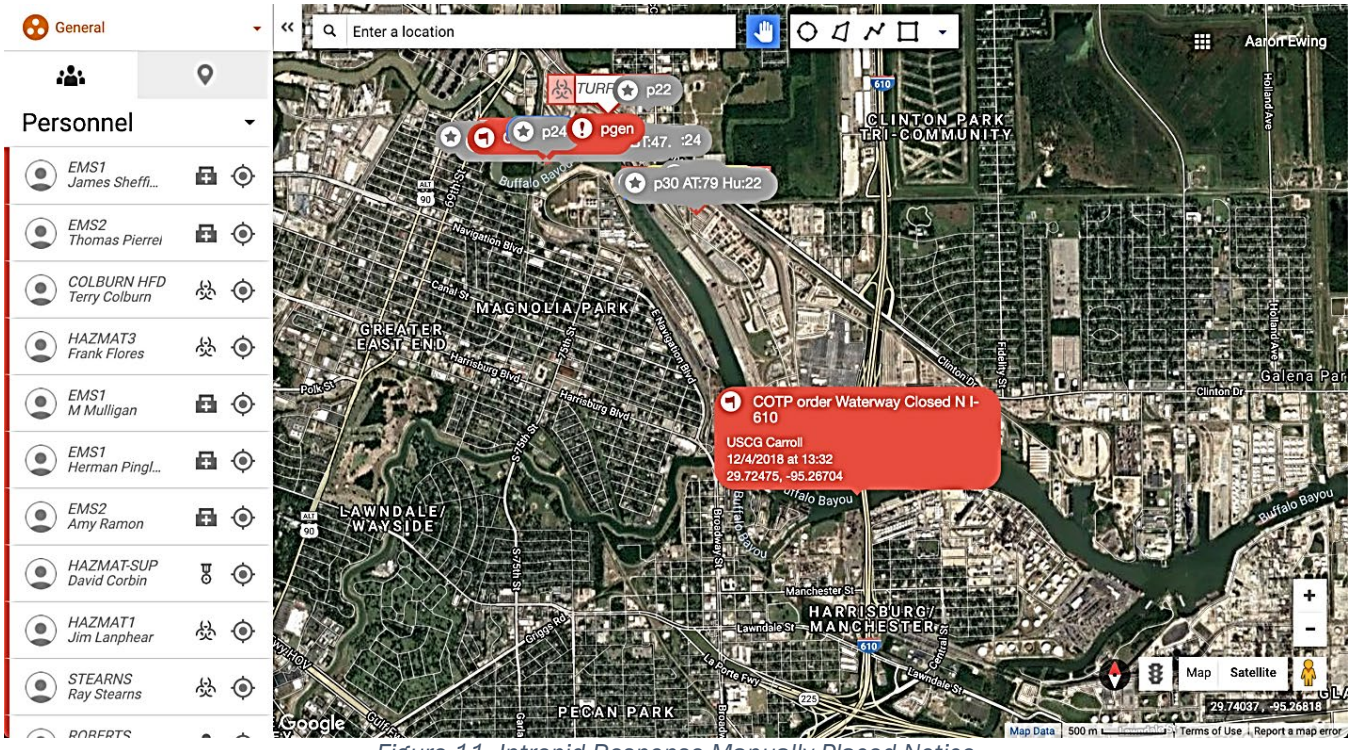

Figure 11. Intrepid Response Manually-Placed Notice

Haystax Constellation, Haystax

During the OpEx, Haystax Constellation was used to send simulated incident briefings and other relevant incident data to and from the players. It was displayed on the monitors and devices used by the dispatchers and the Incident Commander.

