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Grant County - DHS Science and Technology Directorate

# Next Generation First Responder Apex Program Technology Experiment (TechEx) After Action Report

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Next Generation First Responder Apex Program
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# Next Generation First Responder Apex Program
# Technology Experiment (TechEx)
# After Action Report

## Acknowledgments

The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Next Generation First Responder (NGFR) Apex Program would first like to thank the Grant County Sheriff's Office, the Grant County Multi-Agency Communications Center (MACC), Grant County Fire Districts 3 and 5, Grant County Technology Services (GCTS), and the Moses Lake Regional Tactical Response Team (TRT) for their participation in the DHS S&T NGFR Technology Experiment (TechEx).

The development and success of the TechEx would not be possible without S&T partnerships with technical performers such as: Ardent Management Consulting Group, Department of Commerce National Institute of Standards and Technology (NIST) Public Safety Communications Research (PSCR) Division, Integrated Solutions for Systems (IS4S), the Johns Hopkins University Applied Physics Laboratory (JHU/APL), Oceus Networks, Inc. and SpectraRep, LLC. Lastly, DHS S&T would like to acknowledge program management support from Booz Allen Hamilton and CSRA Inc. In addition to being a technical performer, JHU/APL also provided support for program management efforts.

The willingness and dedication of Grant County first responders, as well as S&T partners and performers, has facilitated the development of innovative technology that will help the nation's first responders become better protected, connected and fully aware to maintain the safety of American lives and communities.

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## Handling Instructions

The title of this document is the ***Grant County – DHS Science and Technology Directorate Next Generation First Responder Apex Program Technology Experiment (TechEx) After Action Report***.

This document provides participating agencies' leadership and first responders, public safety partners, technical support entities, technology developers and funding sources with an overview of the implementation and outcomes from the TechEx.

First responder participants were asked to focus on reacting and responding in accordance with their respective response plans, policies and procedures as they pertain to specific scenario-related events.

The preparation and documentation for the Grant County TechEx is unclassified. Any control of information is based more on potential public sensitivity regarding scenario-related events, which are fictional, rather than the actual After Action Report content.

Some content included in this report was intended for the exclusive use of planners, controllers and data collectors, but all participants may view this report.

All reviewers are asked to use appropriate guidelines to ensure the proper control of information within their areas of expertise and to protect this material in accordance with current jurisdictional or agency policies. Public release of information is at the discretion of the U.S. Department of Homeland Security Science and Technology Directorate. For more information about the Grant County TechEx, please consult FRG.

**DHS S&T First Responders Group Contact Information:**

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# Executive Summary

## ES.1 Background

The Next Generation First Responder (NGFR) Apex Program[1] recently partnered with first responders in Grant County, Washington, to assess the capabilities of several NGFR technologies to support their public safety operations. This effort, known as the *Grant County – DHS Science and Technology Directorate Next Generation First Responder Apex Program Technology Experiment (TechEx)*, involved deploying a system of systems set of technologies that facilitated:

- Geo-location of first responder units and personnel on map displays at the Grant County Multi-Agency Communications Center (MACC), command posts and smartphones.
- Wireless data service at the Gorge Amphitheatre concert venue, campgrounds and along the Columbia River valley using various broadband technologies, including cellular broadband (Long Term Evolution (LTE)), Wi-Fi and digital TV Datacasting.
- Ability to stream and view real-time video from Unmanned Aircraft systems (UAs) at the MACC, command posts, emergency management and other destinations from a UAs and smartphones.
- Capability to monitor first responders' physiological data and send wirelessly to the MACC and/or command posts for viewing using a video "dashboard" on a monitor.
- Support for communications and information dissemination using a combination of County-owned land mobile radios (800-MHz P25), commercial mobile networks and a deployable government-band public safety broadband LTE network (Band Class 14 (BC 14)) network for data communications.

The DHS Core/Target Capabilities identified for this experiment included: (*1) Operational Communications, (2) Responder Health and Safety, (3) Situational Awareness, and (4) Public Safety and Law Enforcement*. The overarching objectives that were used for planning and evaluation purposes were to:

1. Perform a needs assessment and establish baseline requirements for participating first responder groups from Grant County, Washington.

[1] The Department of Homeland Security (DHS) Science and Technology (S&T) Directorate, First Responders Group (FRG) launched the NGFR Apex program in January 2015 as a strategic initiative to develop and integrate next-generation technologies with the goal of expanding first responder mission effectiveness and safety. The NGFR Apex program seeks to help tomorrow's first responder be more protected, connected and fully aware. When firefighters, law enforcement officers and emergency medical services have enhanced protection, resilient communications and advanced situational awareness, they are better able to protect our communities and make it home safely.

2. Assess technologies that may provide potential solutions for Grant County's mission requirements and needs.
3. Evaluate the operational deployment of those technologies and their integration with existing first responder/public safety systems through scenario-based testing.
4. Determine the extent to which the deployed technologies are usable, supportable, safe and acceptable to the first responder users.
5. Provide an After Action Report that provides an overview of the TechEx outcomes based on feedback and input from the first responder participants, and includes technology and operations-based recommendations.

## ES.2 Implementation

The TechEx was conducted on June 6-7, 2017, in the area around the Gorge Amphitheatre near George, Washington. It was preceded by two site visits (December 2016 and February 2017), a dry run at the same location in May 2017, as well as technology integration testing in Boulder, Colorado, in April 2017. The scenario was based on a routine concert event at the Gorge Amphitheatre, which attracts up to 30,000 attendees and campers. Grant County first responders provided input and guidance to the scenario to ensure it represented their real-world operations. The scenario was comprised of three vignettes, which involved the Grant County Sheriff's Department and supporting agencies preparing for a weekend of concert events at the Gorge Amphitheatre, and included simulated incidents to prompt response efforts and use of the NGFR technologies.

**Photographs from Onsite Events**

The NGFR Apex Program recognized that the needs and requirements of the first responder community must provide the underpinning framework for the TechEx. Therefore, in Grant

County, as in other similar efforts, the planning team incorporated four key features to help ensure the TechEx reflected the needs and requirements of the Grant County end-users, or first responders: (1) Collaborative Planning, (2) End-user Engagement, (3) Expert Observation, and (4) Rigorous Documentation.

## ES.3 Summary of Results

Fifteen different NGFR technologies were assessed for their first responder support capabilities to: (1) provide or enhance network capability; (2) route or manage data; and (3) enhance situational awareness, which included (4) geo-location, (5) monitoring physical health and (6) video dissemination. These capabilities and sub-capabilities were integrated into an ad hoc (i.e., non-permanent) architecture to support the TechEx. In summary, the data collectors were able to observe, document and collect data to validate the utility of all six aspects of the test configuration, to include:

1. Successful implementation of an enhanced integrated network communications architecture that enhanced public safety communications.
2. Successful implementation of an architecture capable of maintaining connectivity with cloud services, while consistently leveraging the capabilities implemented in each.
3. Implementation of an architecture that provided increased situational awareness and integrated with Grant County's existing systems.
4. Achieved the ability to geo-locate end-users (based upon their devices) and vehicles.
5. Implemented a system architecture capable of disseminating real-time video streams to end-users.
6. Implemented testing of basic data collection and dissemination capabilities for two physiological sensor-based systems.

The TechEx 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 the first responder to identify gaps and needed enhancements to be addressed in future events. The evaluation team was able to verify that the architecture implemented and configured in Grant County was easy to install, easy to use and provided capabilities that were valued by the first responders.

There were twelve capability-related requirements identified and used for the TechEx planning and evaluation. Across the twelve requirements identified for evaluation, a total of 23 tests were planned. Of these 23 tests, 11 tests (48 percent) were categorized as a success or a partial success, four tests (17 percent) were categorized as a failure or conditional failure, and eight tests (35 percent) were noted as a lack of capability. Overall, the technologies evaluated during this

experiment were effectively used and integrated into existing response systems. It is important to note that there were several technologies used in this TechEx that were not yet fully developed and, therefore, affected test results. We have included recommendations relevant to these technologies because all developers can benefit from the direct end-user feedback acquired through this experiment.

For those six tests that were determined to be *failures*, *no test* or *conditional failures*, outcomes were associated with immature technologies still in the development phase. With respect to the three tests that were *not tested*, two of the three tests were associated with alerts and alarms, which can be challenging to quantify in real time during operational testing; a third was affected by the time required to connect to a Personal Area Network (PAN) using Bluetooth. It was acknowledged that for future events, the ability to assess automated alarms and reports will require additional tracking and reporting capabilities for evaluation purposes.

Key findings from the TechEx in the area of connectivity failures and location accuracy, especially during Vignette A, were related to the initial set-up of a technology; however, that was the purpose of Vignette A: to serve as a communications test and roll call, representative of a real-world preparedness event. An example of one of the findings during Vignette A was losing geographic location awareness in the smartphone situational awareness and location tool, Watchtower, due to an error in the software that did not recognize spaces in user names when entered into the application. It was recognized that data included in this report, which reflects such issues, likely represents a need for additional end-user training, recognizing a learning curve for implementing new technologies, need for first responder feedback, and the need to correct technology failures or deficiencies; all are addressed in the Lessons Learned section of this report.

## ES.4 Conclusions

The Grant County TechEx integrated highly complex systems to provide useful capabilities to the first responder community. The capability to view first responder physiological data, as well as real-time footage of situations, effectively enhances situational awareness promoting safety and efficiency when responding to an incident. For example, the ability to view live footage from a UAs on a large screen in the command center was pivotal in providing situational awareness to incident command. Prior to the introduction of this capability, sharing of video footage was limited at best. While some technologies are not sufficiently mature and are still in active development, other technologies are off-the-shelf and have been demonstrated to be of value through the TechEx. These technologies, such as live streaming from smartphones and a UAs through Datacasting, can provide immediate on-going operational support to the Grant County first responder community.

There were four fundamental factors that contributed to the TechEx success. These four factors were used to guide data collection efforts and measure the impact, and they played a key role in ensuring results represented the first responders' input and perspectives:

1. The NGFR technologies were placed directly in the hands of a specific set of first responders for use in their mission-specific operational environment; therefore, the outcomes and analysis found in this report are based directly on end-user needs, requirements and feedback.
2. Quantitative data was captured to the extent possible to help assess enhanced information sharing capabilities (i.e., video quality, timeliness of information shared, and data captured and retained for ongoing situational awareness).
3. A baseline "as-is" state of the Grant County operational environment was completed and used throughout the planning process to support the TechEx analysis.
4. The post-vignette hot wash events were structured to focus on and capture end-users' feedback with questions geared towards assessing improved capabilities and eliciting feedback and participants' recommendations (i.e., enhanced situational awareness, improved data sharing, etc.).

The TechEx was viewed as an overall success. First responder feedback was overwhelmingly positive as per the below sample statements:

- "Planner and participants successfully worked across multiple departments and teams."
- "The majority of connections were reliable and maintained, with improvements in connectivity noted while proceeding from Vignette A to Vignette C."
- "Teams were flexible and engaged; small changes to the scenario to accommodate end-user needs were completed with ease."
- "The planning and implementation was well thought out. Additionally, the playbook was well-designed and supported the events and technology setup."

In summary, the Grant County TechEx was a significant and unique event because it provided an excellent opportunity for the Next Generation First Responder Program to gain first-hand knowledge of first responders' needs and have direct access to their feedback, input, requirements and recommendations—all achieved within the first responders' own operational environment using a scenario representative of their real-world events. "Our first responder community very much appreciated the efforts put forth by DHS to ensure our voices were heard, our guidance considered and our input utilized," said Chief Deputy Darrik Gregg. "Overall, the Grant County TechEx was a positive experience that provided our public safety with insight as well as new capabilities to improve our preparedness and response."

# Chapter 1. Introduction

The Next Generation First Responder (NGFR) Program partnered with Grant County, Washington, on June 6 and 7, 2017, to assess several NGFR technologies and their capabilities to support Grant County public safety operations. This effort, known as the Grant County – Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Next Generation First Responder Apex Program Technology Experiment (TechEx), included technologies that provide: the location of first responder units and personnel; communications, to include wireless voice, data coverage and live video streaming; and live monitoring of responder heart rate and body temperature.

The overarching objective for the event was to conduct a TechEx in Grant County in collaboration with Grant County public safety officials and first responders. The TechEx was based upon the integration of technologies selected by NGFR to support an operationally relevant mission-based scenario centered on law enforcement and emergency response stakeholders. This system of systems TechEx combined multiple technologies to conduct a preliminary experiment of how they could be incorporated into the daily operations of first responders in Grant County to enhance awareness and safety.

## 1.1 Goal of this Report

The After Action Report (AAR) aligns with the Grant County TechEx objectives and the relevant Target (Core) Capabilities. This ensures a consistent taxonomy for follow-on efforts that transcends other experiments, tests and exercises to ensure support for ongoing reporting and analysis. The goal of this AAR is to provide an overview of the performance related to each objective, corresponding technologies and associated core capabilities by documenting the preparation, design, execution and results obtained from the TechEx.

## 1.2 Intended Audience

The intended audiences for this AAR are the participating agencies' leadership and first responders, public safety partners, technical support entities, technology developers and funding sources.

## 1.3 Venue: Grant County and the Gorge Amphitheatre

Grant County, Washington, named for U.S. President Ulysses S. Grant, is located in the center of Washington State. The fourth largest county in the state at 2,791 square miles, major features include the Grand Coulee Dam in the northernmost corner of the county, Moses Lake (its largest

city—and lake), the Columbia River on its western border and the Gorge Amphitheatre concert venue.

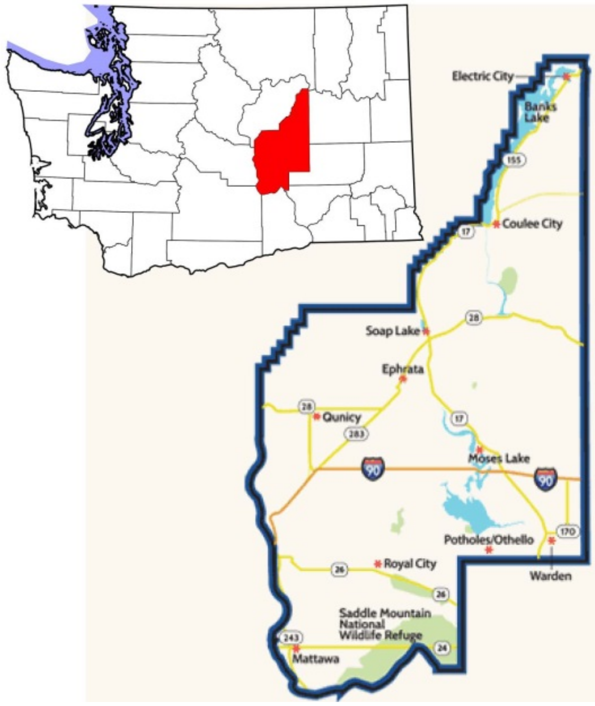


**Figure 1-1. Map of Grant County, Washington**

The Gorge Amphitheatre is a 27,500-seat outdoor concert venue that hosts big-name performers such as Coldplay, Dave Matthews Band, Pearl Jam, Nickelback, Van Halen and the Who. The Gorge Amphitheatre is located in the rural town of George above the Columbia River gorge in Grant County. It is one of the most scenic concert locations in the world, offering concert-friendly summer weather, as well as lawn terrace seating. Opened in 1985, the venue provides sweeping and majestic views of the Columbia River as it skirts the foothills of the Cascade Range southbound, as well as extreme eastern Kittitas County and extreme western Grant County. It is also known for its spectacular views of the Columbia Gorge canyon, as shown in Figure 1-2.

**Figure 1-2. Aerial Views of the Columbia Gorge Canyon**

The Gorge Campground can house 50,000+ campers, who often attend a one-night concert event, but stay the full weekend. Fans can stay in the campground for 24 hours on the day of a single show, or until 12 noon the day after a run of shows ends. Spaces are available on a first-come, first-served basis for one car with up to two two-person tents or a single Recreational Vehicle (RV). Limited RV hookups, potable water, flush toilets, hot showers and a convenience store are available on the grounds. The campground also has a basketball court, volleyball court and 24-hour security. During events, the Gorge becomes the largest community in Grant County.

From a first responder perspective, the Gorge Campground area is where the majority of incidents occur, challenging the communications and situational awareness needs of law enforcement and first responders. During summer events, the combination of heat, alcohol and drugs can be deadly. Recent deaths in 2013 (1) and 2015 (2) were due to drug overdose, and there are multiple arrests every weekend for drugs and assaults. During event weekends, there can be 50 to 150 drug overdoses requiring hospitalization. The surrounding Columbia Gorge area has some rough terrain and hazardous conditions in which campers can suffer injuries or get lost; wildfires burned 600 acres in 2016.

# Chapter 2. TechEx Design

## 2.1 Overall Approach

The TechEx planning committee used a modified version of the guidance and processes recommended by the Homeland Security Exercise Evaluation Program (HSEEP). Although the TechEx is not a true "exercise" as defined by HSEEP, the goals and objectives are driven by ***Capabilities-based Planning***: a universal process developed by DHS and adopted by state and local first responder communities (see Figure 2-1). This approach allows for tracking and comparison of current levels of capability, assessment of overall preparedness, and also supports the following improvement-related processes:

- Alignment with a structure and nomenclature the first responder community uses routinely to assess their capabilities.
- Alignment with DHS Target (Core) Capabilities List, which supports the National Preparedness Goal.
- Ability to use both quantitative and qualitative measures.
- Distinct measurable elements as each capability is comprised of critical tasks.
- Using the NGFR requirements: Protected, Connected and Fully Aware.
- Feedback is provided to both the technology developer and the first responder.
- Gathering baseline data and information for documenting performance and improvement, which can subsequently be used to plan for follow-on testing/spiral event.

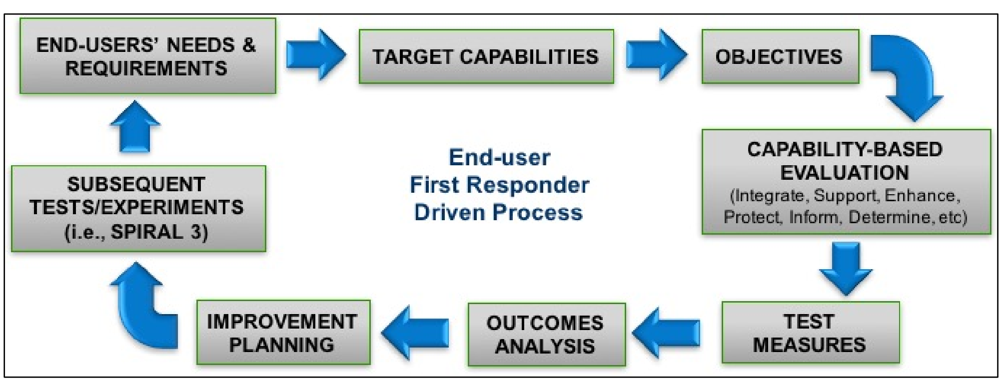


**Figure 2-1. TechEx Planning Process**

## 2.2 Target (Core) Capabilities and Objectives

The overarching objectives of this effort were to:

- Perform a needs assessment and establish baseline requirements for participating first responder groups from Grant County, Washington.
- Assess technologies that may provide potential solutions for Grant County's mission requirements and needs.
- Evaluate the operational deployment of those technologies and their integration with existing first responder/public safety systems through scenario-based testing.
- Determine the extent to which the deployed technologies are usable, supportable, safe and acceptable to the first responder end-users.
- Provide an After Action Report that includes technology and operations-based recommendations.

