Boston Components Communications Experiment

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FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory organized within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responders Group (FRG).

Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of state and local first responders to address the homeland security mission. NUSTL provides first responders with the necessary services, products and tools to prevent, protect against, mitigate, respond to and recover from homeland security threats and events. NUSTL also provides testing and evaluation services to DHS S&T programs, including the Next Generation First Responder (NGFR) Apex Program. This program seeks to help tomorrow's first responders be more protected, connected and fully aware. When firefighters, law enforcement officers and paramedics have enhanced protection, communication and situational awareness, they are better able to save lives and make it home safely.

As part of its support to the NGFR Apex Program, NUSTL participated in an experiment on two communications systems, Mutualink and datacasting, in Boston, Massachusetts, to address requirements defined in Section 212 of Public Law 114-120 2015 (U.S. Congress, 2015). The findings and conclusions from the experiment have been incorporated into this report.

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EXECUTIVE SUMMARY

On October 18, 2016, the National Urban Security Technology Laboratory (NUSTL) conducted an experiment on two communications systems—Mutualink and datacasting—to address requirements defined in Section 212 of Public Law 114-120 2015 (U.S. Congress, 2015). This law stipulates the execution of a pilot of three or more DHS components to assess the effectiveness of commercially available systems certified by the U.S. Department of Defense Joint Interoperability Test Center. These systems should allow multiagency collaboration and interoperability, and wide-area, secure, and peer-invitation-and-acceptance-based multimedia communications.

Mutualink, developed by Mutualink, Inc., is a multimedia communications platform that supports the sharing of radio, voice, text, video, data files and telephone communications in a secure environment. Mutualink operates using Internet Protocol technology over a peer-to-peer-based, distributed architecture. Datacasting—developed by SpectraRep, a Department of Homeland Security (DHS) Science and Technology Directorate (S&T) commercial partner, along with Johns Hopkins University Applied Physics Lab and several Public Broadcasting Service (PBS) television stations—is the usage of a portion of the PBS stations' spectrums, normally used for television programming, to transmit other data for purposes, such as public safety. Datacasting transmits encrypted video, data files and other critical incident information to an unlimited number of first responders anywhere within the TV signal coverage area. The datacasting communications can be shared with controlled access and could reach participants through local PBS broadcasting or through the Internet.

The experiment in Boston, Massachusetts, focused on the movement of voice, video and data information among the participants by integrating Mutualink and datacasting networks into existing communication systems.

The two communication systems provided interoperability and enhanced communication capabilities during a realistic operational response scenario in which the U.S. Coast Guard (USCG) was activated to interdict a vessel four nautical miles offshore that was suspected of importing illicit materials. Voice communication integration and interoperability were accomplished utilizing Mutualink. Data (text, file sharing and video) interoperability was accomplished using datacasting. Video feeds from devices at the incident scene were shared over both the Mutualink and datacasting networks. The information was available to several command centers in the Boston region, including the USCG, Boston Police Department, Federal Emergency Management Agency (Region I), Massachusetts Emergency Management Agency and U.S. Customs and Border Protection.

The communications were also shared over the Mutualink and datacasting networks with other entities at remote locations (USCG and DHS S&T in Washington, DC; USCG in Philadelphia, Pennsylvania; DHS Transportation Security Administration in Florida; and DHS Federal Law Enforcement Training Centers in Georgia) for situational awareness.

Feedback on the two communications systems provided an assessment of their performance and capabilities, and insight into how they could be improved or integrated into current operations. All participants were asked to complete two assessment forms for this experiment. One form rated the quality of the audio and video during the experiment; the other captured outcome success ratings on operational contribution, voice, video, perceived value, effectiveness of tools and improvement over the status quo, as well as comments and recommendations on these topics and the experiment plan.

A discussion with all the participants was conducted after the experiment to gather additional feedback on the technologies and experiment. The information obtained from the participants was the basis of results for this experiment.