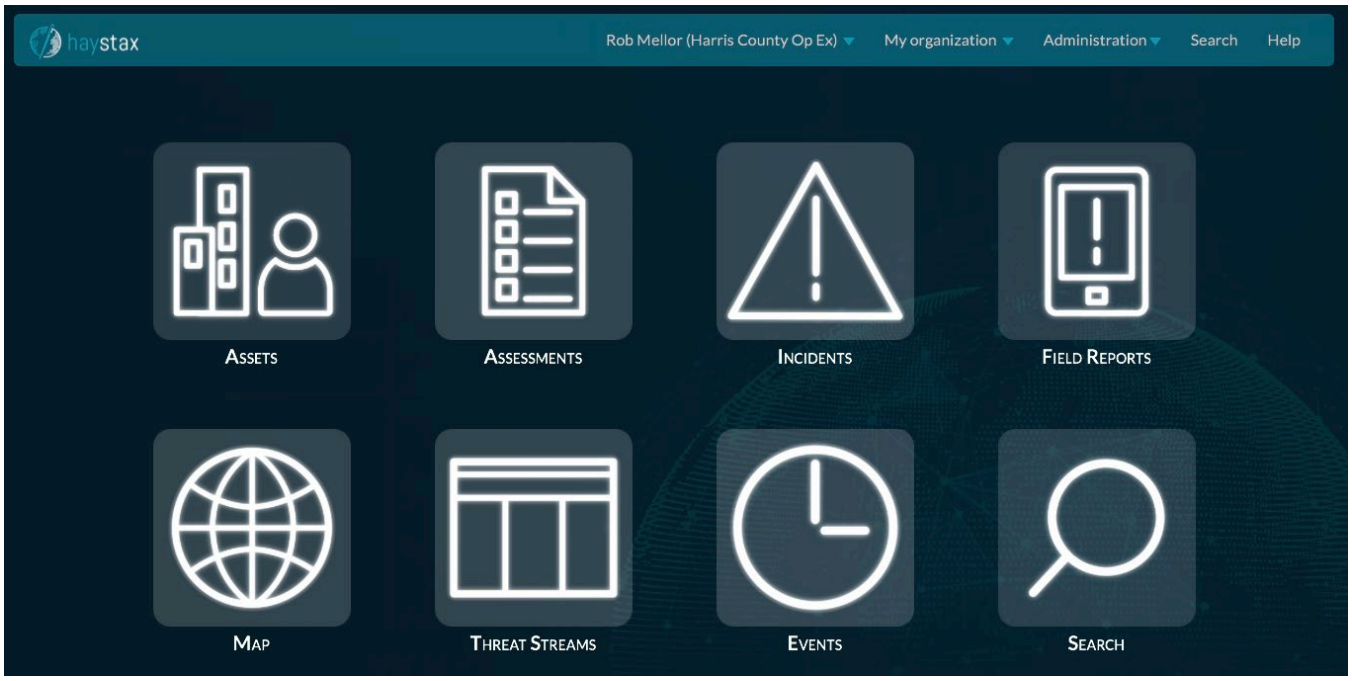

Figure 12. Haystax Constellation Main Menu

One way Haystax Constellation displayed sensor and alert input was via their "threat stream" channel, showing the raw data for sensors and alerts in text boxes on the screen, as shown in Figure 13. The Threat Streams app provided first responders with a real-time streaming view of responder status and sensor device readings. In the Haystax Constellation Threat Streams view, the left most column was set up as an "OpEx Alerts" stream, configured to present only the critical alerts. Other columns were available to monitor specific devices as well.