The TechEx performance objectives are describe below, along with their aligned Target (Core) Capability.

**Target/Core Capability: Operational Communications**

Objective 1: Provide an assessment of each NGFR technology's integration capability to support Grant County's need to establish and maintain an interoperable communications network during critical events.

Evaluate each NGFR technology's ability to:

1. Support the establishment of command and control.
2. Integrate with existing first responder systems.
3. Support first responder operations with minimal physical or decision-making capabilities with their routine response procedures.

**Target/Core Capability: Responder Health and Safety**

Objective 2: Assess the value added of each NGFR technology to support Grant County's need to provide and sustain the health and safety of their first responders.

Evaluate each NGFR technology's ability to:

1. Reduce risks for first responders working in remote locations.
2. Support the ability to monitor first responders' health during high demand and high stress situations.

3. Enhance protection of first responders with minimal interference during their routine missions.

**Target/Core Capability: Situational Awareness**

Objective 3: Measure each NGFR technology's capacity to enhance timely communications and information sharing to include voice, data and video on demand in real time and when needed.

Evaluate each NGFR technology's ability to:

1. Provide information and data relevant to the mission and environment.
2. Help inform decision-making.
3. Project need for required resources and actions.

**Target/Core Capability: Operational Coordination**

Objective 4: Assess and determine the capability of each NGFR technology to support mission-based coordination efforts for inter- and intra-agency first responders.

Evaluate each NGFR technology's ability to:

1. Provide information and data that is operationally relevant for end-users with varying roles and responsibilities.
2. Support multiple end-user needs and requirements.
3. Adapt to evolving critical response environment.

Evaluate the technology in terms of the extent to which it is:

1. Usable, easy to use, intuitive (meets user expectations) and easy to learn.
2. Supportable and easy to maintain.
3. Safe to use.
4. Acceptable to the first responder end-users.

## 2.3 Participants and Technical Support

The Grant County TechEx represents "Spiral 2" of a larger spiral development program to deliver and demonstrate new technologies supported by the NGFR program. Previous spirals include demonstrations at DHS S&T in Washington, District of Columbia; Fairfax, Virginia; and Boston, Massachusetts. Participants for this TechEx included representatives from state and local public safety communities in Grant County, Washington, along with technical support from DHS S&T. Following is the list of participants and technical support entities.

### 2.3.1 First Responder and Public Safety Participants

The TechEx participants, more commonly referred to as participants, included personnel from the Grant County Sheriff's Office, Grant County Fire Districts 3 and 5, Grant County Multi-Agency Communications Center (MACC), Grant County Technology Services, and Moses Lake Regional Tactical Response Team (TRT).

**Grant County Sheriff's Office**

The Grant County Sheriff's Office full-time staff comprises 50 commissioned law enforcement officers, 40 correctional staff and 26 support staff, in addition to 3 part-time staff and volunteers. Of the 39 participants, there were 9 Reserve Deputies, 8 Search and Rescue Members, 19 Mounted Posse Members, 2 Public Information Officers and 1 Chaplain. (http://www.grantcountywa.gov/SHERIFF/)

Major goals of the Grant County Sheriff's Office were to:

- Improve communications and the distribution of information;
- Coordinate effectively with other local, state and federal agencies; and
- Maintain involvement with the Regional TRT and Columbia Basin Investigative Team (CBIT).

**Grant County Multi-Agency Communications Center**

The MACC is the single public safety answering point in Grant County. The MACC supports over 30 agencies and about 1,300 subscribers, which includes law enforcement, fire and emergency medical services, across a 3,000 square mile jurisdiction. The MACC handles over 53,000 calls for service each year, and answers over 57,000 9-1-1 calls and over 157,000 non-emergency calls. (http://macc911.org/home.html)

**Grant County Fire Districts 3 and 5**

Fire District 3 is a multi-service department based out of Quincy, Washington, serving approximately 500 square miles of central Washington. The communities it serves are primarily rural with a population estimate of 8,500. The District is comprised of 7 fire stations, 40 pieces of apparatus, 79 volunteer firefighters, 19 Community Support Division volunteers, 3 District Commissioners and 8 full-time career positions. (http://gcfd3.net/)

Fire District 5 is a multi-service Fire Department based out of Moses Lake, Washington. The District is comprised of 12 fire stations and approximately 140 volunteer firefighters. (http://gcfd5.org)

**Grant County Technology Services**

Grant County Technology Services (GCTS) is the technical support arm for Grant County departments, offices and agencies. In addition to providing technical support, GCTS oversees and manages department enterprise software, along with Grant County network infrastructures. The services office supports 44 Grant County departments, offices and agencies throughout the county in locations such as Ephrata, Moses Lake, Coulee City, George and the Gorge Amphitheater. (http://www.grantcountywa.gov/GCTS/)

**Moses Lake Regional Tactical Response Team**

The TRT, formed in 1999, handles special policing needs for the community. The TRT is comprised of personnel from various Grant County law enforcement entities, including the Moses Lake Police Department, Grant County Sheriff's Department, Adams County Sheriff's Department, Moses Lake Fire Department, Ephrata Police Department, Othello Police Department, Quincy Police Department and the Grand Coulee Police Department. (http://www.cityofml.com/index.aspx?NID=419)

TRT specialties include:

- Entry and perimeter personnel;
- Marksmen observer teams;
- Tactical medic; and
- Training in special weapons, equipment and tactics.

TRT typically responds to 10-15 incidents per year, to include:

- Barricaded suspects;
- High-risk arrest warrants;
- High-risk search warrants;
- Hostage situations; and
- Personnel protection.

### 2.3.2 Supporting Organizations and Technology Developers

**Ardent Management Consulting**

ArdentMC's staff provided the following applications/services for the TechEx:

- Watchtower mobile application;

- Hexoskin/Zephyr sensors;
- Pinpoint application for vehicle laptops;
- Raspberry Pi/Global Positioning System (GPS) automatic vehicle location devices;
- Vortex message switch server environment;
- ESRI Ops Dashboard server environment;
- Cradlepoint router configuration support to Grant County;
- SQL installation/configuration support to Grant County; and
- ESRI Ops Dashboard installation/configuration support to Grant County.

Ardent Management Consulting (ArdentMC) delivers solutions to federal and commercial clients by combining technical and program management expertise. ArdentMC consultants combine applied knowledge of commercial best practices with hands-on experience to deliver Information Technology (IT) and business solutions that meet mission-critical needs. (http://www.ardentmc.com/)

**Cradlepoint**

Cradlepoint provides enterprise network architecture devices using Fourth Generation (4G) Long Term Evolution (LTE). For the TechEx, Cradlepoint routers were used for both a vehicle router and as the LTE/Wi-Fi router in the Mobile Broadband Kit 3G/4G/LTE to provide backhaul networking. (https://cradlepoint.com/)

**Integrated Solutions for Systems**

Integrated Solutions for Systems (IS4S) has expertise in multiple engineering and management disciplines. For the TechEx, IS4S provided their IS4S Comms Hub, which provided both GPS tracking and physiological sensor data connectivity via LTE, land mobile radio (LMR) or Wi-Fi to an IS4S sensor hub for physiological monitoring and geographic tracking of responders. (https://www.is4s.com/)

**Johns Hopkins University Applied Physics Laboratory**

JHU/APL provided overall TechEx planning, scenario development, baseline assessment and development of communication pathways, testing and evaluation, Sonim phone configuration, inventory control, technical integration and program management support, and document editing/preparation services. (http://www.jhuapl.edu) The Johns Hopkins University Applied Physics Laboratory (JHU/APL) provides critical contributions to critical challenges with systems engineering and integration, technology research and development, and analysis.

**Carlow International and BMT Designers and Planners**

Carlow International (http://www.carlow.com) is the prime contractor supporting the S&T Office of Systems Engineering Human Systems Integration Branch, and BMT Designers and Planners is a key subcontractor on that effort. The Carlow team provided testing and evaluation support throughout Spiral 2 by developing structured observational templates that captured data regarding end-user acceptance and human suitability of new technologies throughout the operational scenarios.

**National Institute of Standards and Technology (NIST) Public Safety Communications Research Division**

Public Safety Communications Research (PSCR) laboratories provide research, development, testing and evaluation to foster nationwide communications interoperability. The PSCR program performs research on behalf of our sponsors at DHS Office for Interoperability and Compatibility (OIC), DHS Office of Emergency Communications (OEC) and National Telecommunications and Information Administration (NTIA) FirstNet to advance public safety communications interoperability. PSCR involves public safety practitioners—fire, police and emergency medical services (EMS)—directly in our research and development activities for public safety specific requirements. For the TechEx, the PSCR staff provided communications engineering support, Unmanned Aircraft systems (UAs) video configuration testing, broadband point-to-point system and Band Class 14 system configuration and management, as well as lab space, technical expertise and technical support for the integration testing. (https://www.nist.gov/ctl/pscr/aboutpscr)

**Oceus Networks, Inc.**

Oceus Networks specializes in the delivery of mobile solutions, integrating fixed and wireless broadband technologies that enable secure, high-speed voice, video and data communications. For the TechEx, the Oceus Networks' Xiphos™ Responder, a compact and rapidly deployable 4G LTE broadband solution, was purchased to provide a rugged, secure, public safety-grade mobile broadband communications capability at the Gorge venue for the event. Oceus engineers supported system integration, and provided system configuration and management guidance and troubleshooting expertise. (https://www.oceusnetworks.com)

**SpectraRep**

SpectraRep's Datacasting technology enables broadcast television stations to deliver encrypted and targetable public safety video, data and alerts. This allows existing high-power broadcast signals to securely transmit data to first responders. Datacasting public safety data takes

advantage of the existing television infrastructure that operates on licensed spectrum, allowing those signals to transmit to an unlimited number of recipients without consuming additional bandwidth. For the TechEx, SpectraRep provided a micro-digital broadcast television system to datacast the captured video to the Gorge amphitheater and the large campground. They also provided the viewing software, the TV receiver dongles and the external antennas used by Grant County units to view the Datacast transmission. SpectraRep provided supporting equipment, system installation, training, configuration and application support. (http://www.spectrarep.com)

## 2.4 Scenario Design

### 2.4.1 Structure

The TechEx scenario was developed with significant input and guidance from the Grant County first responder community to ensure it represented real-world events and their respective mission-based response. The scenario was comprised of three vignettes, each focused on testing specific technologies that support first responder response-based capabilities. The underpinning storyline for the scenario was based on Grant Count's first responder community preparing for a long weekend of concert events at the Gorge Amphitheatre followed by several public incidents and subsequent critical events. The DHS Target/Core Capabilities for this experiment included: (1) Operational Communications, (2) Responder Health and Safety, (3) Situational Awareness, and (4) Public Safety and Law Enforcement. The following provides a summary for each vignette.

It was intended that the scenario and vignettes for the TechEx represented a series of events that have previously occurred at the venue, and they were developed so that the events progressed in a logical and realistic manner. However, as with any scenario, there were assumptions made to ensure that it was as realistic as possible to support participation:

- It was assumed that participants had a basic understanding of routine roles and responsibilities.
- Although the scenario was not real, it was assumed to be true, and that all events within the Master Scenario Events List (MSEL) occurred for the purposes of full participation.

It was recognized that the following artificialities and constraints would detract from realism; however, the facilitators, observers and participants accepted these artificialities to help ensure effective participation:

- The TechEx was designed to be conducted in a real-world environment. However, the events were not presented in "real time." There were no time limits for responding to any event.
- All simulated information provided to participants was assumed true and reliable only for the purposes of the scenario.

- The scenario included information and actions that were intended to prompt a response.
- Because the experiment was conducted outdoors, it was recognized that weather-related factors would influence the implementation of the TechEx, as well as potentially affect first responders' capabilities.
- Because this was a communications-based experiment that depended on wireless services, it was recognized that outcomes may vary during a real-world event when there are 30,000 plus campers present (plus staff) using commercial services. On other networks, such as the Band Class 14 LTE network dedicated to first responders, the impact from the large crowd was expected to be minimal.

**Vignette A: Command and Control**

The capability requirements for Vignette A included technologies that support situational awareness and an Incident Area Network (IAN), and focused on establishing command and control for a large National Special Security Event (NSSE)-like event. This was basically a test of all units, resources, capabilities, technologies, etc., similar to a roll call and communications test. The vignette included events related to testing communication systems, multi-jurisdictional and multi-agency coordination, live streaming video tests, and the interoperability and utility of the TechEx technologies.

**Vignette B: Search and Rescue, and Recovery**

Vignette B capability requirements included technologies that support first responder safety and situational awareness. Vignette B included events related to maintaining command and control, situational awareness and protection of first responders while performing life-saving assistance, search and rescue, and recovery operations.

**Vignette C: Public Safety and Security**

Capability requirements for this vignette included technologies that support first responder safety and situational awareness. The vignette had events related to ongoing/maintaining command and control, situational awareness, personnel tracking while in pursuit, protection of first responders, and multi-agency and multi-jurisdiction coordination and communications during an escalating event.

**Figure 2-2. Photographs from TechEx Vignettes**

# Chapter 3. Technologies and Systems Architecture

This chapter describes the capabilities of 16 technologies assessed during TechEx.

## 3.1 Communications

### 3.1.1 Sonim Phones

The Sonim phones (XP7 Smartphones) produced by Sonim Technologies were used by first responders for communications over either AT&T's commercial cellular network or Public Safety Band Class 14 (BC 14) LTE network deployed at the venue specifically to support the TechEx. These Sonim phones had the "Watchtower" application installed that will display the location of other first responders' Sonim devices, while transmitting its location to the Ops Dashboard at the Gorge Dispatch Trailer and the MACC. They also allowed the responders to stream and receive video via the Wowza application, and send video to the Wowza video server for viewing/redistribution to end-users capable of receiving and decoding datacasting transmissions or having access to the Internet.

### 3.1.2 Mobile Broadband Kit

The 4K Mobile Broadband Kit (MBK), developed by 4K Solutions, combined a high capacity battery with a Cradlepoint model IBR1100 Wi-Fi hotspot/4G LTE router, and a dual dock to support a Band Class 14 (BC 14) LTE modem, packaged in a Pelican 1450 case for safe storage, transport and use. For the Grant County TechEx, the MBKs were configured to use either Verizon or BC 14 LTE for network connectivity to the Internet, while the Wi-Fi hotspot acted as the local access point for compatible devices to be connected to a data network. The MBK, configured to work with the BC 14 LTE modem, was placed at the Gorge Amphitheater for the Incident Commander/UAs operator, while another MBK, configured to work with the Verizon network, was installed at the large campground for the foot patrol officers.

### 3.1.3 Xiphos Micro Band Class 14 Long Term Evolution

The Xiphos Micro developed by Oceus Networks is a lower powered, small form-factor self-contained 4G LTE BC 14 network. The Xiphos Micro is a deployable broadband access network, enabling high-speed data, voice and video services for mobile field personnel. The Xiphos Micro LTE eNodeB with 2x5W Radio Frequency (RF) Output Power provides up to 6 hours of operation when connected to two military grade field swappable batteries. It can also be powered by standard 120VAC for continuous operations. The Xiphos was installed at the Gorge Amphitheater with permanent AC power to provide BC 14 LTE data service for the Gorge Amphitheater, the Gorge campground and the Columbia River Gorge adjacent to (to the west of) the Gorge

Amphitheater. This provided an alternate LTE network (separate of the commercial providers AT&T and Verizon) for first responder data communications.

### 3.1.4 IS4S Comms Hub

The IS4S Comms Hub is an intelligent communications interface device capable of providing connectivity between wearable technologies (e.g., physiological sensors) and multiple communications devices (smartphones, land mobile radios, etc.) carried by the first responder. It also had GPS locating capabilities. For Grant County, the IS4S Comms Hub demonstrated connectivity between the Zephyr physiological sensors and the Sonim LTE phones. The wearable sensors data was passed by the LTE phones to the IS4S dashboard for review.

## 3.2 Situational Awareness/Location Reporting

### 3.2.1 Ardent Vortex

The ArdentMC Vortex Switch, implemented using Amazon Web services, is a message switch that provides message receipt and transfer capabilities. For the TechEx, Vortex received location and sensor information messages from Pinpoint, Watchtower and IS4S-equipped devices, and transmitted those messages back to Pinpoint, Watchtower and Ops Dashboard for display and use by the first responders, incident commanders, dispatchers and dispatch supervisors.

### 3.2.2 ArcGIS (ESRI) Ops Dashboard

ArdentMC hosted an instance of ESRI Ops Dashboard, which is a browser-accessible software application developed by ESRI that can display both Geospatial Information System (GIS) layers and dynamic information published to Ops Dashboard. The Ops Dashboard was used for the TechEx to display vehicle and responder locations.

Before the TechEx, ArdentMC assisted the Grant County GIS staff in upgrading their ESRI server and associated SQL server to support the ESRI Ops Dashboard situational awareness application within their County IT environment. This Ops Dashboard would then be used to display vehicles and first responder locations, physiological data from sensor-equipped first responders, Computer-Aided Dispatch (CAD) information, and other sources using Grant County GIS layers and associated data, but without the need to use the ArdentMC Ops Dashboard.

### 3.2.3 Watchtower

ArdentMC has developed a mobile application known as “Watchtower” to enhance first responder mission capabilities, including reporting responder geolocation and integrating with a variety of sensors and other technologies. Watchtower was installed on the Sonim phones, the Grant County-issued smartphones and first responder personal smartphones (optional). Watchtower’s capabilities used for the Grant County TechEx were:

- Ability to uniquely identify user to other Watchtower users and display identity on Ops Dashboard;
- Ability to report geolocation to own user and other Watchtower users and display location on Ops Dashboard;
- Ability to configure the location reporting interval;
- Ability to view My Location, other responder locations, incidents, vehicle locations, static GIS info (Command Control trailer, MACC, etc.) on a map; and
- Ability for the responder to view his/her own physiological sensor information from available sensors (Hexoskin, Zephyr).