The results identify both positive and negative features of the communication systems during the experiment, which should be useful in determining the next steps for these, or similar, technologies. A few issues occurred during the experiment that impacted the intended communications. In one case, video quality was degraded, apparently due to exceeding the available datacasting bandwidth. Reducing the number of videos displayed at a time helped to address this problem. User ratings of the two communication technologies were favorable. The audio quality on Mutualink had an average rating of 4.8 on scale of 1 (poor) to 5 (excellent); while the video quality through datacasting was rated 3.7. The average outcome success ratings for two metrics—perceived value and tool's effectiveness—were given the highest possible rating (4 out of 4); the remaining metrics, operational contribution, voice, video and improvement over status quo, fell just short of that (3 out of 4).

These results highlight how adding new communications technologies and capabilities are perceived as an operational benefit. Specific comments obtained during and after the experiment helped identify whether the technologies were beneficial in the scenario, and gain other user insights on them. Nearly 50 unique comments were obtained, categorized by topic, and flagged as either a pro or con. This feedback may be useful for future development of these technologies.

Overall, the technologies successfully allowed interoperable communications across multiple responders and agencies. They are, however, not without perceived obstacles that would need to be addressed before they could be integrated into operations.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The U.S. Coast Guard (USCG) in conjunction with the U.S. Department of Homeland Security (DHS) Joint Wireless Program Management Office (JWPMO) are statutorily tasked with carrying out a pilot program with not less than three components of DHS to assess the effectiveness of communications systems that: allow multiagency collaboration and interoperability; enable wide-area, secure and peer-invitation-and-acceptance-based multimedia communications; are certified by the U.S. Department of Defense Joint Interoperability Test Center (JITC); and are composed of commercially available, off-the-shelf technology. These requirements are defined in Section 212 of Public Law 114-120 2015 (U.S. Congress, 2015).

On October 18, 2016, the DHS Office for Interoperability and Compatibility (OIC) conducted an experiment in the greater Boston, Massachusetts, area to determine the effectiveness of two different commercially available communication systems, the Mutualink communications system and the datacasting system. Datacasting is a project sponsored by DHS OIC and is currently not certified by JITC, but meets the other criteria of Public Law 114-120 2015 (U.S. Congress, 2015). This report describes the details of this experiment and discusses the results of use of these systems by more than three DHS components.

1.1 Purpose

The purpose of the components' communication experiment was to allow DHS agencies and state/local partners to try communication systems that would provide interoperability and enhanced capabilities during an operational response scenario. The feedback gathered from the participants was used to assess the performance and capabilities of the systems, as well as ways they could be improved or integrated into current operations.

1.2 Objectives

The main objective of this experiment was to demonstrate the ability to provide a commercially available, fully interoperable, JITC-compliant communications suite allowing voice, data and video interoperability between local, state and federal agencies, including at least three different components of DHS, to meet the intent of Public Law 114-120 (U.S. Congress, 2015), Section 212. Voice communication integration and interoperability were accomplished utilizing the Mutualink communications system. Data interoperability was accomplished using the Public Broadcasting Service (PBS) datacasting system. Video broadcasting interoperability was accomplished by both the Mutualink and datacasting system transmissions of video feeds from devices at the incident scene.

A secondary objective was to demonstrate the ability to integrate other developmental equipment to show the added capability of utilizing the established communications network. This equipment included direct video feeds from body cameras and an unmanned aerial system (UAS) with the datacasting system, enabling a multicast from a single source to multiple receivers.

1.3 Responder Capability Need

The DHS Science and Technology Directorate (S&T) Next Generation First Responder (NGFR) Apex Program has a mission scope to make first responders better protected, connected and fully aware.

Enhanced communications systems for first responders are an important part of this mission. These communications systems need to be interoperable, wide-area, secure, peer-invitational-and-acceptance-based systems with multimedia formats to share voice, video and data among those in the network.

1.4 System Descriptions

The experiment was designed to assess two communication systems, Mutualink and datacasting, as described below.