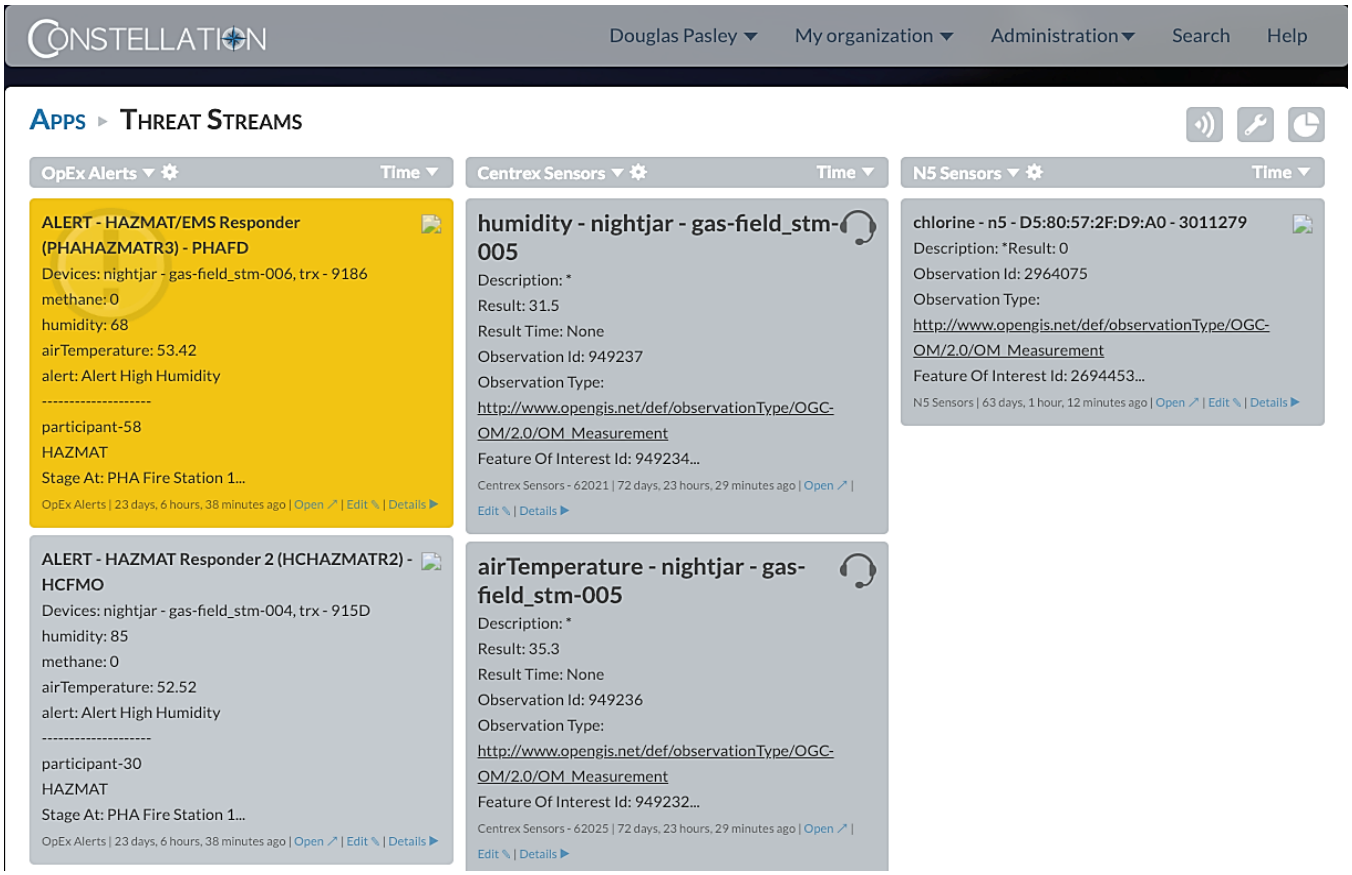

Figure 13. Haystax Constellation Display of Threat Streams

Haystax Constellation was also able to display the information on a map of the area (shown in Figure 14), with the location of each responder and the associated sensor data displayed as clickable icons on the map. Clicking on a first responder presents their full status information in a pop-up window.