#### 3.2.4 ArdentMC Pinpoint Software

For Sheriff's vehicles that did not have Cradlepoint routers, ArdentMC developed an application that was installed on the laptops in the public safety vehicles that provided the same function. This application, called "Pinpoint," transmitted the location of the vehicle via the vehicles' broadband connectivity to the Incident Commander, Gorge Dispatch trailer staff and MACC Supervisor on the Ops Dashboard application.

#### 3.2.5 Cradlepoint Router

Grant County has a program to replace their existing Verizon modems/Wi-Fi routers (termed MiFi devices) in their Sheriff's vehicles with Cradlepoint routers capable of performing the same function. The Cradlepoint routers have built-in GPS receivers and, with the addition of an inexpensive GPS antenna and minor configuration changes, can provide the vehicles' locations to an appropriate map display for tracking purposes. For the few Grant County Cradlepoint routers installed for the TechEx, these vehicle locations were received by Vortex and passed on to the ESRI Ops Dashboard Situational Awareness system for display, so that the Incident Commander, Gorge Dispatch trailer staff and MACC Supervisor could track the vehicles.

### 3.3 Physiological Sensors

#### 3.3.1 Hexoskin Smart Shirt

The Hexoskin Smart Shirt (https://www.hexoskin.com) was worn by selected first responders to document their heart and respiration rates, skin temperature and physical movement. The shirt transmitted these readings via Bluetooth to the first responder's smartphone, and displayed on the Watchtower application.

#### 3.3.2 Zephyr

The Zephyr physiological monitor (https://www.zephyranywhere.com) is a small Bluetooth-enabled sensor that was used to monitor heart rate and transmit data to a smartphone equipped with Watchtower or the IS4S Comms Hub. The data from the IS4S Comms Hub was then sent to

the IS4S Sensor Dashboard for display to the Incident Commander, Gorge Dispatch staff or MACC Supervisor.

## 3.4 Video Capture/Presentation/Transmission

### 3.4.1 Datacasting

Datacasting uses available capacity in digital television transmissions to transmit encrypted video, text files and other types of data to designated recipients. The datacasting capability deployed in Grant County was developed by SpectaRep, Inc. and, because it is a broadcast concept, it is capable of one-to-many content delivery to an unlimited number of recipients, thereby reducing congestion on commercial cellular networks and/or land mobile radio networks. It allows public safety agencies to wirelessly transmit encrypted video and data to authorized recipients using an alternate wireless technology that is not dependent on commercial access networks.

Past implementations of datacasting have involved transmitting the datacasting information using a Public Broadcasting Service (PBS) channel in the desired coverage area. Because no PBS stations provide coverage to Grant County, a portable lower powered digital TV white space transmitter was used instead. The transmitter was set up next to the Grant County Deputies' Gorge Dispatch trailer at the Gorge campground. First responders who were identified to receive datacasting broadcasts were equipped with a receiver (dongle) and associated antenna connected to their computer to receive and decode information from the portable TV transmitter. These dongles were installed in participating Grant County Deputies' vehicles, and the software was installed in their laptops to manage reception and target and display images to participants at the Gorge venue.

### 3.4.2 Wowza GoCoder

The Wowza GoCoder application, developed by Wowza Media Systems, is a client application that was loaded onto a smartphone (either iOS or Android) and used to stream real-time video from the phone's camera to a centralized Wowza video server for redistribution. The Wowza GoCoder was integrated into the Datacasting system allowing cell phone video to be displayed on the dashboard.

### 3.4.3 Wowza Multimedia Server

SpectraRep, developers of the IncidentOne application, provided a laptop that monitored live streaming Internet video and forwarded selected streams (i.e., social media streams) to SpectraRep's Wowza server for ingest and transmission to targeted receivers over the broadcast transmitter. Among the data received was real-time video from the UAs and from first responder cellular phones with the Wowza GoCoder application installed.

The IncidentOne software (also referred to as the SpectraRep "dashboard") was used to display and control the SpectraRep server and video distribution. The IncidentOne application allowed the SpectraRep operator to control the video streams and select which one(s) to be sent to the micro-TV transmitter for datacasting.

#### 3.4.4 NanoStationM

NanoStationM, developed by Ubiquiti, is an indoor/outdoor point-to-point microwave radio offering wireless network connectivity between two NanoStationsMs with a range of up to 2 miles' line-of-sight distance and speeds of 20+ Mbps. It operates in the frequency range from 5.745 to 5.825 GHz. It weighs 14 ounces and its dimensions are about 3 inches by 1.2 inches by 11.6 inches. The Ubiquiti NanoStationM was used to wirelessly connect the Xiphos BC 14 base station located at the amphitheater to the Internet drop located in the Gorge Dispatch trailer, approximately ¾ of a mile away.

### 3.5 Baseline Technical Requirements

High-level requirements were acknowledged and documented based on the needs expressed by Grant County end-users and subsequently used for developing the TechEx objectives. The technical requirements for the Grant County TechEx were derived from technical requirements identified during the Project Responder 4 focus group study. Some Grant County TechEx requirements (for example, "Aural, haptic, and visual alerts to responders when vital signs exceed acceptable parameters") are comprised of multiple NGFR requirements. Table 3-1 provides the 12 high-level requirements and correlating test measures applicable to this TechEx.

**Table 3-1. TechEx Requirements/Test Measures**

| | |
|---|---|
| **1)** | **Requirement: Allow individual responders (field units) to upload video and other large file size data types** |
| | a) Test Measure: Success/failure |
| | b) Test Measure: Time to upload |
| **2)** | **Requirement: Aural, haptic, and visual alerts to responders when vital signs are out of range of acceptable parameters** |
| | a) Test Measure: Success/failure for legitimate alerts |
| | b) Test Measure: Number of false alerts divided by total number of alerts |
| **3)** | **Requirement: Automatic transmission of responder (and victims) health status and alerts to command centers, dispatchers, and incident commanders** |
| | a) Test Measure: Success/failure on available health status data |
| | b) Test Measure: Delay between alert being triggered and alert received |
| **4)** | **Requirement: Connects to Incident Area Network (IAN) using Band Class 14 LTE, commercial LTE, and/or Wi-Fi without delaying operations** |
| | a) Test Measure: Success/failure for each protocol |
| | b) Test Measure: Time required to set up connection |
| | c) Test Measure: Connect ion stability |
| **5)** | **Requirement: Connects to Personal Area Network (PAN) using Bluetooth or other wireless protocols** |
| | a) Test Measure: Success/failure for each protocol |
| | b) Test Measure: Time required to set up connection |
| | c) Test Measure: Connection stability |
| **6)** | **Requirement: Enable geolocation of first responders (FRs) and FR assets** |
| | a) Test Measure: Accuracy of geolocation |
| | b) Test Measure: Time interval between location updates |
| **7)** | **Requirement: Enable geolocation of hazards** |
| | a) Test Measure: Accuracy of geolocation |
| **8)** | **Requirement: Indication to responder that critical communications have been received** |
| | a) Test Measure: Success/failure on confirmation of communication receipt |
| **9)** | **Requirement: Live video from traffic cameras, closed circuit camera, and vehicle- and/or body-mounted cameras (multiple sources)** |
| | a) Test Measure: Success/failure for access to each individual video source |
| | b) Test Measure: Success/failure for access to multiple video sources simultaneously |
| **10)** | **Requirement: Measure vital signs such as heart rate, respiratory rate, and body temperature** |
| | a) Test Measure: Time interval between measurements |
| | b) Test Measure: Measurements follow expected trends |
| **11)** | **Requirement: Provide location of nearest fire hydrant, hospital, fuel supply, potable water supply, general water supply, medical cache, equipment storage, hazmat,** |
| | a) Test Measure: Success/failure on ability to access resource list and visual display |
| **12)** | **Requirement: Stream and record intelligible voice, video, and data in real-time (real-time usable data)** |
| | a) Test Measure: Success/failure of ability to record voice, video, and data |
| | b) Test Measure: Video Quality |

23 test measures for 12 requirements

## 3.6 Architecture

The schematic in Figure 3-1 below represents the high-level architecture used for the Grant County TechEx system. Individual architectures follow as well.

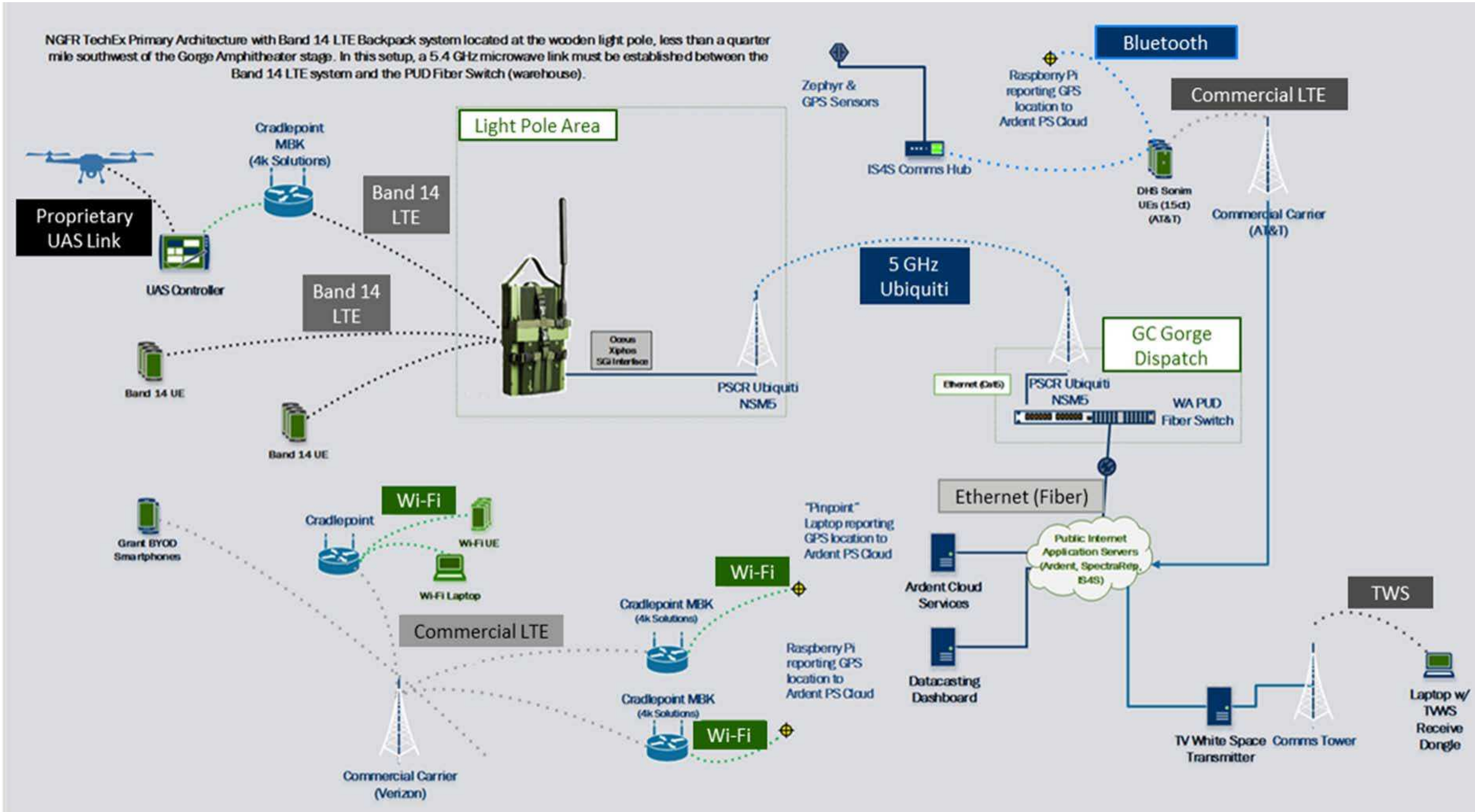


**Figure 3-1. Overall TechEx Architecture**

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Figure 3-2 represents the first responder's point-of-view (POV) while using the network during the TechEx.

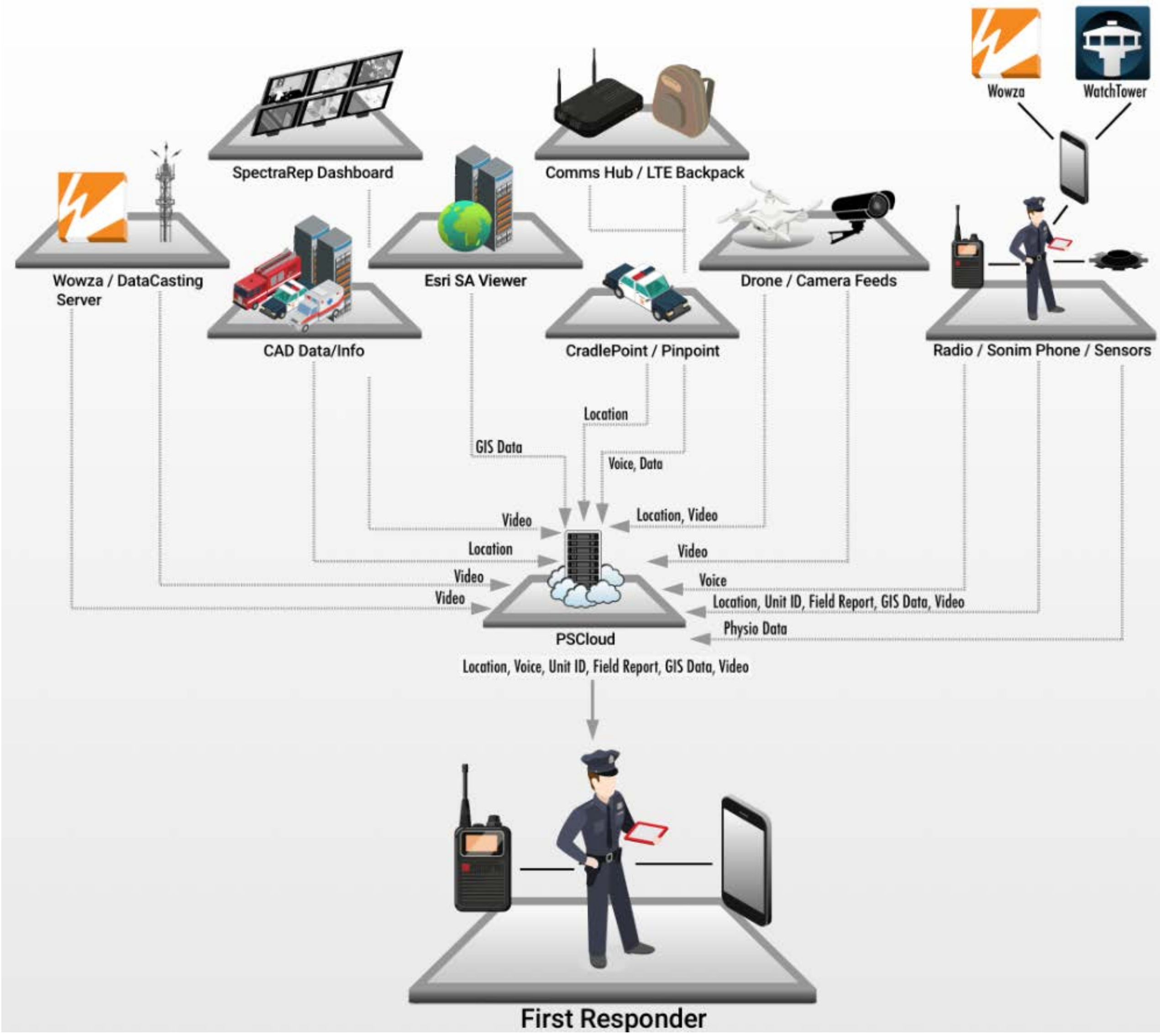


**Figure 3-2. First Responder Point of View**

### 3.6.1 Individual Architectures

**Band Class 14/Ubiquiti**

The Band Class 14/Ubiquiti architecture is shown in Figure 3-3. As noted above, the Ubiquiti point-to-point link was implemented to provide backhaul connectivity between the deployable Band Class 14 LTE device and the Internet at the Gorge Dispatch Trailer.

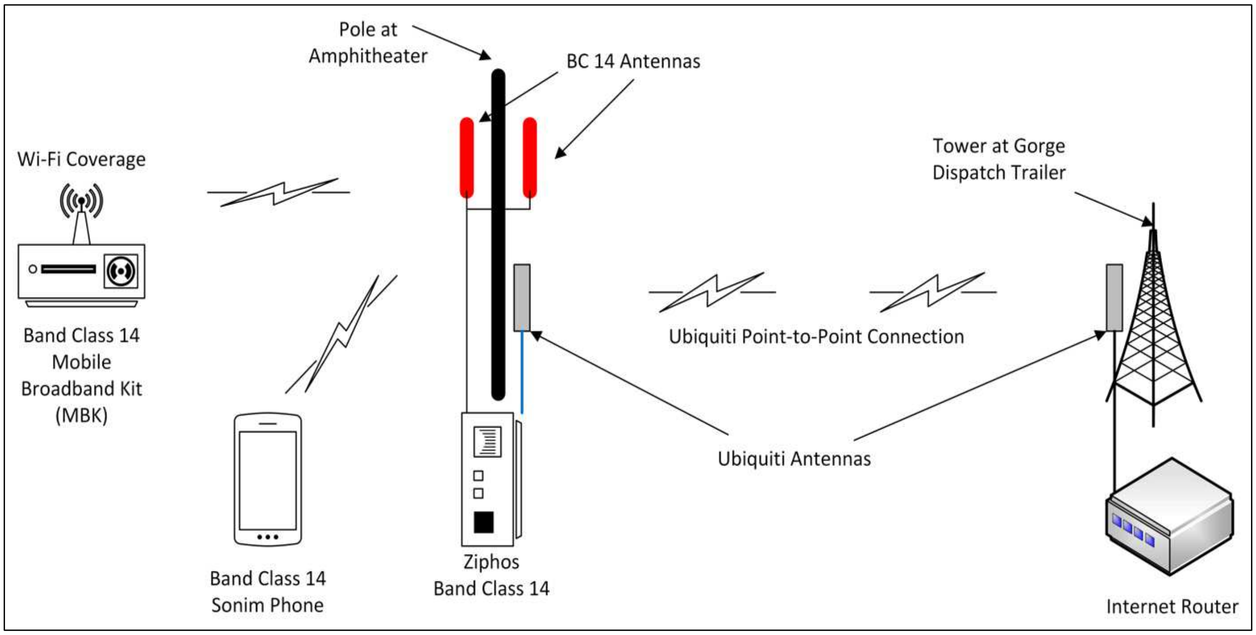


**Figure 3-3. Band Class 14/Ubiquiti Architecture**

### Video/Datacasting

The video/datacasting architecture is shown in Figure 3-4. The video was captured on several devices, forwarded to the SpectraRep server, and either accessed via web browsers using the IncidentOne software or transmitted via the TV transmitter to dongle-equipped laptops in Grant County vehicles.