1.4.1 Mutualink Communications System

Mutualink is a multimedia communications platform developed by Mutualink, Inc. The system supports sharing of radio, voice, text, video, data files and telephone communications in a secure environment. Mutualink operates using Internet Protocol (IP) technology over a peer-to-peer-based, distributed architecture. The end-users have the flexibility to accept or deny participation in any collaboration incident. Disparate communication resources can be bridged with this system. The administrator maintains control of the communications assets and other media resources shared during a communication session.

Mutualink has a graphical user interface for collaboration sessions that allows the users to open or share available communications by drag and drop functionality. The software runs on computer systems or through applications available for both Apple and Android devices. Gateways are used to bridge different communications systems (e.g., analog and digital voice). Sharing of information requires either intranet or Internet connections. Figure 1-1 is a screen capture of the Mutualink application.

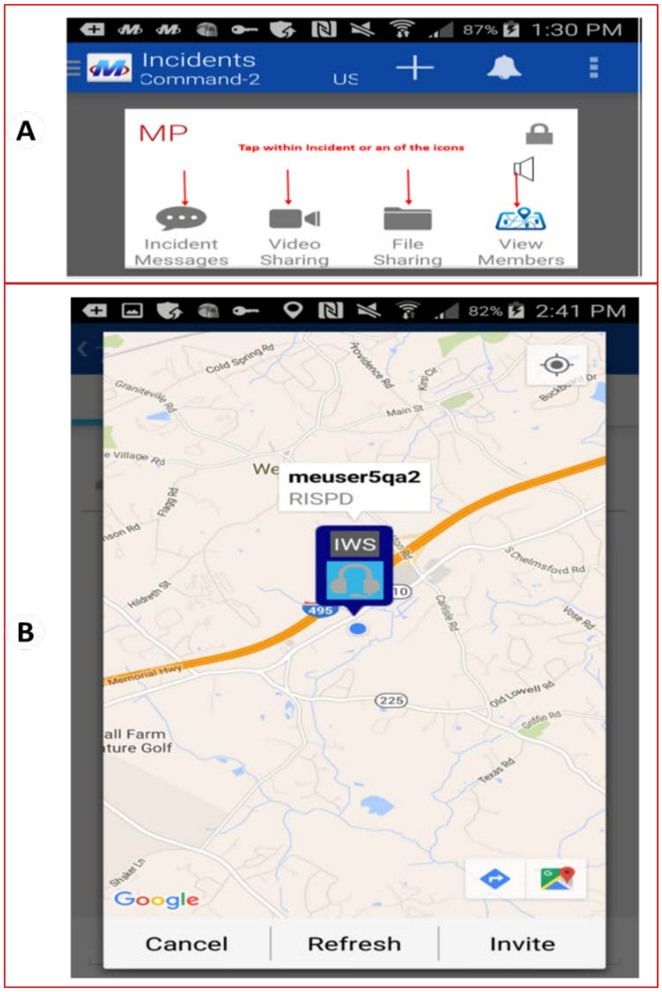

Figure 1-1 Images of the Mutualink Phone App
A—Incident communications icons screen
B—Layout allowing a user to join a chat session
(Photos courtesy of Mutualink, Inc.)

1.4.2 Datacasting System

Datacasting is the usage of a portion of the PBS stations' spectrums, normally used for television programming, to transmit other data for purposes such as public safety. SpectraRep, a DHS S&T commercial partner, along with the Johns Hopkins University Applied Physics Lab and several PBS television stations around the country partnered to develop this capability.

Datacasting transmits encrypted video, data files and other critical incident information (e.g., building blueprints and live security video) to an unlimited number of first responders anywhere within the TV signal coverage area. This system provides the capability for large-scale distribution of content (video, images, messaging) without relying on commercial cellular networks that may be overwhelmed or unavailable during an emergency event.

Datacasting hardware is set up at the television station to enable this capability. The data recipients use a small antenna connected to a computer via a universal serial bus (USB) dongle (see Figure 1-2) or a Linux appliance to receive the information being broadcast from the PBS station. Datacasting software allows broadcasters to selectively grant access to transmissions to individual users or groups across various agencies and political jurisdictions. Broadcasters also have full control over the information transmission and can even delete their data on remote computers at any time if a security breach is suspected, or if a receiver is stolen or misplaced.