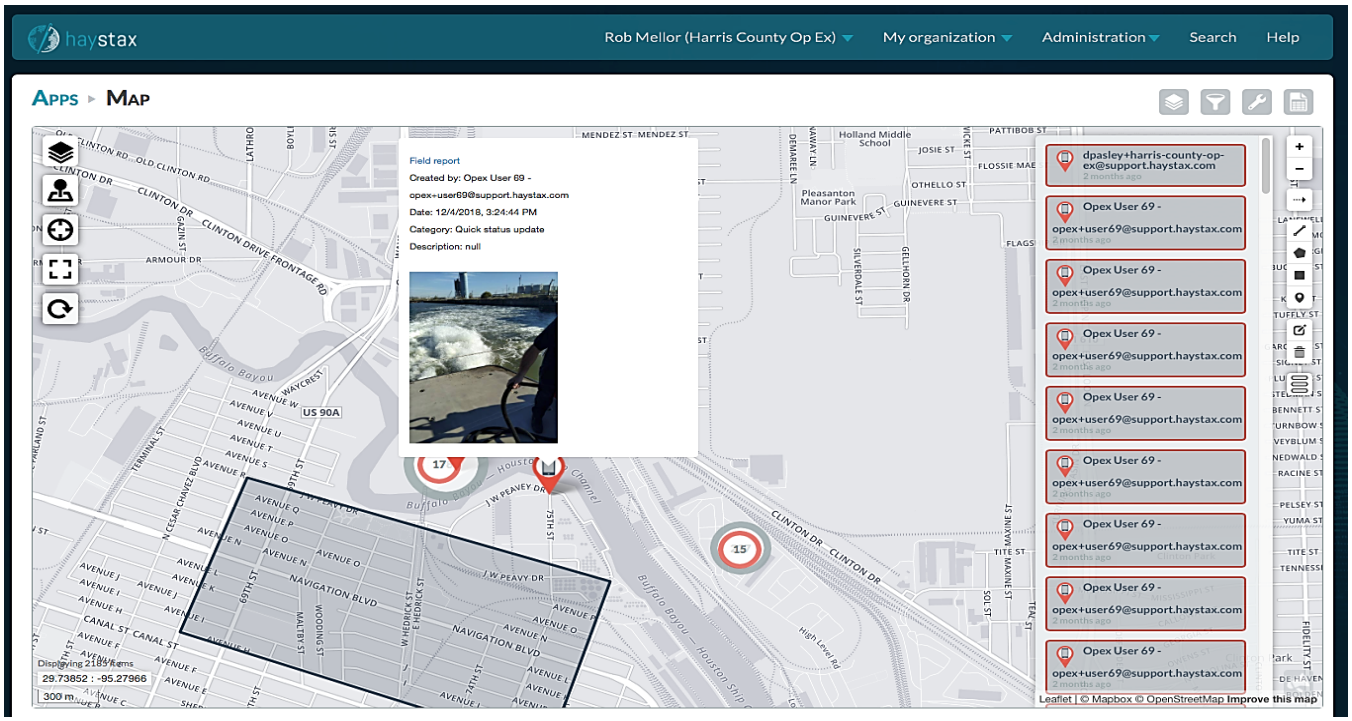

Figure 14. Haystax Constellation Map

In addition to monitoring first responders and their sensors, Haystax Constellation also provided a Field Report capability that allowed first responders to submit photographs and observations directly from the field using a mobile app. These Field Report submissions immediately became viewable on the main command map, providing a boots-on-the-ground view of the unfolding situation for everyone. Field Reports are seen in Figure 15.