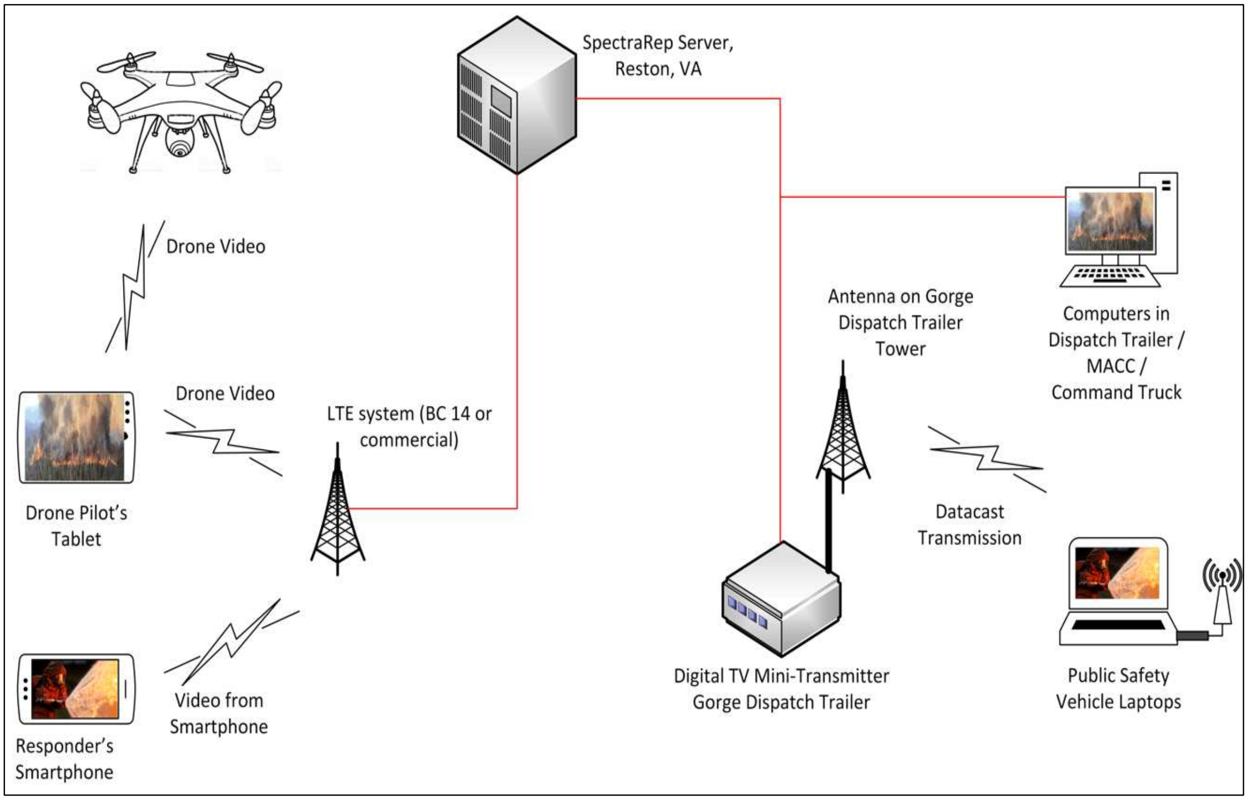


**Figure 3-4. Video Capture/Datacasting Architecture**

### Sensors

The ArdentMC sensor system received physiological data from Hexoskin and Zephyr sensors and displayed the data on the local responder's smartphone. The IS4S sensor system passed sensor data via LTE to a sensor dashboard, visible to responders at the Incident Command site or MACC.

Note:

In addition to sensor information, the IS4S sensor system passed the GPS location of the Comms Hub to the IS4S Dashboard for display. The sensor architecture is shown in Figure 3-5.

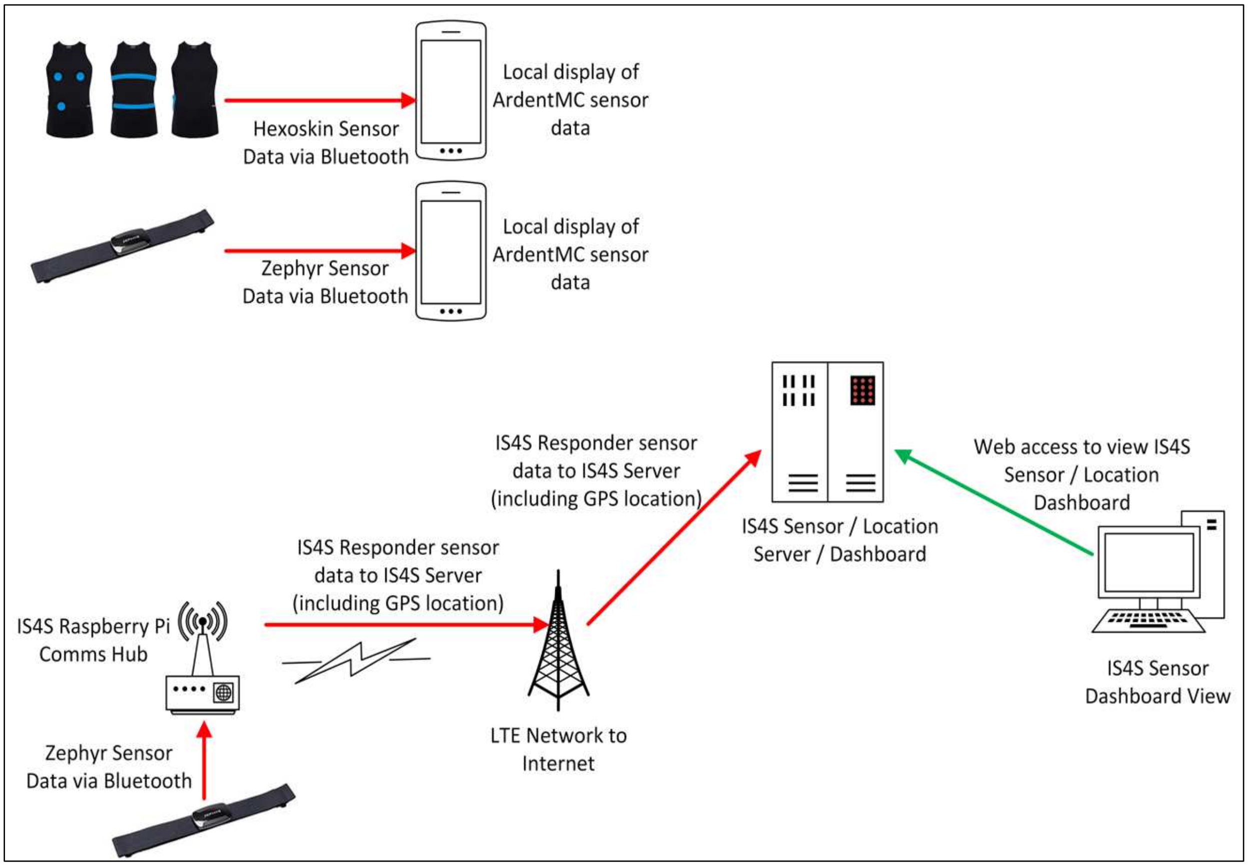


**Figure 3-5. Sensor Architecture**

**Location/Situational Awareness**

The location/situational awareness architecture is shown in Figure 3-6 (see Figure 3-5 for IS4S location architecture). It involved three location sources:

1. Smartphone location via Watchtower application;
2. Laptop-equipped vehicle location via Pinpoint software on the laptop; and
3. Non-laptop equipped vehicle location via Raspberry Pi device via Wi-Fi to an MBK or smartphone.

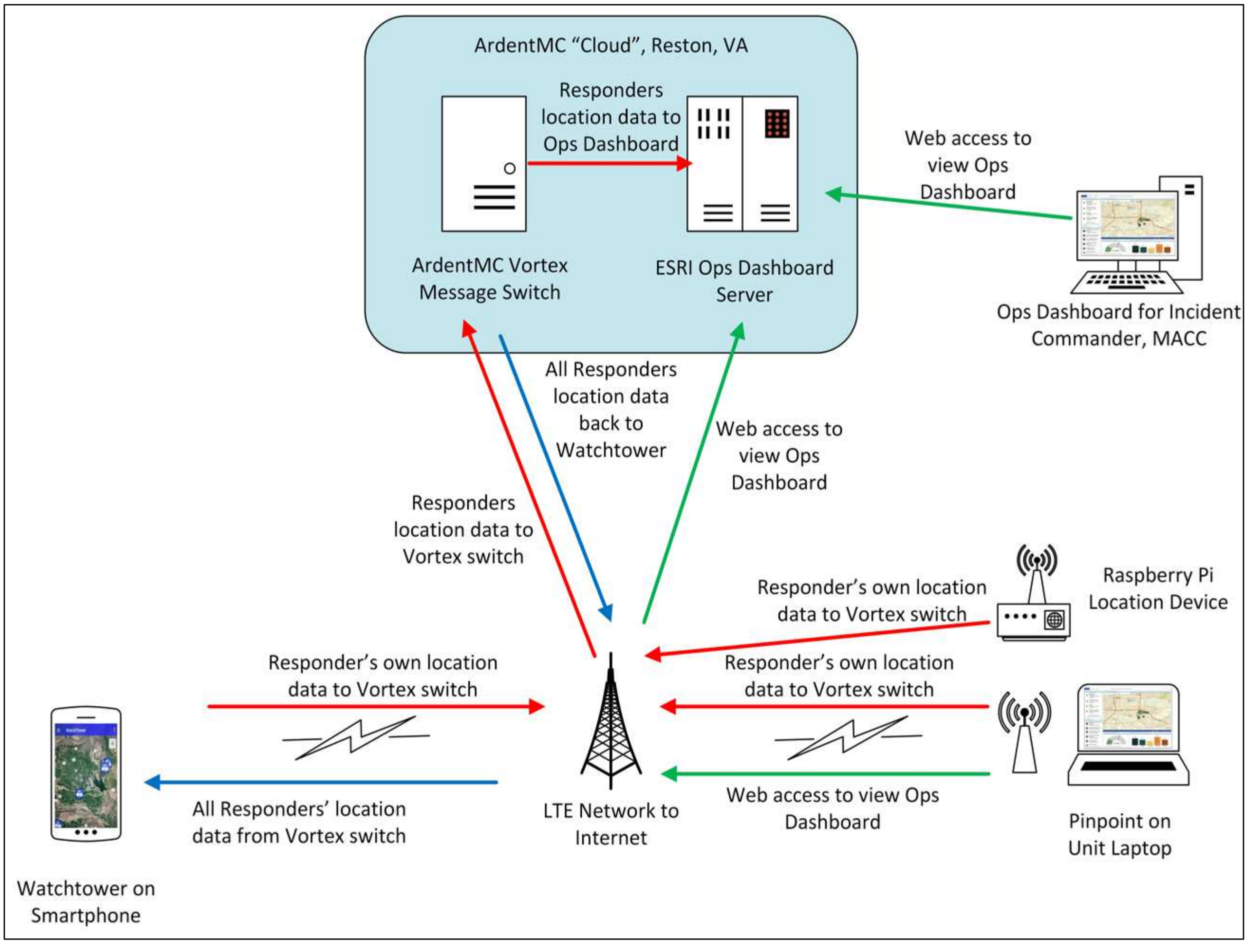


**Figure 3-6. Location/Situational Awareness Architecture**

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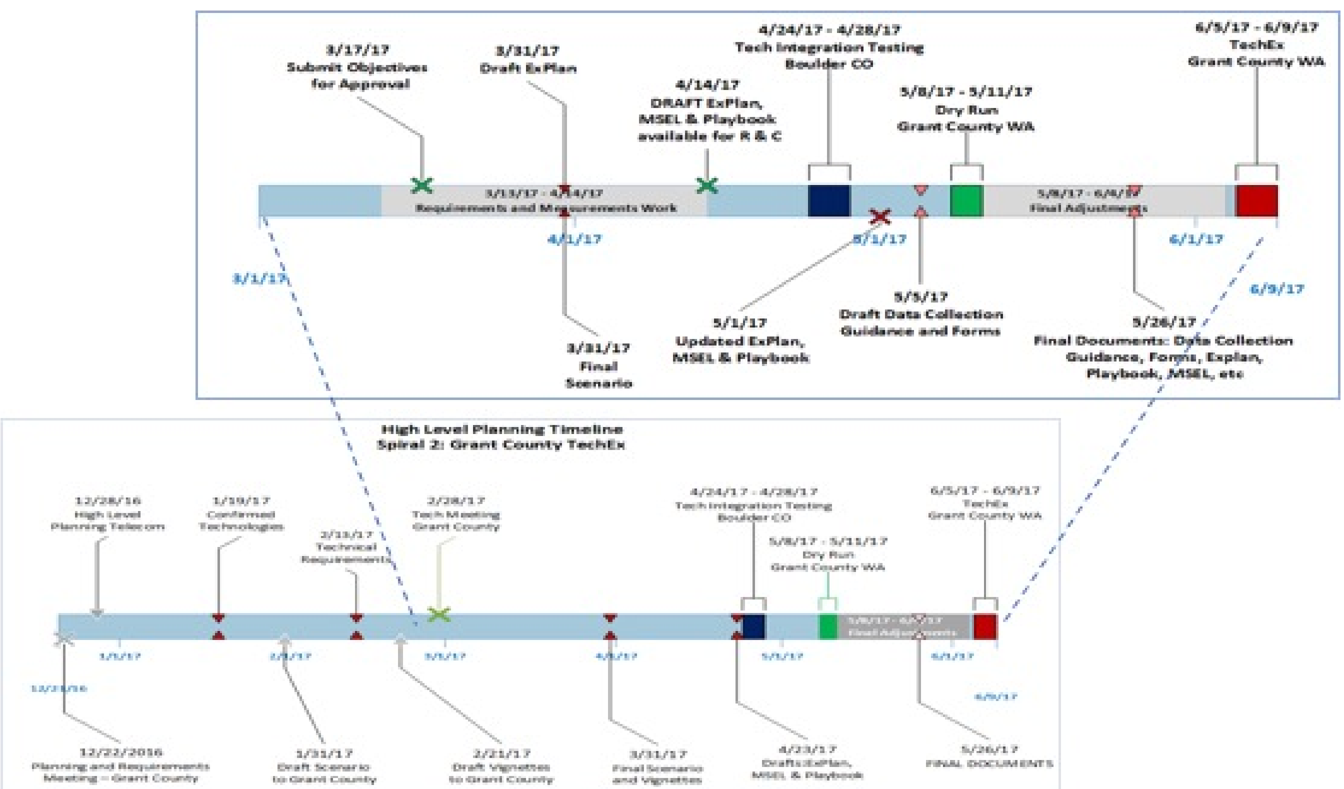
# Chapter 4. TechEx Planning

The Grant County TechEx required extensive planning and collaboration between federal, state, local and private partners. A core planning committee was established, and from that the following four sub-committees were implemented:

1. Technical Integration;
2. Scenario and MSEL Development;
3. Testing and Evaluation; and
4. Logistics.

The core planning committee, led by DHS S&T, met on a weekly basis. The four sub-committees also met weekly and reported on their efforts and progress. Representatives from each sub-committee participated in a weekly teleconference with public safety representatives from Grant County. All core meetings were documented, to include participants, detailed notes and action items. The timeline shown in Figure 4-1 was developed early in the planning process and was used weekly for tracking and reporting efforts for mutual understanding.

**Figure 4-1. Spiral 2 TechEx Project Timeline**



## 4.1 Site Surveys/Initial Discussions

### 4.1.1 December Site Survey

During a December 2016 site visit with Grant County representatives, initial on-site planning identified the following needs:

1. *Location and Tracking*. Because Grant County covers nearly 3,000 square miles and is 120 miles end-to-end, knowing the current location of all active personnel is a priority for the Grant County Sheriff's Office due to the terrain and limited resources in the Area of Responsibility (AOR).
2. *First Responder Safety*. A high-priority addition to the ability to track personnel is monitoring first responders' health.
3. *Situational Awareness*. Mobile GIS capabilities, data and information, and video streaming are needed.
4. *Search and Rescue*. In addition to needing location and tracking of officers, a priority requirement is for a search and rescue capability for missing campers along the Columbia River.
5. *Incident Area Network*. Help in configuring communications as needed (e.g., vehicle router capability, or a deployable bandclass-14 LTE network) to provide secure, standards-based and dedicated network bandwidth for first responders that operates independent of commercial cellular networks that often become overloaded and inaccessible during an emergency.
6. *Decision Support Tools*. These tools are needed to strengthen incident management and increase reliability of information and speed of communication.
7. *Cyber Security*. Secure digital communications, applications and network are essential.

From these seven needs, correlating Target (or Core) Capabilities were identified from the DHS Core Capabilities List, which employs a universal planning and evaluation process, often referenced as Capability-based Planning. This planning process was developed by DHS with collaboration from first responders, and has been long adopted by the state and local first responder communities. It allows for the tracking and comparison of current levels of capability and assessment for overall preparedness. It also helps to correlate outcome-based objectives with the capabilities that first responders require for optimal preparedness and response. (For more information: https://www.fema.gov/pdf/prepared/crosswalk.pdf.)

### 4.1.2 February Technical Discussions

The technical discussions held in Grant County in February 2017 helped to: narrow down the technologies to be demonstrated, understand Grant County Public Safety Operations, refine the scenarios and result in a draft architecture for the TechEx (see Figures 4-2 and 4-3).