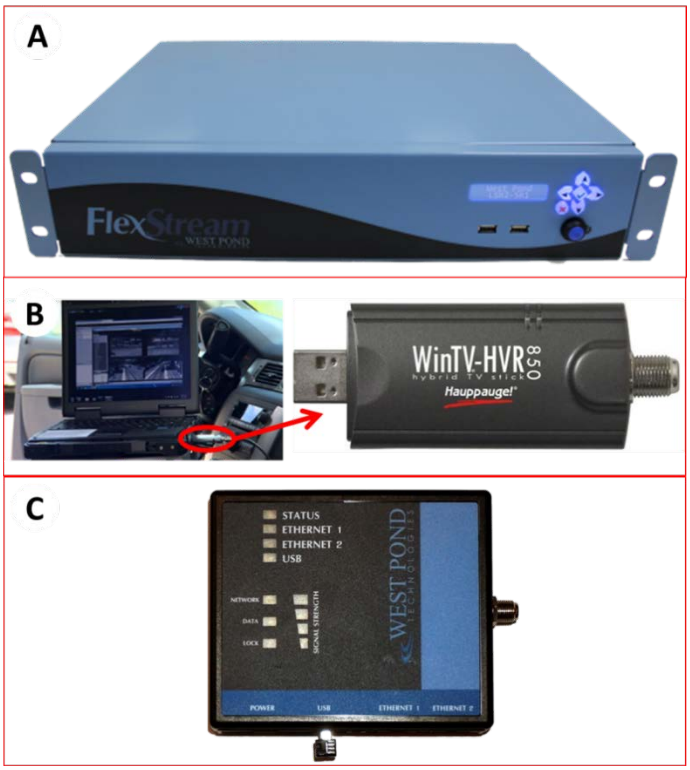

Figure 1-2 Hardware for the Datacasting System
A—Multiplexer installed at WGBH and WHUT PBS sites
B—Laptop connected to datacasting via the USB dongle receiver
C—Linus appliance receiver
(Photos courtesy of SpectraRep)

2.0 EXPERIMENT DESIGN

The experiment followed a script detailed in the Concept of Operations (ConOps) for the DHS Interoperability Pilot with the Commonwealth of Massachusetts (U.S. Department of Homeland Security, 2016). The last version of this document was shared with the participants on the day prior to the experiment, October 17, 2016, following refinements upon completion of a dry run. The ConOps document listed the sequence of events that were to take place, as well as the various points of communication checks and data collection points during the experiment. See Appendix A for the sequence of events listed in the ConOps.

2.1 EXPERIMENT DESIGN

The experiment incorporated communication technologies into an exercise simulating the response to, and interdiction of, a vessel suspected of carrying illicit items and located 4 nautical miles outside of Boston Harbor. Figure 2-1 shows the location of the incident site. The experiment focused on the movement of voice, video and data information among federal, state and local agency participants by integrating Mutualink and datacasting as described below. These technologies were integrated and ran simultaneously during the experiment. The information was shared with controlled access and could reach participants via PBS station broadcasts or the Internet.

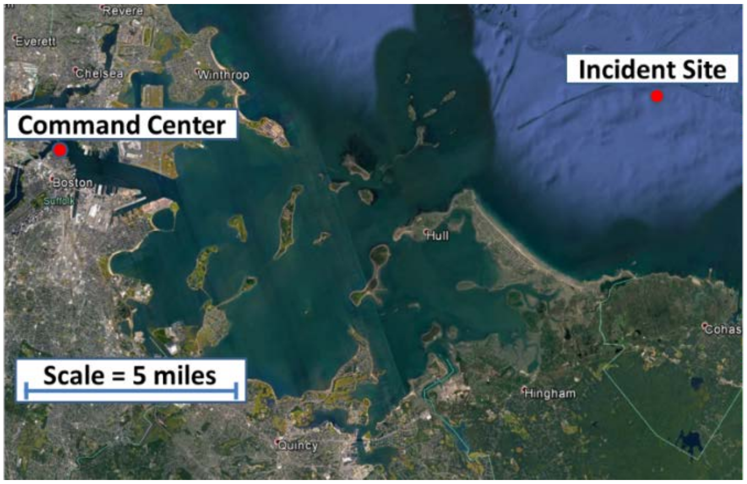

Figure 2-1 Location of Experiment in Boston, Massachusetts
(Mapped using Google Earth)