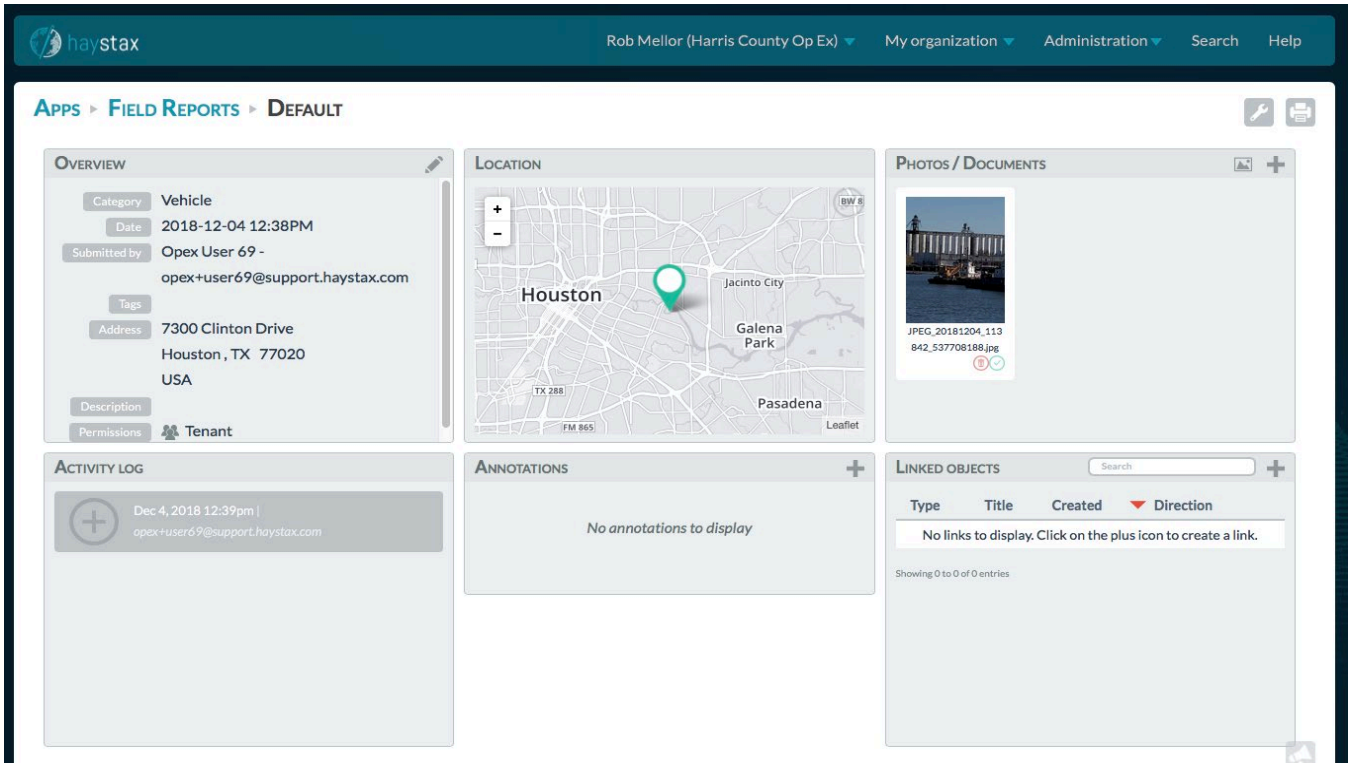

Figure 15. Haystax Constellation Display of Field Report Details

NEON Command, TRX Systems

During the OpEx, the Incident Commander used the TRX NEON Command 3D visualizer to track the responders as they searched the M/V Sam Houston and USCGC Hatchet for HAZMAT victims. NEON displayed the location of the first responders in three dimensions, showing the actual floor level on which they were searching. The LTE connectivity of the Sonim phones penetrated the hulls of USCGC Hatchet's barge and the M/V Sam Houston sufficiently for the responders to be tracked accurately. Although the NGFR team was unable to provide ships blueprints for either the USCGC Hatchet (and its barge) or M/V Sam Houston, the NEON solution was able to display when the HAZMAT responder was at the level of the main deck or above the main deck on M/V Sam Houston (see Figure 16).