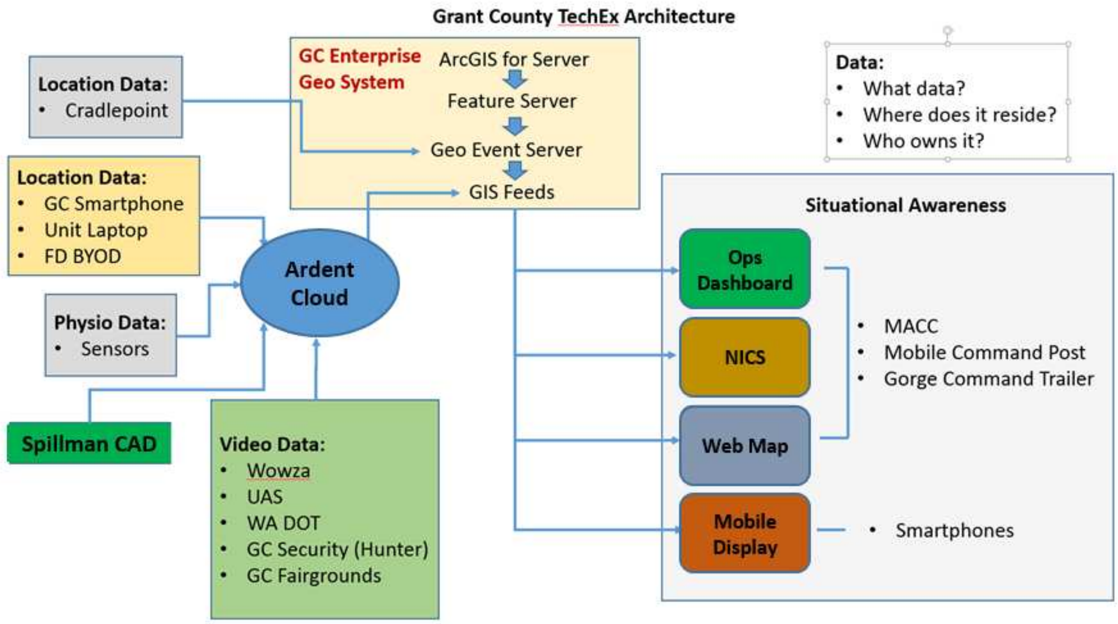



**Figure 4-2. Grant County TechEx Notional Architecture**

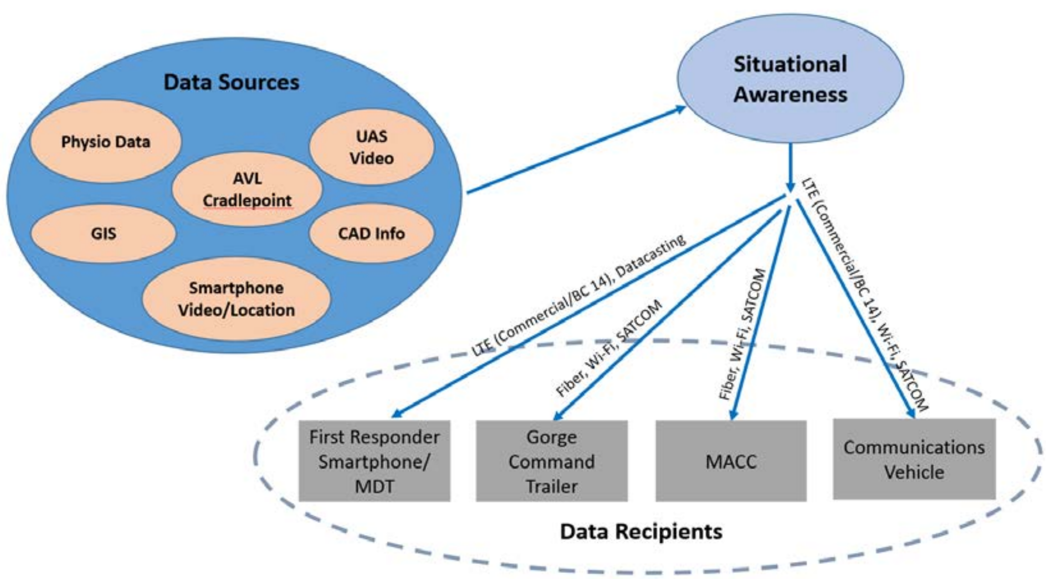



**Figure 4-3. Grant County Notional Data Architecture**

### 4.1.3 Boulder Integration Testing

The integration and testing session in Boulder, Colorado, which took place during the week of April 24, 2017, enabled the team to test and integrate the various technologies in a laboratory setting. The Band Class 14, MBK, UAs and Wi-Fi systems were also tested in the field at the NIST Tabletop Mountain facility on the third day of the integration testing. The Boulder integration testing allowed for the identification of systems and communication paths points of failure. Upon completion of the testing, solutions implemented during the Dry Run (described below) and the TechEx were identified and implemented.

### 4.1.4 Dry Run

A TechEx Dry Run was implemented from May 8–11, 2017, at the TechEx event location in Grant County. During the dry run, the TechEx planning team installed antennas and tested systems onsite to determine baseline Wi-Fi coverage, and to identify and validate suitable locations and channels for the MBK routers. While the installation and testing of the Oceus Xiphos was desirable, it was not installed due to Special Temporary Authority (STA) limitations for the Band 14 transmission and security. However, the Ubiquiti NanostationM base stations were installed on both ends and tested in preparation to connect and turn up the LTE network during the final system and equipment check prior to the start of the actual TechEx event. A large group of the TechEx planning team donned physio sensors and, using IS4S comms hubs, Sonim phones and/or bring-your-own-device (BYOD) phones, hiked the trail from the large campground into the Columbia River valley and back up to the Cave B winery to simulate the expected movements and locations of first responders planned for Vignettes B and C. During that time, wireless coverage and performance was also assessed. The experiences and insight gained during this trek, and the baseline efforts, resulted in some modification to the vignettes and the MSEL, as well as some changes to the technologies.

**Table 4-1. TechEx Schedule**

| GRANT COUNTY TECHEX – FINAL, JUNE 1, 2017 | | | | |
|---|---|---|---|---|
| **DAY** | | **TIME** | **ACTIVITY** | **LOCATION** |
| **Jun 5** | **MON** | 0800-1200 | Equipment set-up and configuration | Gorge |
| | | 1200-1400 | Lunch - Meeting with leadership to review plan for the week | Quincy |
| | | 1400-1600 | Training for Data Collectors | Gorge |
| **Jun 6** | **TUES** | 0700-0800 | Participant Check-in Day 1 (Required for all Participants) | Gorge Dispatch Trailer - Campground |
| | | 0800-1200 | Technical Team: Final equipment checks | Gorge |
| | | 0800-1000 | Walk through Vignettes with Participants | Gorge |
| | | 1000-1200 | Equipment Training for Participants | Gorge |
| | | 1200-1300 | Lunch (Provided by The Soup Ladies) | Gorge |
| | | 1300-1700 | Vignette A (followed by hot wash) | Gorge |
| **Jun 7** | **WED** | 0630-0730 | Participant Check-in Day 2 (Required for all Participants | Gorge Dispatch Trailer - Campground |
| | | 0800-1100 | Vignette B (followed by hot wash) | Gorge |
| | | 1100-1300 | Lunch (Provided by Westside Pizza) | |
| | | 1300-1600 | Vignette C (followed by hot wash) | |
| | | 1600-1700 | Hot wash - Everyone | Gorge |
| **Jun 8** | **THURS** | 1000-1200 | Hot wash – DHS Planning Team | Hotel |
| | | 1300-1600 | Equipment tear down and pack | Gorge |

#### 4.1.5 Master Scenario Event Lists

There were three MSELs—one for each Vignette. The MSELs were developed using a spreadsheet format and contained detailed steps to be executed by the TechEx participants. Each MSEL step was numbered for tracking/reference purposes, and included: a participant's name, the action to be taken, the time at which the action was expected to occur, the location of participants, the data collector assigned to observing the event and a space for additional relevant notes. The MSELs are provided in the TechEx Playbook (available upon request; see Handling Instructions in this document).

### 4.2 Test Plan/Data Collection

Several types of data were captured and used for analysis to generate results for this report. The majority of data was obtained using data collection. This was supplemented with logs from technical support personnel to help interpret which technologies were involved, and other details when data collection sheets may be ambiguous. Data for evaluation was also collected in the form of electronic logs from specific technologies that had retrievable data. Lastly, data from the hot wash was incorporated as participants' questionnaires, and data collector notes were collected.

Some test measures developed for NGFR requirements associated with the NGFR technologies were also assessed during this event. In many cases, these were to indicate whether the technologies have certain features deemed necessary. These binary results were captured on the collection sheets during the experiment. Other recorded data related to NGFR requirements identified the time it takes for an action to occur or durations between actions. This data was used to provide the range and average of times recorded. Video quality was assessed by asking all the responders (who had an opportunity to watch) to rate the quality on a scale from 1 to 5 (5 as best). These findings were summarized to report the range, average and any particularly noteworthy observations.

The human systems integration data gathered was used to indicate how well the technologies integrated with the end-users and their current mission-based requirement. Identifying the suitability and usability of technologies in operations was a primary goal of this analysis. The resulting data supported analysis of the frequency, persistence, nature and severity of issues that occurred with the technologies during their use in operational situations.

The feedback on technologies from Grant County end-users captured during the technology experiment was consolidated, interpreted and summarized for this report. End-user feedback was also obtained and provided insight regarding how the technology supported their mission (technical, operational and physical factors) and includes end-users' recommendations on how the technology can be further enhanced or improved. This feedback and other input from the

Grant County end-users captured during the technology experiment were consolidated, interpreted and summarized in this report.

## 4.3 Equipment Placement/Coverage

Figure 4-4 shows the location of the equipment used for the TechEx, with the approximate coverage shown in Figure 4-5.

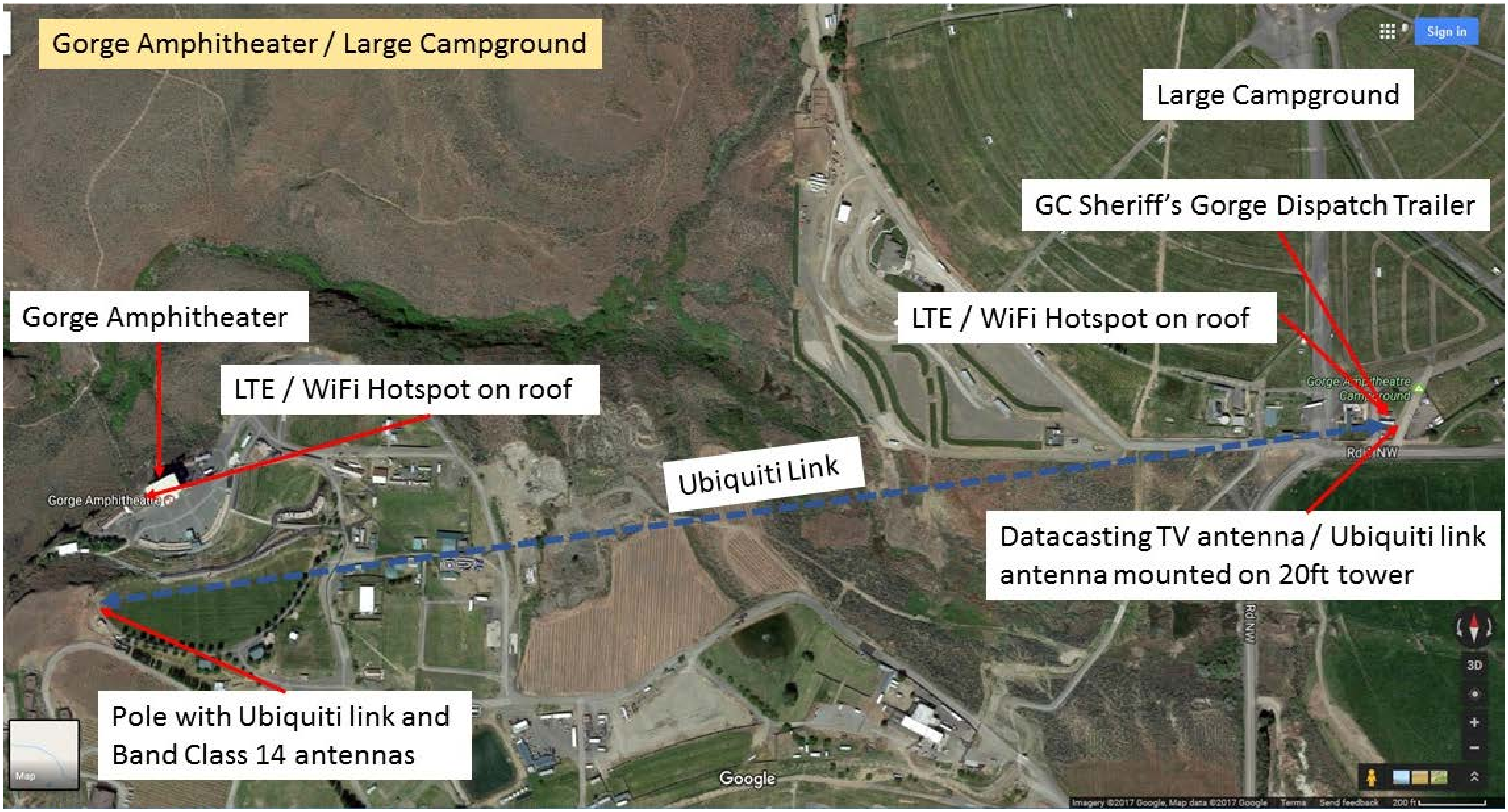



**Figure 4-4. Equipment Placement**

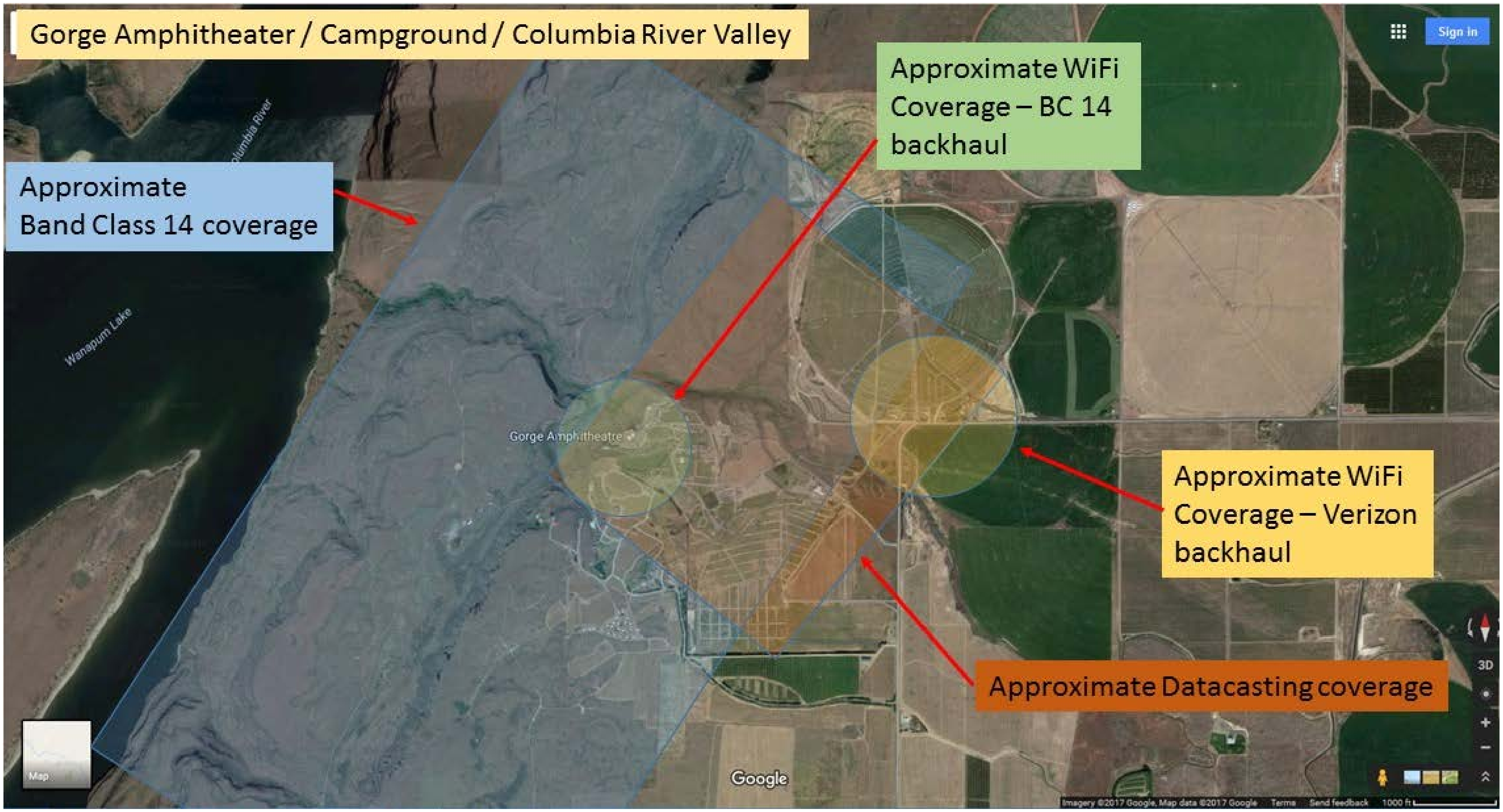



**Figure 4-5. Approximated Communications Coverage**

### 4.4 Assignment Matrix

Assignment matrices were used to track first responders, their respective roles and responsibilities, technologies assigned to each first responder, data collectors' assignments, etc., for each of the three vignettes. The Assignment Matrices are available in the TechEx Playbook, mentioned previously.

### 4.5 Narrative of Events

#### 4.5.1 Day 1 – Monday, June 5, 2017

**Setup**

Most of the Spiral 2 Team arrived in Grant County on Sunday, June 4 and reported to the Gorge Monday morning, June 5. The morning of June 5 was used to perform a final system setup, equipment installation, configuration and testing prior to the start of the actual TechEx. The equipment was loaded with final software applications, such as Watchtower and Wowza, locked down, and color coded to ensure each participant was issued appropriate devices consistent with their role and the technology identified in the Assignment Matrix.

**Data Collection Training**

In the afternoon, the TechEx team members assigned as data collectors received training from members of the TechEx evaluation team on how to use the data collection forms. Clipboards, data collection forms, stopwatches and pens were provided to all data collectors.

**Consultation with Key First Responders**

TechEx planning personnel held discussions with the Battalion Chief for Training from Fire District 5 regarding the proposed location for the "ropes" rescue event planned for Vignette B. The Battalion Chief noted that, had there been a real incident where the team initially positioned the lost hiker, they would have called in a helicopter to rescue the injured hiker, not the Ropes Team. Based upon input from the Battalion Chief, the location for the Lost Hiker in Vignette B was changed to allow a Ropes Rescue from a location near the VIP quarters to the right of the Gorge main stage. A mannequin was also provided (referred to as "Hoseman"), which was tossed off the cliff just prior to Vignette B to simulate an injured hiker needing rescue.

### 4.5.2 Day 2 – Tuesday, June 6, 2017

**Registration**

TechEx planning team personnel registered the participants on the morning of the first day, which included check-in, provision of name tags, signing the Rules of Behavior form and receiving the TechEx Playbooks.

**Equipment Handout**

TechEx planning team personnel documented and tracked the assignment of participants to the vignette via the "Assignment Matrix" worksheet, which then matched the participants with the devices they would be using during the vignette. In compliance with the worksheet, ArdentMC's team handed out Hexoskin and Zephyr sensors, installed Pinpoint and Watchtower applications, and installed GPS receivers in vehicles. Zephyr sensors and Comms Hub equipment pouches containing the comms hub and either smartphones or LMRs for connectivity were distributed to appropriate participants. Planning team personnel installed datacasting dongles, antennas and software in the appropriate vehicles. Participants received training on the technologies they carried in preparation for the vignette.