Voice communications were initiated from each agency's own radios and their assigned frequencies. The radio communications were patched[i] with the Boston Police Department's Zetron model 7032 radio dispatch switch. The voice communications were then captured in Mutualink using a donor radio on one of the patched frequencies (LE-4 located at FEMA) for sharing over the established incident networks. Figure 2-2 shows the network established with Mutualink for the experiment. Data (voice, video and electronic documents) were shared with the participants invited to the experiment through Mutualink as well.

[i] A radio patch is created using audio signals from each of the communications channels of a land mobile radio (LMR) network and feeding each of these audio channels into a switch, which, in the Boston system, was a Zetron 7032 unit. A patched voice communication network enables radio users on different LMR channels to communicate with each other.

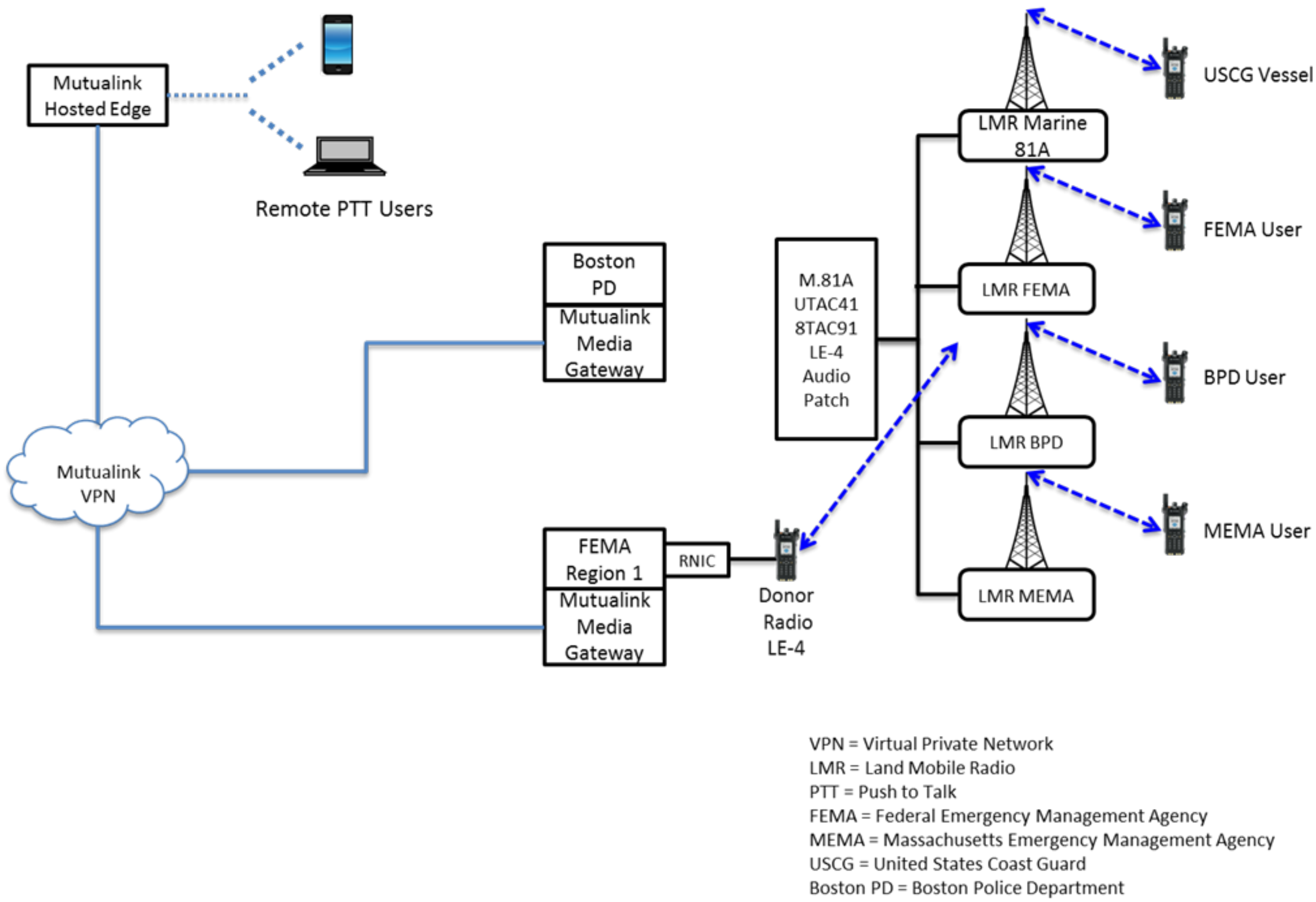

Figure 2-2 Voice Communications Network Diagram

Video was sourced using two devices in this experiment. Video cameras (Garmin VIRB® XE) were placed onboard boats deployed in the scenario. The other device that was used to obtain video was an InstantEye UAS from Natick Soldier Research, Development and Engineering Center with electro-optic (EO), white-hot infrared (IR) and black-hot IR video capability. The UAS was launched from the interdiction vessel while underway.

All videos were routed wirelessly using Wi-Fi signals to a long term evolution (LTE) hotspot installed on the boat and transmitted over band class 14 (B14) frequency[ii] to a communications cell-on-wheels (COW) mobile LTE base station that was positioned on a hilltop at an elevation of about 100 feet near the coast in Hull, Massachusetts. Commercial 4G LTE served as the backhaul to the B14 COW base station, carrying the video signal to the datacasting server.

Datacasting was set up to share the video by broadcasting it over two PBS stations (WGBH—Boston, Massachusetts, and WHUT—Washington, DC). Participants in the broadcast range of either station with datacasting access were able to receive the videos through the respective PBS transmission towers.

[ii] Band class 14 (B14) is a 3rd Generation Partnership Project (3GPP) LTE frequency band, which was authorized by Congress in 2012 to be dedicated to the operation of a National Public Safety Broadband Network, known as FirstNet, operating with a downlink frequency of 758-768 MHz, and an uplink frequency of 788-798 MHz.

Participants outside of the PBS broadcast areas were provided with Internet access to the data through a datacasting dashboard. Mutualink also pulled the video data from the over-the-air datacasting receiver and shared it over its network. The schematic in Figure 2-3 depicts the architecture of the datacasting system used.