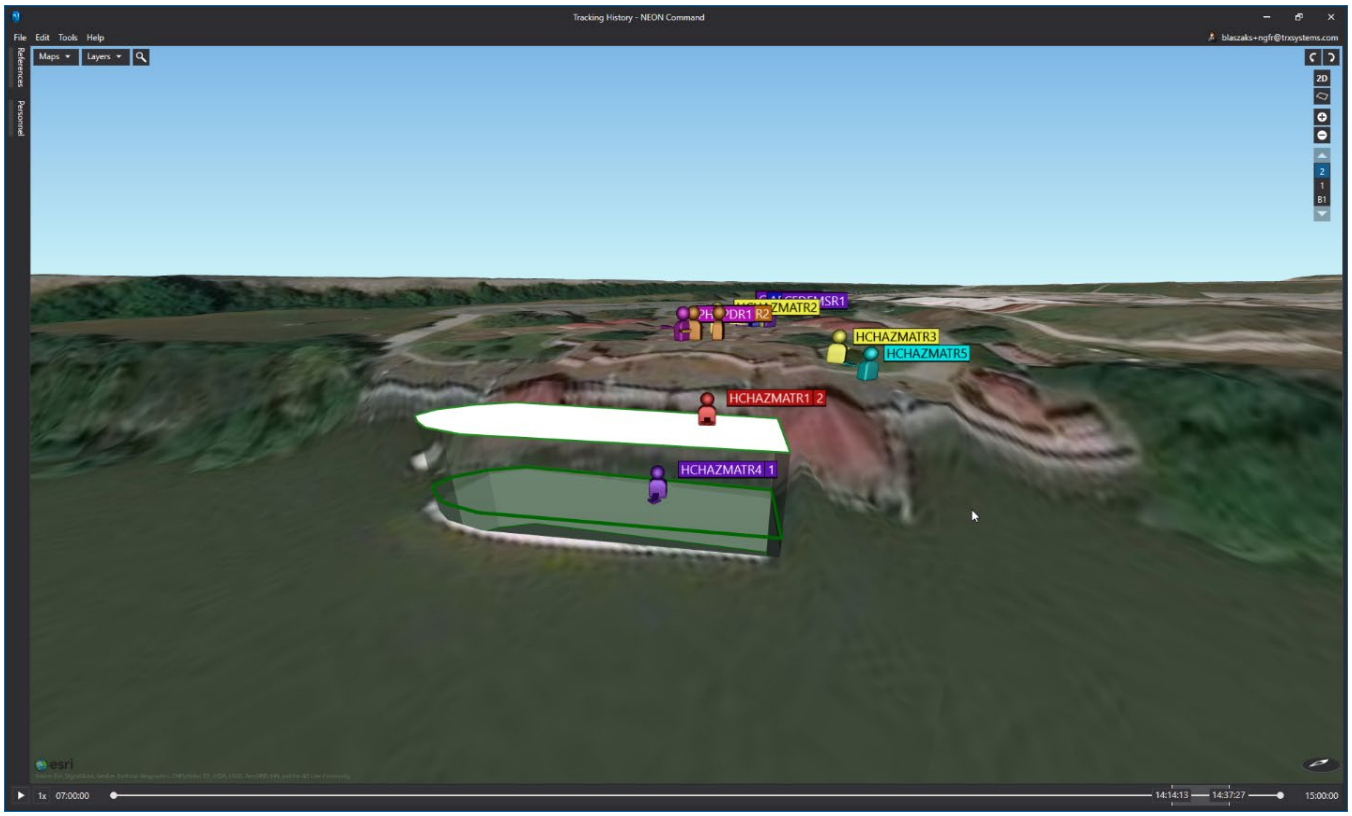

Figure 16. NEON Command 3D Tracking of HAZMAT Responders on M/V Sam Houston

NEON Command was also able to show a "breadcrumb" trail of tracked responders within the OpEx venue as shown in Figure 17. All the NEON Tracking information was recorded and available for after action review by OpEx participants.

Figure 17. NEON Command Breadcrumb Trails of Responders on Marine Units

Esri Ops Dashboard, Esri via Ardent MC, and Vortex Router, Ardent MC

The Esri Ops Dashboard is an Esri-based situational dashboard which uses Esri Portal and ArcGIS awareness to display and help visualize the data collected in the Vortex Router from both personnel and vehicles for use in emergency situations. During the OpEx, the Esri Ops Dashboard was used as a backup situational awareness platform in case one of the primary situational awareness platforms failed. It was also used to demonstrate the integration of the sensor data because many smaller jurisdictions only have a CAD system and an ArcGIS-based system for use as situational awareness applications, and CAD integration is frequently expensive, requiring additional development.

The Esri Ops Dashboard displayed responders and provided base maps and several different customizable layers via the Vortex Router for filtering points on the map. Each point was selectable, and when selected would display additional information about the point (e.g., responder identification, sensor readings).

The Vortex Router was the primary data "bridge" between the SensorUp SensorThings API server and the Intrepid Response server. The SensorUp server provided data to the Vortex Router using the Organization for the Advancement of Structured Information Standards (OASIS) Emergency Data Exchange Language (EDXL) Distributed Element (DE) format. The feed from the Vortex Router to Intrepid Response was ingested and the data was displayed as shown above in Figure 8, Figure 9, Figure 10 and Figure 11.

OpEx RESULTS

The OpEx successfully demonstrated both the advantages of the situational awareness platforms and their shortfalls as currently implemented. All of the requirements were fulfilled with the delivered capabilities, but with varying degrees of success. The feedback from participating first responders was overwhelmingly favorable.

The Incident Commander, other command staff and first responders were very pleased to be able to view the location of all participating first responders and sensor data on their smartphones, tablets and monitors. In addition, the Port of Houston and Harris County dispatchers who provided dispatcher services for the event were able to see the location of each first responder and their sensor data across the incident area, which the OpEx data integration work made possible. It was particularly important that they could see data from multiple response agencies and multiple jurisdictions in one place, which met several local requirements identified during the Hurricane Harvey after action review.