**Lunch**

Grant County personnel arranged for the "Soup Ladies" and local caterers to provide lunch for the participants. A location near the Gorge Dispatch Trailer with a canopy and picnic tables was identified, additional chairs and tables were obtained from the Mobile Command Truck, and the location became a meeting place used for meetings and hot washes for the TechEx.

**Vignette A (Roll Call) Execution**

Vignette A commenced at 1304 on Tuesday, June 6. The Deputy assigned as the Gorge Dispatch quickly understood the progression of communications checks and equipment testing that was contained in the MSEL steps, and the vignette progressed faster than originally scheduled. Some technology problems were experienced due to a lack of day-to-day familiarity with the systems, but the on-site technical staff quickly helped to resolve these issues. A hot wash was held after the vignette at the canopy/picnic tables to give the participants and the TechEx planning team an opportunity to communicate outcomes from the vignette, report on the performance of the various technologies, and discuss what worked and what could be improved upon for the following day's events.

### 4.5.3 Day 3 – Wednesday, June 7, 2017

Vignette B (Lost Hiker) Execution: The Incident Commander initiated Vignette B by dispatching the Deputies and directing the UAs to be launched to find the mannequin ("Hoseman"). However, the dun-colored "Hoseman" had landed in the shadow of the cliff, and both the Deputies and the UAs had a very difficult time locating it. Eventually the mannequin was found and the Ropes Team was dispatched for rescue. The UAs remained dispatched and provided streaming video of the preparations for and rescue of "Hoseman" back to the Incident Commander, Gorge Dispatch and the MACC.

**Vignette C (Fire/Altercation) Execution**

The Incident Commander directed the UAs operator to fly the UAs over the reported location of the "fire" and transmit video back to the Incident Commander, Gorge Dispatch and MACC. The unit tracking system was used to track the brush trucks as they approached the fire from the south by placing a Verizon–enabled Wi-Fi hotspot on one of the vehicles. The Incident Commander was able to track the first responders as they moved toward the location of the simulated fire, and later to track the Deputies as they pursued the altercation suspect in the large campground area. The UAs flew over the activities taking place near the Columbia River gorge throughout the vignette.

**Final Hot Wash**

After the completion of Vignette C, the TechEx team met with all participants under the canopy for a final hot wash, during which time data collectors documented feedback and recommendations. The participants returned their equipment and NGFR representatives expressed gratitude to all participants, recognizing their efforts and commitment of resource, and awarded certificates to all participants prior to adjournment.

### 4.5.4 Day 4 – Thursday, June 8, 2017

**Spiral 2 TechEx Planning Team Hot Wash**

The hot wash with the TechEx planning team took place at the Best Western Motel in Ellensburg, Washington. There were 19 attendees along with at least six more on the conference bridge line. The full minutes of the hot wash are available upon request. Recommendations, lessons learned and best practices that were identified in the hot wash are included in the Lessons Learned and Best Practices section of this report. Overall, the TechEx planning team felt that the event was planned and well executed, and the predominant perspective was that the Grant County first responders view the event as a positive opportunity.

# Chapter 5. Results

Key findings as presented in this chapter should be interpreted with an understanding that several limitations related to the applied research methods were considered throughout the duration of the experiment. In addition, there were artificialities and assumptions that had to be considered and recognized given this was an operational experiment using a simulated scenario with limited resources (see Section 2.4.1).

## 5.1 Observational Methods

The data presented in this report was limited to what observers recorded, which was impacted by a range of confounding variables such as the activity level of the observer (e.g., walking or hiking while taking notes), interruptions, terrain and other unanticipated breaks that occurred during a vignette. While observers made efforts to note interference with their observations, the observers may not have captured or recorded every instance of a key event such as a connectivity failure. In addition, due to the large number of participants, it was not possible to have a 1:1 ratio of observers to first responders. During some vignettes, observers were working with four or more first responders, which may have impacted the number of key events that the observer was able to record.

Observational methods were also limited to what an observer could see, and what the observer was told by users throughout an experiment. Recorded key events may be biased to reflect the most easily observed events, while less obvious events could have occurred without notice or comment. Similarly, each observer's professional expertise, interest, vignette activities and focus may have also introduced some bias while recording key events.

Due to the observer-to-first-responder ratio, and confounds present due to observational methods, the number of key events or issues cannot be presented as a proportion or percentage. For instance, it is not possible to state that four percent of users had to restart or reset an application or technology to restore connectivity.

The Grant County TechEx provided an exciting opportunity for the NGFR Program to gain first-hand knowledge of first responders' needs and have direct access to their feedback, input, requirements and recommendations. There were four key factors used to guide data gathering efforts and measure the impact:

1. The NGFR technologies were placed directly in the hands of first responders for use in their mission-specific operational environment; therefore, the outcomes and analysis found in this report are based directly on end-user needs, requirements and feedback.

2. Quantitative data was captured to the extent possible to help assess enhanced information sharing capabilities (i.e., video quality, timeliness of information shared, data captured and retained for ongoing situational awareness).
3. A baseline “as-is” state of the Grant County operational environment was completed and used throughout the planning process to support the TechEx analysis (see TechEx Playbook).
4. The post-vignette hot wash events were structured to focus on and capture end-users' feedback with questions geared towards assessing improved capabilities and eliciting feedback and participants’ recommendations (i.e., enhanced situational awareness, improved data sharing, etc.).

### 5.1.1 Preliminary Setup and Learning

Key findings related to connectivity failures or location accuracy, especially during Vignette A, were related to the initial set-up of a technology. An example of this issue includes losing location awareness in Watchtower due to included spaces in user names entered into the application. Data included in this report that reflects such issues likely represents a learning curve for implementing new technologies rather than a technology failure or deficiency.

### 5.1.2 Limitations

Some of the key findings described in this section should be considered with an understanding of several limitations related to the applied research methods, as well as the availability of resources and first responder roles and responsibilities. Key findings related to connectivity failures or location accuracy, especially during Vignette A, were related to the initial set-up of a technology; however, that was the purpose of the vignette–it was to serve as a communications test and roll call, representative of a real-world event. An example of one of the findings during Vignette A was losing geographic location awareness in Watchtower due to the fact that when initial set-up of the application occurred, spaces in user names were included.

## 5.2 TechEx Objectives – Results

The following summarizes efforts that were implemented to address each TechEx objective.

**Objective 1: Perform a needs assessment and establish baseline requirements for participating first responder groups from Grant County, Washington.**

A key focus of the NGFR Apex Program is to help tomorrow’s first responder be better ***protected, connected and fully aware***. To accomplish this, the NGFR Apex program recognizes that the needs and requirements of the first responder community must be the underpinning of the program’s efforts. Therefore, in Grant County, as in other efforts, the team incorporated four key

features to help ensure the TechEx reflected the needs and requirements of the Grant County end-users (first responders).

*Collaborative Planning:* The Grant County first responder community was engaged early in the planning efforts. At each step of the planning process, first responders from Grant County played an active and influential role to ensure the TechEx represented their operational mission and was focused on addressing their needs. Grant County also made decisions related to the selection of venue (i.e., the Gorge Amphitheatre) and surrounding locations, the scenario and vignette details, and help to develop the MSEL to ensure the TechEx reflected realistic activities to the extent possible. The emphasis was on the first responders' needs and their extensive involvement throughout the planning process to help produce relevant outcomes.

*End-User Engagement:* A second critical aspect of the TechEx was the ability to place emerging technologies directly in the hands of the first responder community and provide them with the opportunity to use the technology. By creating high-fidelity operational scenarios where actual end-users engaged with the technologies, the evaluation team was able to obtain insights regarding what technology capabilities were deemed useful. The evaluation team was able to glean valuable insight related to the integration of the technologies with existing technical and human systems.

*Expert Observation:* Having technical and subject matter experts (SMEs) accompany the first responders throughout the experiment greatly enhanced opportunities for data collection and provided insight regarding the relevance of the technology to mission requirements. First-hand observation of the capabilities and limitations of the technologies, and the capabilities and limitations of the first responders using the technologies, provided a unique opportunity to identify key issues related to integration, implementation and human use. The opportunity to interact with technical experts who could explain features of each technology also enhanced end-user investment and engagement in the experiment.

*Rigorous Documentation:* As a method of assessing operational needs and requirements, DHS S&T NGFR has emphasized characterization of end-user feedback regarding the utility and integration of communications systems. During the Grant County TechEx, this effort was greatly expanded as multiple opportunities were provided for end-user feedback through one-on-one discussions, surveys, observer notes and hot wash discussions. This rigorous process provided a method for capturing multiple aspects of data and information, to include "in the moment" end-user perspectives, recommendations, end-user feedback and time-based evaluation of the systems.

**Objective 2: Assess technologies that may provide potential solutions for Grant County's mission requirements and needs.**

Based on meetings with the Grant County first responder community and outcomes of stated needs from those meetings, 16 technologies were identified for the TechEx and provided support for the core capability areas:

1. Operational Communications;
2. Responder Health and Safety;
3. Situational Awareness; and
4. Operational Coordination.

These technologies were assessed for their capabilities to: (1) provide or enhance network capability; (2) route or manage data; (3) enhance situational awareness, which included (4) geo-location, (5) monitoring physical health, and (6) video dissemination. These capabilities and sub-capabilities were integrated into an ad hoc (i.e., non-permanent) architecture.

The evaluation team was able to observe, document and collect data to validate the utility of five of six aspects of the test configuration:

1. Successful implementation of an enhanced integrated network communications architecture that enabled public safety officers to communicate using commercial cellular, dedicated Band 14, Microwave, Bluetooth, Wi-Fi and unidirectional UHF operating in white space.
2. Successful implementation of an architecture capable of maintaining connectivity with two sets of cloud services, while consistently leveraging the capabilities implemented in each.
3. Implementation of an architecture that provided increased situational awareness and integrated with Grant County's existing systems.
4. Achieved the ability to geo-locate end-users (based upon their devices) and vehicles.
5. Implemented a system architecture capable of disseminating real-time video streams to first responders and leadership.
6. With respect to the physiological systems (i.e., Zephyr sensors and Hexoskin Smart Shirts), these technologies were tested during the dry run, at which time inaccurate and unreliable results were observed and recorded.)

**Objective 3: Evaluate the operational deployment of those technologies and their integration with existing first responder/public safety systems through scenario-based testing.**

The TechEx scenario provided sufficient realistic opportunity for the evaluation team to assess the various technologies' utility and integration with existing systems (technical and human), as well as the ability to identify gaps and enhancements to be addressed in the future:

1. At least one use-case was identified where the availability of video enhanced operational performance. This use-case was both readily observable by technical observers and confirmed by end-users.
2. At least one use-case was identified in which the geo-location of personnel enhanced operational performance. This use-case was both readily observable by technical observers and confirmed by end-users.
3. At least one potential interface enhancement was identified that would make the technology more readily usable by first responders.

**Objective 4: Determine the extent to which the deployed technologies are usable, supportable, safe and acceptable to the first responder users.**

The technical performance and human systems integration evaluation team used a three-step process to evaluate the technologies and to ensure efficient and effective data collection:

1. Technologies to be integrated and tested in Grant County were initially configured and tested under controlled conditions at the NIST PSCR Lab in Boulder, Colorado, the week of April 24, 2017.
2. Technologies to be integrated and tested were configured and tested by technical experts under operational conditions at the Gorge Amphitheatre in Grant County, Washington, the week of May 8, 2017.
3. Technologies to be integrated and tested were configured and tested by end-users under operational conditions at the Gorge Amphitheatre in Grant County, Washington, the week of June 4, 2017.

While a robust assessment of the usability, supportability, safety and acceptability of a network architecture would require more time and access to more end-users than could possibly be achieved in the allotted time frame, the evaluation team was able to verify that the test architecture implemented and configured in Grant County was easy to install, easy to use and that it provided a significant number of capabilities valued by the first responders.

**Objective 5: Provide an After Action Report that includes technology and operations-based recommendations.**

This document represents a comprehensive After Action Report.

## 5.3 Key Requirements – Results

### 5.3.1 Development

The TechEx planning team, in close collaboration with the Grant County first responders, identified 12 requirements for evaluation during the TechEx. A total of 23 tests was planned to help evaluate the 12 key requirements. The evaluations below should be considered preliminary because several technologies were still under development and the assessments were conducted within the limitations of an experiment rather than a real-world event. As such, the results of this experiment could help to identify areas where further development of the technologies could focus, whether requirements are suitable and how the requirements could be addressed in future, more rigorous testing. Note that the technologies in this TechEx functioned as a system-of-systems with inherent interdependencies. When possible, the function of individual components was assessed, but in several instances, there are aspects of multiple components or the entire system that affected outcomes.

Table 5-1 provides definitions for the result categories used for the tests. This reflects the assessment made of the degree to which each requirement was or was not verified.

**Table 5-1. Test Result Definitions**

| Result Category | Definition |
|---|---|
| Success | Test successful, no incidents or issues |
| Partial Success | Test met most criteria, but may have been inconsistent across various outcome measures or across vignettes |
| Conditional Failure | Test failed; however, external factors likely attributed to the failure (e.g., user out of range) |
| Failure | Test outcome did not meet criteria |
| Lack of Capability | Testing was not completed due to the maturity and/or current capabilities of the technology |

**Requirement 1: Allow field units to upload live video**

During Vignette A, participants were able to upload video for dissemination. There were two instances in which it was observed that end-users were unable to upload video from a Sonim phone using the Wowza GoCoder application, and one instance in which end-users were unable to upload data to the datacasting system. During Vignettes B and C, no additional issues related to uploading videos were documented.

Based upon analysis, it was concluded that the primary cause of the data upload failure was a lack of connectivity. More specifically, for the instance where the end-user was unable to upload data to the datacasting system, the issue was resolved after switching to Wi-Fi connection rather than LTE connection, and the datacasting capability was restored. Because the experiment did not involve assets capable of providing ubiquitous coverage throughout the entire site, this result is consistent with the technology deployment. The experiment architecture appeared to meet this first criterion with few noted exceptions: ability to upload video.

The second criterion associated with this requirement is the ability to upload video in a timely manner. There was no capability available during the test event to measure upload time. DHS S&T NGFR has identified methods for measuring the time from capture of an image within a data stream until it appears at the receiving terminal; however, because execution of these methods would have interfered with end-user operations, they were not implemented during the TechEx.

*Test 1a – Ability to upload live video: Vignette A - Partial Success, Vignettes B, C - Success*

*Test 1b – Ability to upload data in a timely manner: No measurements made*

**Requirement 2: Aural, haptic and visual alerts to responders when vital signs exceed acceptable parameters**

Evaluation of this requirement was not possible because none of the technologies deployed during the test possessed these capabilities. It should be noted that the result of Test 2b is conditional upon the result of Test 2a.

*Test 2a – Successful triggering of legitimate alerts: Lack of Capability*

*Test 2b – Minimized rate of false alerts: Lack of Capability*

**Requirement 3: Automatic transmission of responder health status and alerts to command centers, dispatchers and incident commanders**

This requirement addresses the ability of command units to monitor the health status of field units. During the execution of the TechEx, there were five instances of failure by IS4S communications hubs, three instances of failure by the Hexoskin Smart Shirts and three instances

of failure by the Zephyr. None of these devices was deemed sufficiently reliable to constitute a usable capability. In addition, the physiological readings generated by the Hexoskin Smart Shirts and the Zephyr sensor were not accurate. Technologies could collect and send data, but could not alert, and the data was not accurate. The test team did not have a capability to measure the latency between alert trigger and receipt during the experiment.

*Test 3a – Field unit health status data available to command units: Partial Success*

*Test 3b – Automatic alerting in a timely manner: Lack of Capability*

**Requirement 4: Connects to Incident Area Network using Band Class 14 LTE, commercial LTE and/or Wi-Fi without delaying operations**

The following devices connected to the IAN on a consistent basis within a time noted for specific technologies: Sonim phones, Oceus Xiphos Micro (eight minutes), Ubiquiti Nanostation M (one second), Mobile Broadband Kit (four minutes), IS4S Communications Hub (minutes), datacasting, datacasting dongle and Wowza GoCoder application. Connections were not always stable, and loss of connectivity did, on occasion, cause test procedures to fail. The failures noted may not have been a result of the networks established, but rather may have reflected whether the end-users were within the effective range of these networks.

*Test 4a – Ability to Connect:*

— Sonim phones, Oceus Xiphos Micro, Ubiquiti Nanostation M Mobile Broadband Kit IS4S Communications Hub, datacasting, datacasting dongle, Wowza GoCoder application: Success

*Test 4b – Time to Connect:*

— Ubiquiti Nanostation M Mobile: Success

— Oceus Xiphos Micro, Mobile Broadband Kit, and IS4S Communications Hub: Success

— Datacasting, datacasting dongle, Wowza GoCoder application, Sonim phones: Lack of testing capability

*Test 4c – Connection stability: Conditional Failure*

**Requirement 5: Connects to Personal Area Network using Bluetooth**

Sonim phones were successfully connected to health sensors via a personal area network (PAN) using Bluetooth. No attempt was made to measure the time required to establish a connection given constraints of the experiment. Bluetooth connections were not stable; loss of communication was a common cause of failure for test procedures.

*Test 5a – Ability to Connect: Success*

*Test 5b – Time to Connect: Lack of Capability*

*Test 5c – Connection stability: Failure*

**Requirement 6: Enable geo-location of first responders (FRs) and FR assets**

There were four instances of incorrect or inaccurate location due to connectivity issues using Ardent Watchtower application. Location was found to update approximately every five seconds when there was a continual connection. No failures were reported for other geo-location technologies. The experiment successfully showed the feasibility and utility of geo-location; however, the configuration was not fully robust due to connectivity/software maturity issues.

*Test 6a – Accuracy of geo-location: Partial Success*

*Test 6b – Time between updates: Success*

**Requirement 7: Enable geo-location of victims and hazards**

There was no attempt to explicitly evaluate this requirement during the experiment due to the costs and challenges of providing simulated victims with geo-location. Versions of the technologies also lacked the capability to provide this feature (e.g., participants were not able to pin or place items, victims or hazards on maps).

*Test 7: Awareness of locations of victims: Lack of Capability*

**Requirement 8: Indication to responder that critical communications were received**

None of the technologies deployed had this capability.

*Test 8: Confirmation communications received: Lack of Capability*

**Requirement 9: Measure vital signs such as heart rate and respiratory rate**

This requirement addresses the ability of physiological monitoring devices to measure and collect physiological data. The Hexoskin vital sign measurements were reported in real-time; however, the vital sign values captured using Hexoskin were inaccurate when compared to first responders' actual vital signs. Therefore, because the real-time data was captured for Hexoskin, it was inaccurate and unusable. The team was not able to collect data from the Zephyr devices.