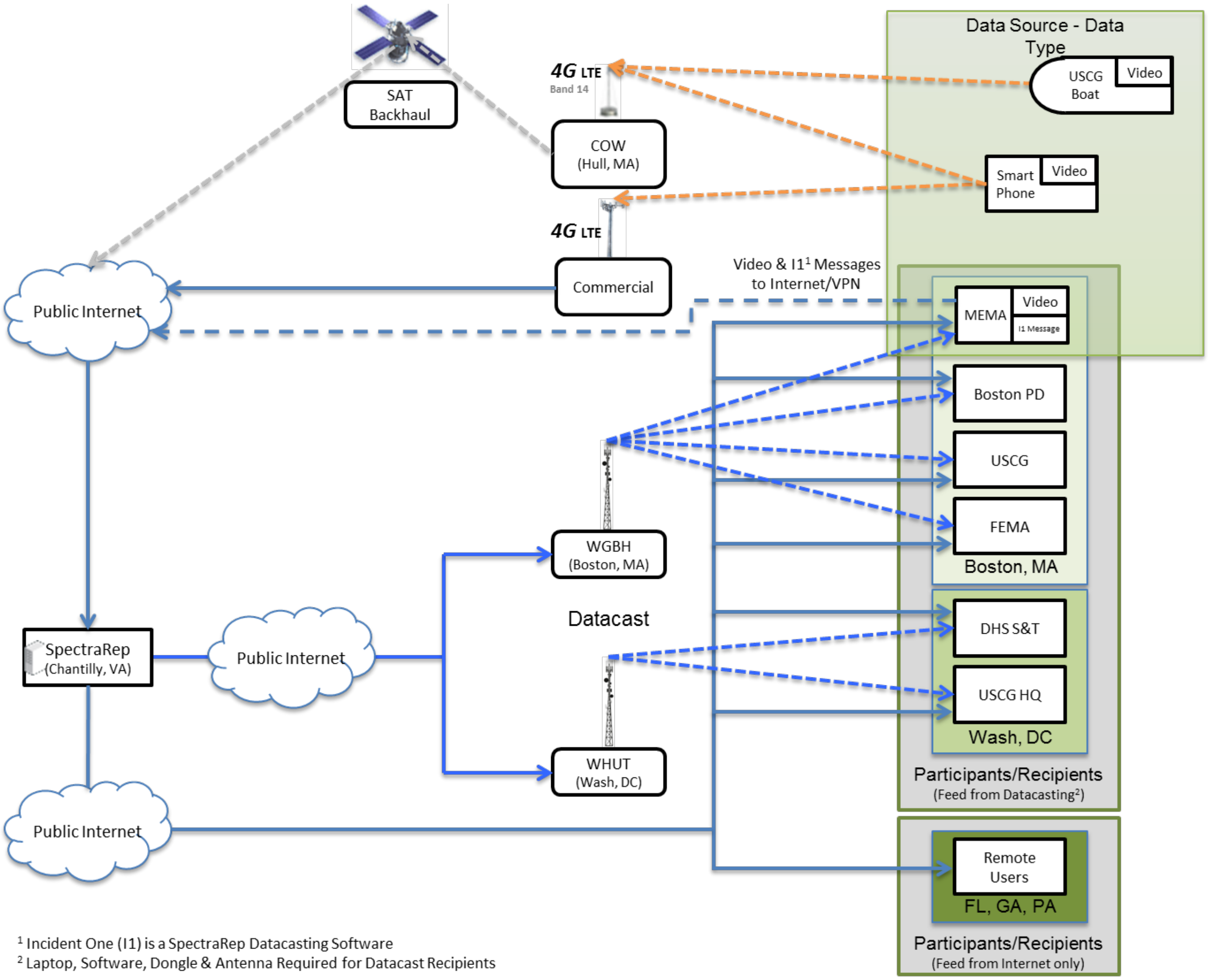

Figure 2-3 Datacasting Network Diagram

The experiment also used Mutualink and datacasting to push information to on-scene responders. The data delivered was in the form of documents to serve as alerts and updates for the responders. The datacasting system broadcasted multimedia alert messages containing text and photos to targeted datacasting PBS receivers in Washington, DC, and Boston, as well as to online participants via the datacasting online dashboard. One of the targeted datacasting receivers was located at a Mutualink facility in Boston, which then relayed the alert message to targeted Mutualink user devices.

The personnel and other resources in this experiment were provided by a range of federal, state and local organizations. The USCG provided two staffed boats for the experiment: one was the target vessel, and the other was the interdiction vessel.

Multiple command centers from several organizations were established for this experiment, which included USCG Station Boston, Federal Emergency Management Agency (FEMA) Region I, Massachusetts Emergency Management Agency (MEMA) and Boston Police Department (BPD). Several organizations provided remote participants as observers: Customs and Border Protection (CBP), Transportation Security Administration (TSA), USCG headquarters, DHS S&T headquarters and Federal Law Enforcement Training Centers (FLETC).

All participants were asked to complete two assessment forms for this experiment. One form addressed the quality of the audio and video during the experiment, and can be seen in Appendix B. The participants rated the quality on a scale of 1 (poor) to 5 (excellent) at each step throughout the experiment and provided comments for ratings less than excellent. The other form, in Appendix C, was designed to capture outcome success metrics with a scale of 1 (no aspects achieved) to 4 (all aspects achieved) for operational contribution, voice, video, perceived value, effectiveness of tools and improvement over status quo, as well as to gather comments and recommendations on these topics and the experiment planning. A discussion that was conducted by telephone conferencing after the experiment gathered additional feedback on the technologies and experiment itself from all the participants. All forms of information obtained from the participants were the basis of results for this experiment.