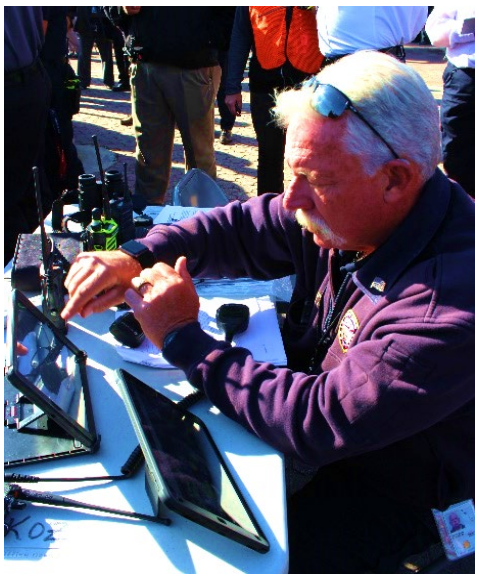

Figure 18. Port of Houston Fire Command Staff Views a Dashboard

Additional information can be found in sources listed in the References and Recommended Reading section. A complete Harris County OpEx After Action Report is under development and will be posted at www.dhs.gov/NGFR and available upon request from NGFR@hq.dhs.gov.

IMPLEMENTATION FOR YOUR AGENCY

During the NGFR – Harris County OpEx, DHS S&T deployed an integrated suite of IoT devices and situational awareness platforms that enabled public safety decision makers with real-time incident information. How can your agency apply this case study and best practices to improve your capabilities? DHS S&T has developed the following questions to help your agency and/or all of the public safety agencies in your community determine situational awareness requirements, current capabilities, target capabilities and implementation considerations.

One of the most important features of the NGFR – Harris County OpEx was getting the data for responders from different agencies and jurisdictions integrated into a unified situational awareness platform. If your agency regularly responds to multi-jurisdictional incidents, you would likely benefit from a similar unified multi-agency approach to situational awareness. Even if different agencies own different brands of equipment, with NGFR integration approaches the data can be shared through common situational awareness platforms. To plan for multijurisdictional interoperability, bring your regular public safety partners to the table when using this guidance to define your approach to situational awareness solutions.

Due to the significant capability differences between agencies and their capabilities around the country, there is not a one-size-fits-all approach for situational awareness. However, DHS S&T believes that these questions will help guide your agency and partners towards implementing and deploying situational awareness solutions that are right for your community.

Determine Enhanced Situational Awareness Requirements

The first step for your agency is to assess your enhanced situational awareness requirements. DHS S&T recommends involving a variety of responders at different levels of command in your requirements discussion to ensure all perspectives are considered. Discussion topics include:

- **Who**: Who needs enhanced situational awareness? Public safety answering point (PSAP) and Dispatcher? Incident Commander? Other command staff? Frontline first responders? Think through all stages of an emergency from 9-1-1 call through conclusion and think about the different types of information each of these roles need at each stage of response.
- **What**: What is the scope of enhanced situational awareness solutions that your agency requires and has budget for (types of sensors, situational awareness platforms)? What information do your responders and commanders need real-time access to make better decisions about responder and community safety? What types of sensor information best aligns with the high impact or high probability threats your community faces (e.g., HAZMAT sensors for cities with chemical manufacturing factories)? Which platform and sensor options are nice to have versus necessary, and how does your agency and partners prioritize the possibilities?
- **Where**: Where is enhanced situational awareness needed? Will it be deployed to the edge (incident scene) or mostly used by command at a PSAP or station house? Will the capabilities be easily deployable for significant multijurisdictional incidents or mutual aid situations?
- **When**: Does your agency need an enhanced situational awareness solution on a full-time or part-time basis? Is it a surge capability for major incidents, used to manage everyday incidents, or both?

Identify Current Enhanced Situational Awareness Capabilities

The second step is for your agency to determine your current capabilities for enhanced situational awareness. Discussion topics include:

- What legacy situational awareness platforms do you have in operation? Think of applications in the PSAP and in the field that provide real-time information about your personnel, resources, environment and hazards.
- What sensors are currently in use by your or other participating agencies? Think of networked and non-networked sensors, such as handheld HAZMAT detectors. Also think of other types of sensors that might provide useful incident information, such as traffic cameras, in-building sensors and weather stations.
- Does your agency have the capability to host or contract with a server-provider to integrate the sensor data?
- Given your current capabilities, which of your previously-identified requirements remain unmet?