*Test 9a – Accuracy of physiological measurements: Failure*

*Test 9b – Time between updates: Failure (if the data is not accurate, the update interval is irrelevant)*

**Requirement 10: Provide location of nearest fire hydrant, hospital, fuel supply, potable water supply, general water supply, medical cache, equipment storage, hazmat, etc.**

Grant County maps containing this data were successfully overlaid on the Ops Dashboard. Although the location information was successfully integrated into the dashboard maps, there was no explicit testing of whether end-users directly engaged with or used these features. Command continued to communicate information regarding resource location, and first responders in the field relied on that communication. Testing of this requirement was focused on the ability to transfer geo-tagged resources to dashboard maps, rather than operational use of the mapping feature.

*Test 10: Provide location of critical response resources: Success*

**Requirement 11: Receive live video from traffic cameras, closed circuit camera, and vehicle- and/or body-mounted cameras (multiple sources)**

The team was able to successfully receive and disseminate real-time video data. During the experiment, the ability to stream data from handheld devices using the Wowza GoCoder application and from websites identified by a Uniform Resource Locator (URL) was successfully demonstrated. Video data was streamed to the SpectraRep datacasting cloud; from there it could be transmitted via datacasting to laptops in the field equipped with the IncidentOne software and a UHF dongle within range of the white space broadcast, or able to connect through the secure Internet dashboard. Multiple video streams were broadcast simultaneously during the test.

*Test 11a – Ability to stream live video: Success*

*Test 11b – Ability to broadcast multiple video streams: Success*

**Requirement 12: Stream and/or record intelligible voice, video and data in real-time (real-time usable data)**

During the experiment, the ability to consistently stream video with clearly discernible images was demonstrated, but the frame rate was not consistently high enough to support operations. This limitation was attributed to both connectivity and compatibility issues.

*Test 12a: Recording live video - Lack of Capability*

*Test 12b: Streaming live video with discernable images - Partial Success*

### 5.3.2 Summary of Results Based on Requirements

Across the 12 requirements identified for evaluation, a total of 23 tests were planned. Of these 23 tests, 11 tests (48%) were categorized as a success or a partial success, 4 tests (17%) were

categorized as a failure or conditional failure, and 8 tests (35%) were noted as a Lack of Capability (Table 5-2).

**Table 5-2. Summary of Tests, Outcomes and Outcome Justifications**

| Requirement | Test | Outcome | Justification |
|---|---|---|---|
| 1. Allow field units to upload live video | 1.a. Ability to upload video | Partial Success | Limited challenges uploading video during Vignette A, users able to upload videos in Vignettes B and C |
| | 1.b. Ability to upload video in a timely manner | Lack of Capability | Unable to measure upload time |
| 2. Aural, haptic and visual alerts to responders when vital signs exceed acceptable parameters | 2a. Successful triggering of legitimate alerts | Lack of Capability | Technology lacked capability to deliver aural, haptic and visual alerts |
| | 2b. Minimized rate of false alerts | Lack of Capability | Unable to determine due to lack of capability (2a) |
| 3. Automatic transmission of responder health status and alerts to command centers, dispatchers and incident commanders | 3a. Field unit health status data available to command units | Partial Success | Command center was able to view physiological data from first responders in the field |
| | 3b. Automatic alerting in a timely manner | Lack of Capability | Time-sensitive alerting capability unavailable |
| 4. Connects to IAN using Band Class 14 LTE, commercial LTE and/or Wi-Fi without delaying operations | 4a. Ability to connect (Band Class 14 LTE/Wi-Fi) | Success | Devices were able to successfully connect to the IAN using prescribed pathways |
| | 4b. Time to connect (Band Class 14 LTE/Wi-Fi) | Partial Success | Some technologies were able to connect to the IAN in prescribed time periods (refers only to technologies where time was validated) |
| | 4c. Connection stability (Band Class 14 LTE/Wi-Fi) | Conditional Failure | Loss of connection was observed, and was observed to have a negative impact on some test procedures; failures likely attributed to users inadvertently leaving network range |

| Requirement | Test | Outcome | Justification |
|---|---|---|---|
| 5. Connects to PAN using Bluetooth | 5a. Ability to connect | Success | Users were able to connect to PAN/Bluetooth |
| | 5b. Time to connect | Lack of Capability | Unable to measure time to connect |
| | 5c. Connection stability | Failure | Bluetooth connections were generally unstable; this was identified as a common factor in test procedure failures |
| 6. Enable geo-location of FRs and FR assets | 6a. Accuracy of geo-location | Partial Success | Geo-location widely successful; however, at times inconsistent |
| | 6b. Time between updates | Success | Location updated approximately every 5 seconds |
| 7. Enable geo-location of victims and hazards | 7. Awareness of locations of victims | Lack of Capability | No capability to mark or pin locations in interface |
| 8. Indication to responder that critical communications were received | 8. Confirmation communications received | Lack of Capability | Technology unable to provide user feedback regarding successful transmission of communication |
| 9. Measure vital signs such as heart rate and respiratory rate | 9a. Accuracy of physiological measurements | Failure | Data was inaccurate |
| | 9b. Time between updates | Failure | 9a was a failure, so 9b became irrelevant |
| 10. Provide location of nearest fire hydrant, hospital, fuel supply, potable water supply, general water supply, medical cache, equipment storage, hazmat, etc. | 10. Provide location of critical response resources | Success | Grant County maps, including existing resources, were successfully overlaid on Ops Dashboard |
| 11. Receive live video from traffic cameras, closed circuit camera, and vehicle- and/or body-mounted cameras (multiple sources) | 11a. Ability to stream live video | Success | Users successfully streamed videos using Wowza GoCoder |
| | 11b. Ability to broadcast multiple video streams | Success | Multiple video streams were broadcast during the test event |
| 12. Stream and/or record intelligible voice, video and data in real-time (real-time usable data) | 12a. Recording live video | Lack of Capability | No capability to record video |
| | 12b. Streaming live video with discernable images | Partial Success | Video quality was high resolution, but had inconsistent, and at times very slow, frame rate |

## 5.4 Capability-based Results

### 5.4.1 Communications

Communication findings are associated with the Sonim phone and BC 14 LTE/AT&T connectivity and usability, as these were the observable communication technologies throughout each vignette. Incidents or events related to communication technologies and communication topics were separated into three categories: Loss of Connection, Device Design and Radio Communication.

**Loss of Connection/Application Problems**

Observers reported eight events directly related to the connectivity of the Sonim phone, with four occurring during Vignette A, three during Vignette B and one during Vignette C. Sonim phones required a reboot or reset in all three vignettes (six of eight events) to restore connectivity. After resetting or rebooting the phones, connectivity was restored in each instance. One of these instances was prompted due to a user noticing that applications on the Sonim phone were frozen or inoperable. During Vignette B, while users were engaged in activities in the Columbia River gorge, Sonim phones lost connectivity or were roaming independent of Sonim Watchtower (two instances).

**Device Design**

In addition, observers reported that users had difficulty finding a place to store the Sonim phone during Vignette B (two instances). In one instance, the storage pack for the phone became unbuttoned or loose during a physically challenging portion of Vignette B, while the other instance was a general comment on the lack of on-person storage for the phone.

**Land Mobile Radio Communication**

Outside of the new communications technology, use of a single Grant County LMR radio channel for first responder coordination and communication during Vignette B revealed challenges for the users. Observers recorded three instances of first responders either losing radio communication, reporting difficulty coordinating with one another due to use of a single radio channel, or requiring alternative modes of communication to clarify ongoing actions.

### 5.4.2 Situational Awareness/Location Reporting

Situational Awareness and Location Reporting findings are associated with Watchtower, ESRI Ops Dashboard, Raspberry Pi and Pinpoint technologies. Observers recorded 34 events under this technology category, with 22 occurring in Vignette A, nine in Vignette B and three in Vignette C. The changes in reported issues across the three vignettes are notable, as they likely reflect issues

associated with initial set-up processes and user learning versus a technology issue. Note that the number of connectivity events reported per technology is influenced by the number of users per technology, and Watchtower was one of the most widely used technologies that could be assessed through observation. Situational Awareness and Location Reporting findings were separated into three categories: Loss of Connection, Location Accuracy and Display Design.

**Application Problems**

In 20 Situational Awareness and Location Reporting events, observers recorded a loss of connection using the various technologies, with 15 events occurring in Vignette A. In 14 of the 20 connection loss events, Watchtower was the primary technology recorded by observers. The ESRI Ops Dashboard was associated with three loss of connection events, Raspberry Pi was associated with two loss of connection events and Pinpoint was associated with one event.

Loss of connection/application problems associated with Watchtower included issues such as users who were not able to be located with the application, user icons that disappeared or stopped responding while using the application, and sporadic connectivity for certain users where their icon would appear and disappear unpredictably. In one instance, a user was unable to reset the Watchtower application on a Sonim phone, and no locations were shown on the map. Connectivity issues related to Watchtower in Vignette A (11 events, or 55% of all recorded events) may have been attributed to the way that user information was entered into the Watchtower application. If users used a space in their “Resource” field name, the application had difficulty accurately locating the user. During Vignette B and C where this particular issue was addressed, only three loss of connection events were associated with Watchtower.

The ESRI Ops Dashboard lost connection three times, with two instances associated with a system log-out that could potentially be attributed to inactivity (once during Vignette A, and once during Vignette B). During Vignette C, the ESRI Ops Dashboard lost connectivity for a duration of approximately three minutes.

Observers noted two instances of Raspberry Pi losing connection, with both occurring during Vignette A. In one instance, the icon disappeared and reappeared sporadically, and in another instance, the location was not displayed at all.

During Vignette A, one observer reported that Pinpoint was not working. This connectivity event might also be attributed to the original set-up and configuration during the preliminary vignette.

**Location Accuracy**

In 10 Situational Awareness and Location Reporting events, observers recorded location accuracy events, with four location accuracy events occurring in Vignette A, four in Vignette B and two in

Vignette C. Of the 10 events, seven were attributed to Watchtower and three were attributed to the ESRI Ops Dashboard.

Watchtower's location accuracy was dependent on connectivity and the capacity for a consistent and rapid refresh rate. Of the seven recorded events during Vignette A, an observer recorded two issues related to an incorrect location of the Mobile Command Trailer. The observation team also recorded four additional events where a first responder's location was inaccurate or incorrect, and one event where a new person suddenly appeared on the Watchtower application.

During Vignette B, three location accuracy events were recorded for the ESRI Ops Dashboard. First responders who had access to both the UAs video stream and location information noted that the ESRI Ops Dashboard locations were inconsistent with the video feed, with one instance of the display showing three first responders, but the video feed showing eight first responders; and one instance of the display showing responders far away from a cliff location, but the video feed showing the responders rappelling from the cliff. In addition, observers noted that the ESRI Ops Dashboard was not updating the icon locations as expected.

**Display Design**

Situational Awareness and Location Reporting is often highly dependent on display design and the ability for users to quickly understand how to interpret information from the application. Observers recorded four instances of display design events, with three associated with Watchtower and one associated with the ESRI Ops Dashboard.

Watchtower's interface was nearly unanimously easy to understand; however, there were three instances where observers recorded display design and interface events. In two instances, users found it challenging to identify specific users or units because of the icon label design. In addition, one observer recorded the responder's need for assistance in turning location reporting on and establishing a user profile.

The ESRI Ops Dashboard was associated with one event, where the user required assistance in how to understand and view a unit location on a laptop.

### 5.4.3 Physiological Monitoring

Physiological sensors are associated with the IS4S Dashboard, Hexoskin and Zeyphr technologies. Observers recorded 18 events associated with these technologies, as well as some preliminary data regarding the accuracy of the physiological sensors. Physiological sensor observations posed some challenges for observers who were unable to differentiate between the types of sensor worn by a first responder. Due to this issue, the Hexoskin and Zephyr technologies are grouped together. Physiological Sensor incidents were separated into four categories: Technology Failure, Connectivity, Communication and Sensor Accuracy.

**Technology Failure**

- Observers reported inability to view or access physiological sensors and/or sensor data via dashboards a total of seven times, with two events during Vignette A and five during Vignette B.
- Observers reported four incidents of the IS4S technology not working, and one incident where the IS4S Dashboard crashed and stopped working.
- Observers recorded three incidents of the Hexoskin and Zephyr technologies not working, where the user could not access the physiological data or where the data was not transmitted.

**Connectivity**

All nine of the Physiological Sensor connectivity incidents were associated with Hexoskin and Zephyr. Responders reported that the sensors would lose connectivity with their phones, and there was no way to automatically reconnect to the phone. In addition, use of Bluetooth connections when multiple users were in close proximity made pairing specific phones to specific sensors challenging. Users were unclear whether their phone was connected to their own physiological sensor or to another user's phone or sensor.

**Application-Specific Results**

Communication regarding physiological monitoring and status was challenging for users in the field and users in command centers. Two incidents were recorded regarding this issue. When using the Comms Dashboard, one user had difficulty understanding how to access and read physiological data. One field user was also unclear on whether the command center or other location would read physiological data to him, or if he should report his data to the command center. These issues, while minor, reflect a need to identify operational strategies and communication patterns for using physiological data.

During Vignette C, one observer who was working with a team of four first responders, recorded the sensor heartrate readings and actual heartrate readings (see Table 5-3). The discrepancy between the sensors and the measured pulse rate of first responders highlights the need to continue development of physiological sensors to ensure that readings are accurate in all operational scenarios.

Anecdotally, throughout the experiment, other first responders reported that they did not believe their physiological sensors were providing an accurate reflection of their level of exertion.

**Table 5-3. Physiological Sensor Heart Rate Readings versus Measured Pulse Rate**

| User | Hexoskin/Zeyphr Heart Rate | Pulse Rate |
|---|---|---|
| 1 | 162 | 110 |
| 2 | 170 | 120 |
| 3 | 94 | 94 |
| 4 | 129 | 100 |

### 5.4.4 Video Transmission

Video capture, presentation and transmission were associated with Datacasting, Wowza Go Coder, Wowza Multimedia (SpectraRep) and UAs video transmission. While the UAs video technology was a technology already available rather than a technology introduced in this experiment, video quality and transmission related to the UAs video was incorporated into these findings because it was made available through technologies being evaluated. Overall, there were 13 events or incidents related to video capture, presentation and transmission. Findings were grouped into categories: Connectivity, Design, UAs Video and Video Quality.

**Connectivity**

Five instances related to the ability to connect to video streams or the ability to view video streams recorded by observers. Three of these incidents were recorded without reference to a specific technology. Observers reported that one user was unable to load a video, and was only able to see a screen that displayed a “loading” message. Another user was only able to capture a blank screen; however, it is unclear if the source of this issue was the technology or user error. Another user required help accessing and identifying the URL for viewing the video. Datacasting technology was associated with the remaining two events, where one user was unable to access or use datacasting, and another user reported a lost connection.

**Design**

One design issue was identified, where a user desired the ability to zoom in on a video feed to aid in the identification of key information from the video. This was not a feature of the service as deployed, but was noted for a future capability.

**UAs Video**

Use of UAs video feeds generated seven events during Vignette B. Three of these events included alerts and alarms associated with the need to change the UAs battery. Two instances were related to difficulty maintaining connectivity and signal with the UAs, which could have larger reaching operational impacts when used outside of a training setting. Another incident involved losing sight of, or having difficulty seeing, the UAs while it was flying. The use of a spotter, while helpful, was not always possible due to competing demands of the users. Finally, broadcasting UAs video was dependent on the battery life of the iOS device used by the UAs operator. It is currently not possible to charge the device while flying the UAs, which limited the flying time.

**Video Quality**

The streaming video from the UAs to the UAs controller was observed to be of poor quality at times, depending on the configuration. As a result, the video received at the command center was also observed to exhibit the same poor artifacts.

At other times, the observers noted that the video quality was very good (e.g., high resolution), but the frame rate was insufficient. In this instance, the source video from the UAs to the UAs controller was observed to be good with high detail and fluid motion, but the video footage received at the command center lacked fluidity. This resulted in video footage that had very good detail, but lacked overall smoothness.

While an underlying cause of the frame rate problem was not determinable in the field setting, cursory field tests pointed to compatibility issues between the UAs video and the Wowza/Datacasting transcoder. This seemed to be further validated by the observers reporting significantly better video quality from the Datacast network when viewing footage sent from first responder on their smartphones. Live streaming from a smartphone shared similar paths with the UAs, but did not exhibit fluidity issues as it was streamed through the Datacasting network. While there was not time to make adjustments during the experiment, it is likely that encoding adjustments could be made for future use that will reduce the quality issues.

For Vignette C, a Sonim phone subscribed to the AT&T network and running the Wowza Gocoder app was used to live stream video from the Fire District 3 team. The observer of the Sonim phone spoke via the open conference bridge with Mark O'Brien of SpectraRep to confirm receipt of the video–there was no visual indication the video was successfully streamed to the Wowza server—as some participants pointed out. With the phone showing the signal reception of roughly one to two signal bars on the AT&T LTE network, the SpectraRep dashboard displayed the live streaming with smooth, full-motion video quality with no image degradations such as pixilation or video buffering. Live streaming video was able to convey more actionable information than the

traditional voice descriptions over LMR. For example, seeing the UAs video firsthand, even at lower frame rates, was better than hearing a description of what the UAs operator was seeing.

## 5.5 End-user Feedback

### 5.5.1 Survey Results

Observers administered a survey to participants (survey template provided in the TechEx Playbook). While portions of the survey allowed for open-ended responses, the final 11 questions were rated on four- or five-point Likert Scales. Open-ended response information is distributed throughout the end-user feedback sections, while scaled responses are summarized below.

Of the 11 scaled questions, the first six referred to the equipment and technologies that first responders typically use rather than to the equipment and technologies introduced during the TechEx. Table 5-4 summarizes these responses.

**Table 5-4. Survey Responses Regarding Previously Existing Technologies**

| Question | Scale | Mean Response |
|---|---|---|
| Are the tactics, techniques and procedures you use in operating your current equipment formalized, effective and responsive to the situation? | 1 = Never<br>2 = Rarely<br>3 = Usually<br>4 = Always | 3.00, Usually |
| Do you currently have all the information you need to do your job with the current equipment and technologies used? | 1 = Never<br>2 = Rarely<br>3 = Usually<br>4 = Always | 3.00, Usually |
| Do you currently have all the information you need at the right time to make informed decisions? | 1 = Never<br>2 = Rarely<br>3 = Usually<br>4 = Always | 2.69, Rarely/Usually |
| Do you currently have all the up to the minute information you need to maintain awareness of the tactical situation? | 1 = Never<br>2 = Rarely<br>3 = Usually<br>4 = Always | 2.62, Rarely/Usually |

| Question | Scale | Mean Response |
|---|---|---|
| How effective is your current equipment in alerting you to potential hazards or threats to your safety and that of your associates? | 1 = Not at all<br>2 = Poor<br>3 = So-So<br>4 = Good<br>5 = Excellent | 2.20, Poor/So-so |
| Does use of your current equipment at times distract you from your primary tasks and become a hazard? | 1 = Never<br>2 = Rarely<br>3 = Usually<br>4 = Always | 2.08, Rarely |

Responses to questions regarding first responder technologies and information sharing reflect issues captured in the TechEx situational awareness objectives. Most notably, the average response of “Poor/So-so” for the effectiveness of current equipment in alerting first responders to hazards highlights the importance and relevance of situational awareness technologies introduced during the TechEx.

The remaining five scaled responses addressed the TechEx technologies. Table 5-5 summarizes these responses. These five questions used the same 5-point Likert Scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree. In general, the response to new technologies introduced during this experiment was positive. The new technologies were viewed as improvements over currently available equipment, and viewed as tools that may improve communication and information sharing.

**Table 5-5. Survey Responses Regarding TechEx Technologies**

| Question | Mean Response |
|---|---|
| These technologies are an improvement on technologies or approaches that I currently use. | 4.23, Agree/Strongly Agree |
| The interface was intuitive and easy to understand and engage with. | 3.88, Neutral/Agree |
| The technology could be easily integrated into my organization’s operations. | 4.31, Agree/Strongly Agree |
| This technology increases my ability to communicate and disseminate information during an event or incident. | 4.08, Agree |

| Question | Mean Response |
|---|---|
| This technology can improve my ability to review and report information back to my leadership. | 4.38, Agree/Strongly Agree |

### 5.5.2 Live Video Streaming

Users stated a preference for wearable push-to-record video capability over handheld video capability. In operational settings, first responders would be unable to stop moving, take a phone or handheld technology out, open an application and record video. In some instances, handheld video capabilities are useful, but wearable push-to-record devices allow users to continue to perform their duties while simultaneously recording information.

In addition, while using Wowza Go-Coder video applications, users were unable to determine whether their video stream was successfully transmitted. The current user interface should be improved by providing feedback to the user through an icon that reflects successful video transmission, or another type of feedback that shows that the video was successfully uploaded. To provide further confirmation, standardized communication between first responders taking videos and team members in command and/or dispatch centers should be established.

### 5.5.3 Comms Hub Carrying Pack

Users found the carrying pack for this technology to be bulky, heavy and difficult to wear while walking. Distributing the weight and bulk of this technology across the user's current gear, for instance by using Modular Lightweight Load-carrying Equipment (MOLLE) tactical vests, may be one design solution for ensuring this technology can be used in operational settings.

Users were unable to determine whether the technology was working, due to a lack of visual or other feedback regarding system status and connectivity. Users need to have a simple way of identifying system status, and for identifying instances where their connectivity is limited or unavailable.

### 5.5.4 Sonim Phone

Some users found the Sonim phone to be too bulky and large to carry. In addition, users in the field commented that they did not have an adequate place to store the phone while engaging in other activities. The bulk and size of the phone is likely related to the durable covering, which is also an advantage for this phone.

### 5.5.5 Dashboards

Toggling between various dashboards to access different types of information was challenging for users. Users requested the ability to integrate all of the information into one screen. This request, however, should be taken into consideration within the context of user centered design processes. Integrating too much information into one dashboard increases the chance of visual

clutter, increased cognitive workload and decreased user satisfaction. Usability assessments of the dashboards, including issues such as menu design, user interface design, use of fonts, use of color and other characteristics, should be completed for future iterations of this technology to ensure they are in a format that is easier to use.

### 5.5.6 Physiological Sensors

Generally, the sensors were not accurate enough to use, and physiological data generated by the sensors was challenging to access for users. Users requested the ability to set their own upper and lower heart rate limits, but until the sensors are more reliable and accurate, these settings will be difficult to implement. In addition, the purpose of the sensors and information generated by the sensors was unclear for users. Sensor wearers requested clarification regarding communication of physiological status (e.g., should the user wearing the sensor report their information to dispatch/command, or should dispatch/command report to the user?), which illustrates a need to establish operational standards for using this type of technology.

In terms of wearability, both the Hexoskin and Zephyr sensors were uncomfortable for users to wear. The material used in the Hexoskin t-shirt garment, in particular, was not a breathable or sweat-wicking fabric and users reported feeling very hot while wearing it. The Zephyr chest-band sensor had fewer reported issues, but several users stated that it was uncomfortable to wear.

### 5.5.7 Watchtower

The Watchtower application was used by the majority of participants in this experiment, and was widely accepted and enjoyed by the users. Design and functionality improvements, including constraints and consideration for design development, for the Watchtower application included the five items described below.

#### *5.5.7.1 Icon Design*

Users found it challenging to differentiate between user icons, especially in areas where there were a large number of first responders using the application. Users requested the ability to color code icons based on resource type.

Incorporating colors and/or other types of icon differentiation may be advantageous, but may also contribute to visual clutter. Usability assessments should be performed on updated versions of the interface that include additional icon design characteristics such as shape and color. All colors used should also accommodate color blind users.

#### *5.5.7.2 Information Filtering*

Users requested the ability to filter available information by agency (or other characteristics) to limit the amount of information on the display.

Filter settings should be easy to access and use on a handheld device, which may be challenging to design depending on checkbox size or dropdown menu size (or other filtering design mechanism). In addition, users should be able to easily identify that a filter is applied, to reduce the risk of inadvertently filtering out information.

#### *5.5.7.3 Messaging Capability*

Users requested the ability to send and receive messages.

Users should have the ability to turn messaging off and on, to reduce the chances of disruption due to interruptions by unsolicited messages. When sending a message to another user, the receiving user's status should also be displayed.

#### *5.5.7.4 User Selection of Map Orientation*

This capability should be accompanied by a visual marker that allows users to see their orientation status within the interface.

#### *5.5.7.5 Pin Points of Interest*

The ability to pin and share points of interest to facilitate coordination regarding specific events or needs may improve response time.

Pushing location information through the Watchtower application to other users should be designed to accommodate various types of pins. For instance, the urgency of the information and the type of response needed could influence the design of the pin, or influence the type of notification received by other users.

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# Chapter 6. Recommendations and Lessons Learned

This chapter provides a summary of feedback from a variety of sources, to include the DHS planning team, sub-committees, participants, senior leaders and technology developers. The recommendations were acquired during each of the three vignette hot washes, as well as from the from the TechEx Planning Team's hot wash, which took place the day after the TechEx.

## 6.1 Communications and Outreach

- Extensive communications among the team members, participants and other responders before, during and after the event fostered cooperation, enhanced understanding and ensured the needs of the first responder community were shared.
- Using SMEs, specifically persons with first responder experience similar to the Grant County participants, played a key role in communications and coordination, and also helped to limit the burden on participating first responders who have vital roles in their full-time jobs.

## 6.2 Logistics

- Inviting the right stakeholders to planning meetings, engaging them in the meetings, and tracking proceedings and decisions through detailed meeting minutes helped the success of the event.
- Detailed notes and action items from each meeting were key to ensure milestones were achieved and the schedule was met.
- Distinct check-in, staging, equipment distribution and meeting/debrief areas need to be pre-planned and disseminated to the event organizers and participants.

## 6.3 Project Management

- Using persons with first responder experience (i.e., experience as a state and local first responder) is critical for establishing realistic timelines and expectations.
- Gaining the involvement of responders for all aspects of planning is critical to the success of the event.
- Implementing a technical integration and testing session, as well as a dry run session, gave the technical and testing staff time to integrate, configure, test, and troubleshoot the various systems and mitigate problems prior to the actual event.
- Planning teams should recognize that working with end-users (i.e., first responders) *always* takes longer than anticipated due to real-world events and day-to-

day roles and responsibilities. This should be factored into schedules, and contingency plans developed accordingly.

## 6.4 Scenario Development/Execution

- Scenarios work best when developed with extensive involvement of the participant first responders. However, involvement and consultation with the participating first responder community must be managed carefully to ensure a balance of requests and communications, as well as to avoid burdening them with redundant communications.
- Having the flexibility to adapt the scenario to align and represent their routine operations enhanced the usability of the TechEx for training purposes.
- Implementing events (i.e., experiments, tests, exercises) "in the field" *always* results in the need for some adjustments; therefore, the planning team should not strive for "perfection," but rather a framework that allows for the inevitable flexibility that will be required due to unanticipated issues.
- Dry runs are critical to ensuring the relevance and achievability of scenarios prior to end-user participation.
- End-user time is arguably the limiting resource, and identifying and correcting limitations in scenarios prior to their participation is critical.

## 6.5 Testing and Evaluation

- Having enough trained data collectors in the right locations with the right data collection tools improves the quality and quantity of data that can be collected and used for analysis.
- Design and development of data collection and observational templates that mirror objectives and provide space for recording events related to specific technologies improves data quality and analysis.
- Metrics used to evaluate communications networks, especially with regard to their utility in achieving mission objectives, are largely qualitative. Future investment in methods for evaluating telecommunications networks in quantitative terms and in automated data collection tools to enhance characterization of network use and performance would improve results.
- As it is difficult for the observers to maintain cadence with the script while making observations, periodic broadcasts from the event orchestrator to synchronize scenario events among all participants would be helpful.

## 6.6 Technologies

- Technologies need to be reliable enough to provide valuable functionality and be operationally useful for similar events.

- Participants should receive training on the technologies before the event so that they can take full advantage of the technology capabilities during the event.
- Public safety end-users are increasingly demanding that their communications-related capabilities mirror those of their personal devices; it is critical that communications networks and devices provided keep pace with improvements in the commercial world.

## 6.7 Overall TechEx Recommendations

The following recommendations are for subsequent spirals and similar events:

- Spiral 3 should build upon the planning process, outcomes and recommendations from the Spiral 2 TechEx; this should be referenced throughout the planning, implementation and evaluation processes.
- Careful consideration of additional technologies should be applied because new technologies will limit comparability to the previous Spiral. Improved versions of the current technologies should be priority.
- Spiral 3 and similar events should use the same planning, implementation and evaluation format as the Spiral 2 to ensure a high probability of successful and measurable outcomes. Progress and improvements can therefore also be linked, tracked and documented accordingly.
- Follow-on events should consider scenarios that can be executed outside the range of commercial communications networks.
- Consider including technologies that may have previously underperformed, but showed tremendous benefit to the end-users and have now matured enough to be more reliable.
- Some consistency in the project implementation team is recommended because it may prove helpful to ensure lessons learned are carried forward.

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# Appendix A. Experimentation Plan (ExPlan) Overview

## A.1 Introduction

The following information provides an overview, as well as the tools used to support evaluating the NGFR technologies' ability to meet first responders' needs, data collection and analysis, integration with existing technology systems, integration with human systems, and reporting processes for the Grant County TechEx. This plan was developed with an intent to measure the NGFR technologies in operational scenarios and the severity of issues that occurred during their use. The full ExPlan was included as a component of the TechEx Playbook, which can be made available (see "Handling Instructions" for the Point of Contact to request a copy of the TechEx Playbook).

The feedback on technologies from Grant County end-users captured during the technology experiment was to be consolidated, interpreted and summarized for this report. Much of this input was obtained through notes collected during the vignette debrief hot washes. End-users were also asked to identify ways the technology supported their mission. End-users readily provided recommendations on how they felt technology can be improved.

## A.2 TechEx Target Capabilities, Objectives and NGFR Requirements Matrix

The evaluation efforts under each target capability included efforts to gather and document outcomes to:

- Gain insight into each NGFR technology's capabilities to meet end-user requirements;
- Assess what additional human factors integration requirements should be considered; and
- Determine if the technology could readily integrate into existing end-user systems.

## A.3 Network Connections Data Collection Forms

Instructions: Please fill out the following table before the start of Vignette A. Use your best estimate to the nearest second or minute for the Time to Connect column.

| Technology | Network* | Connected? (Y/N) | Time to Connect | Notes |
|---|---|---|---|---|
| Sonim Phones | IAN | | | |
| | PAN | | | |
| Oceus Xiphos Micro (Backpack LTE) | IAN | | | |
| Ubitquiti Nanostation M | IAN | | | |
| Mobile Broadband Kit | IAN | | | |
| IS4S Comms Hub | IAN | | | |
| | PAN | | | |
| Ardent Vortex | IAN | | | |
| Wowza Multimedia Server | IAN | | | |
| ESRI ArcGIS Ops Dashboard | IAN | | | |
| Ardent Watchtower | IAN | | | |
| | PAN | | | |
| Cradlepoint Router | IAN | | | |
| Ardent Pinpoint | IAN | | | |
| Hexoskin | PAN | | | |
| Zephyr | PAN | | | |
| Datacasting | IAN | | | |
| Datacasting Dongle | IAN | | | |
| Wowza GoCoder App | IAN | | | |

*IAN = Incident Area Network
PAN = Personal Area Network

### A.3.1 Vignette A

Use this table as a reference to the event narrative. Some cells have italicized questions. Answer these questions in the Notes column.

| Time | Event | Notes |
|---|---|---|
| 1300 | Simulate Saturday morning's command center report, roll call and equipment check. | |
| 1700 | Command center provides SitRep to conclude Roll Call. Communications to officers to deploy as directed and report back with any suspect observations. | |
| 1545 | After Roll Call, MACC receives 911 call from civilian reporting suspicious activity at Wanapum Dam. States he will send video.<br>*Was Good Samaritan video received? Quality of video*? | |
| 1550 | PUD control room operators also report observing suspects in boat landing on dam attempting forced entry into secure area.<br>*Was dam operator video received? Quality of video*? | |
| 1555 | Good Samaritan states he will provide video evidence to MACC from video captured on smartphone. | |
| 1620 | Suspects flee in boat northbound.<br>Video footage is available for identification of suspects and vessel, and is distributed to law enforcement units of Grant, Kittitas, Chelan and Douglas Counties, and Washington State Fish and Wildlife. | |

## A.3.2 Vignette A: Field Observation Template

**Location:** ____________________ **Field Shadow** Date: ____________________

**Observation Hour: (ex: 1 of 2)** ____________________ **Vignette A** Observer Initials: ____________________

**Start Time:** ________ End Time: ________ First Responder Role: ____________________

| Activity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Communication [RADIO] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PERSON/PERSON] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PHONE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tracking/Situation Awareness | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physiological Monitoring | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [VIEW] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [CAPTURE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [UPLOAD] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OTHER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Key Behaviors/Incidents | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seek Assistance [Tech] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Seek Assistance [Situation Awareness] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alerts/Alarms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Technology Failure/Connection Lost | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physical Exertion/Distress | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video Quality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physio Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Location Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Average update interval for responder location?
Average upload time for responder video?
Average update time for responder physio?

### A.3.3 Vignette B: Field Observation Template

**Location:** ____________________

**Observation Hour: (ex: 1 of 2)** ____________________

**Start Time:** ________ End Time: ________

**Field Shadow**
**Vignette B**

Date: ____________________

Observer Initials: ____________________

First Responder Role: ____________________

| **Activity** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Communication [RADIO] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PERSON/PERSON] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PHONE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tracking/Situation Awareness | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physiological Monitoring | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [VIEW] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [CAPTURE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [UPLOAD] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Walking/Tracking | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ropes/Rappel | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SUAS Operation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Direct Care (aid) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OTHER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| **Key Behaviors/Incidents** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seek Assistance [Tech] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Seek Assistance [Situation Awareness] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alerts/Alarms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Technology Failure/Connection Lost | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physical Exertion/Distress | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video Quality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physio Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Location Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Average update interval for responder location?
Average upload time for responder video?
Average update time for responder physio?
Average update interval for UAs location?

### A.3.4 Vignette C: Field Observation Template

**Location:** ____________ **Field Shadow** Date: ____________

**Observation Hour: (ex: 1 of 2)** ____________ **Vignette C** Observer Initials: ____________

**Start Time:** ______ End Time: ______ First Responder Role: ____________

| Activity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Communication [RADIO] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PERSON/PERSON] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PHONE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tracking/Situation Awareness | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physiological Monitoring | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [VIEW] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [CAPTURE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [UPLOAD] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Walking/Tracking | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Driving | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Crowd Control | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Direct Care (aid/contact) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fight Fire | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OTHER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Key Behaviors/Incidents | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seek Assistance [Tech] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Seek Assistance [Situation Awareness] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alerts/Alarms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Technology Failure/Connection Lost | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physical Exertion/Distress | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video Quality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physio Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Location Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Average update interval for responder location?
Average upload time for responder video?
Average update time for responder physio?
Average update interval for UAs location?

## A.3.5 Vignette ABC: Dispatch Command – MACC Observation Template

**Dispatch/Command**
**Vignettes ABC**

**Location:** ____________________
**Observation Hour: (ex: 1 of 2)** ____________________
**Start Time:** ________ End Time: ______

Date: ____________________
Observer Initials: ____________________
First Responder Role: ____________________

| Activity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Communication [RADIO] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PERSON/PERSON] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Communication [PHONE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tracking/Situation Awareness | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physiological Monitoring | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [VIEW] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [CAPTURE] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video [UPLOAD] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OTHER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Key Behaviors/Incidents | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seek Assistance [Tech] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Seek Assistance [Situation Awareness] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alerts/Alarms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Technology Failure/Connection Lost | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physical Exertion/Distress | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Video Quality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Physio Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Location Accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Average update interval for responder location?
Average upload time for responder video?
Average update time for responder physio?
Average update interval for UAs location?

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# Appendix B. Abbreviations and Acronyms

| | |
|---|---|
| 4G | Fourth Generation |
| AAR | After Action Report |
| AOR | Area of Responsibility |
| CAD | Computer-Aided Dispatch |
| CBIT | Columbia Basin Investigative Team |
| DHS | Department of Homeland Security |
| DHS S&T | DHS Science and Technology Directorate |
| EMS | Emergency Medical Services |
| FR | First Responder |
| FRG | First Responders Group |
| GCTS | Grant County Technology Services |
| GIS | Geospatial Information System |
| GPS | Global Positioning System |
| HSEEP | Homeland Security Exercise Evaluation Program |
| IAN | Incident Area Network |
| IS4S | Integrated Solutions for Systems |
| IT | Information Technology |
| JHU/APL | The Johns Hopkins University Applied Physics Laboratory |
| LMR | Land Mobile Radio |
| LTE | Long-Term Evolution |
| MACC | Multi-Agency Communications Center |
| MBK | Mobile Broadband Kit |
| MSEL | Master Scenario Events List |
| NGFR | Next Generation First Responder |
| NIST | National Institute of Standards and Technology |
| NSSE | National Special Security Event |
| NUSTL | National Urban Security Technology Laboratory |
| OIC | Office for Interoperability & Compatibility |
| PAN | Personal Area Network |
| PBS | Public Broadcasting Service |
| PSCR | Public Safety Communications Research |
| RF | Radio Frequency |

| | |
|---|---|
| RV | Recreational Vehicle |
| S&T | Science and Technology Directorate |
| TechEx | Technology Experimentation |
| TRT | Tactical Response Team |
| UAs | Unmanned Aircraft Systems (small single-user system) |

Homeland Security

Science and Technology