Identify Enhanced Situational Awareness Solutions

Once your agency has determined your situational awareness requirements and current capabilities, you need to identify which solutions can fulfill those gaps. Your agency should follow internal guidance to evaluate the costs of and functionality provided by each solution to determine which one(s) to select.

First, determine which types of sensors are necessary based on your requirements:

- Physiological sensors (For responders, patients or both?)
- HAZMAT sensors (Chemical gas and substance sensors? Radiation sensors?)
- Environmental sensors (Flashover heat levels? Weather conditions, including wind direction? Floodwater depth and current sensors?)
- Location sensors (2D or 3D? Indoor/outdoor or just outdoor? Person, vehicle or both?)

Your agency then needs to identify legacy (or new) situational awareness platforms that you wish to integrate into, considering:

- CAD systems;
- Map-based situational awareness applications; and
- Collaboration and messaging applications.

Finally, your agency needs to consider the technical requirements of implementing a situational awareness system with real-time sensor integration onto situational awareness applications. Discussion topics include:

- Are there solutions that could be deployed within your agency's existing infrastructure?
- Are there cloud-based solutions that could be integrated into your agency's existing infrastructure while meeting security and privacy guidelines?
- What are the technical capabilities of agency-provided or bring-your-own-device smartphones, tablets and computers (ruggedization, storage, network access, data plans, processing power)?
- What are the technical capabilities of internet access in the field, including bandwidth for pushing steady streams of sensor data and/or large packets of video and voice data?
- Where will the data integration server reside, whether hosted by your agency or hosted by the server vendor?
- Does your agency have adequate technical support staff for set-up, device management and troubleshooting?

Implement Solutions

Once your agency has selected the sensor and situational awareness platform solution(s), you should develop an implementation plan for the system(s). The plan would include processes for:

- Procurement of the software and hardware;
- Installation of the components;
- Configuration of the devices and associated applications;
- Training support personnel on the maintenance of the devices and applications; and
- Training the first responders on using the systems.

After implementing and testing sensor integration, your agency will be able to monitor real-time sensor data using enhanced situational awareness applications.

SUMMARY

This NGFR case study provided an overview of the NGFR – Harris County OpEx, with a focus on the implementation of enhanced situational awareness capabilities to augment mission response through information sharing and common operating pictures. It also provided a discussion guide that may help your agency determine requirements, current capabilities, target capabilities and implementation considerations for situational awareness solutions.

If your agency finds this NGFR case study useful for improving your situational awareness capabilities and solution implementation, DHS S&T would greatly appreciate your feedback. Please contact the NGFR team with stories from the field, questions or comments by emailing NGFR@hq.dhs.gov.

Figure 19. OpEx Director Sridhar Kowdley Describes How OpEx Technologies are Deployed

REFERENCES & RECOMMENDED READING

Next Generation First Responder Apex Program (https://dhs.gov/ngfr)

This website provides NGFR Apex program descriptions, updates and knowledge products.

NGFR Integration Handbook (https://dhs.gov//science-and-technology/ngfr/handbook)

This three-part document provides technology developers with a standards-based architecture for developing and integrating interoperable first responder technologies.

NGFR – Harris County OpEx Playbook, expected February 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document is the guide that was used to execute the NGFR – Harris County OpEx.

NGFR – Harris County OpEx After Action Report, expected March 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document thoroughly describes the planning, execution and results of the NGFR – Harris County OpEx.

NGFR Case Study: Data Integration, expected February 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document describes sensor data integration during NGFR – Harris County OpEx.

NGFR Case Study: Mobile Device Management, expected February 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document describes mobile device management during NGFR – Harris County OpEx.

NGFR Case Study: Patient Monitoring, expected February 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document describes patient monitoring applications during NGFR – Harris County OpEx.

NGFR Case Study: Sensor and Event Alerts, expected February 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document describes standard formats for sensor and event alerts during NGFR – Harris County OpEx.

NGFR Case Study: Sensors, expected February 2020 (will be posted on https://dhs.gov/ngfr and available upon request from NGFR@hq.dhs.gov)

This document describes various sensors used during NGFR – Harris County OpEx.