2.2 Experiment Summary

The technologies were integrated into the various locations by technical leads during the week prior to the experiment or earlier. This integration culminated with a dry run on October 17, 2016, to confirm all systems were operational and would function jointly. The experimentation was executed on October 18, 2016, as scheduled. A manned telephone conference line was established and active during the experiment for any participants to call if they had questions related to the experiment. All time listed below are Eastern Daylight Time.

Mutualink incident invites were sent to participants at approximately 9:00 a.m. Separate administrative and operations networks were established in Mutualink as a way to keep the response communications free of any management of the experiment. Radio checks were performed through Mutualink prior to conducting the experiment. Simultaneously, other equipment was prepped to begin the experiment. The interdiction vessel was outfitted with a mast-mounted Garmin camera, two personnel wearing body-mounted cameras, a UAS and Sonim phones. The target vessel was outfitted with one individual wearing a body-mounted camera, Sonim phones and a mock rocket propelled grenade prop. The COW was set and powered, and datacasting was configured and activated. The target boat was deployed at about 10:30 a.m. to begin the experiment. The target boat streamed video to check datacasting as it approached the incident location.

At about 10:30 a.m., intelligence was relayed about a maritime drug trafficking operation from the BPD's Law Enforcement Command Center (LECC); this information was also provided to regional law enforcement agencies initiating the experiment. A radio communication patch was requested by the LECC and approved by the Massachusetts Statewide Interoperability Coordinator (SWIC). The Mutualink operations network transmission of video streams from datacasting was enabled and audio/visual communication checks were performed. The USCG was deployed to intercept the target vessel at about 11:10 a.m.

Audio communications and video images of the response were shared with all participants over the Mutualink and datacasting networks. Figure 2-4 shows the display of datacasting video content through a Mutualink smartphone application connected to the network through commercial LTE coverage. From approximately 11:20 a.m. to 11:45 a.m., three separate alerts were sent to the USCG intercept boat (shared with all on the networks) through datacasting and uploaded on Mutualink to provide additional details on the incident. These alerts included photographs and descriptions of the target vessel and its crew.

Figure 2-5 shows a photograph of a command monitor that includes the video image from the intercept boat's mast camera and a shared alert. At approximately 12:00 p.m., the UAS was launched from the intercept boat to obtain and transmit video images of the target vessel as it attempted to flee. Personnel on the intercept boat pursued, stopped and boarded the target boat at about 12:15 p.m. The crew was apprehended and the vessel was secured to tow ashore. The experiment officially ended at 12:34 p.m.

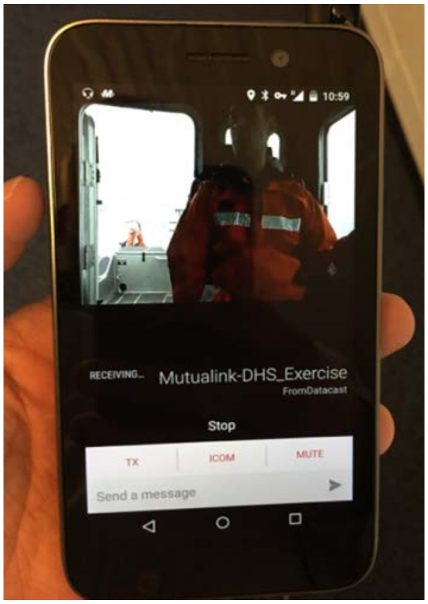

Figure 2-4 Mutualink Streaming Video from Datacasting during Experimentation

All participants were asked to provide completed data collection forms to USCG and DHS S&T leads at the conclusion of the experiment. A discussion with all participants was held at 2:00 p.m. following the experiment. There were some issues identified during the experiment, which are incorporated into the following results section.

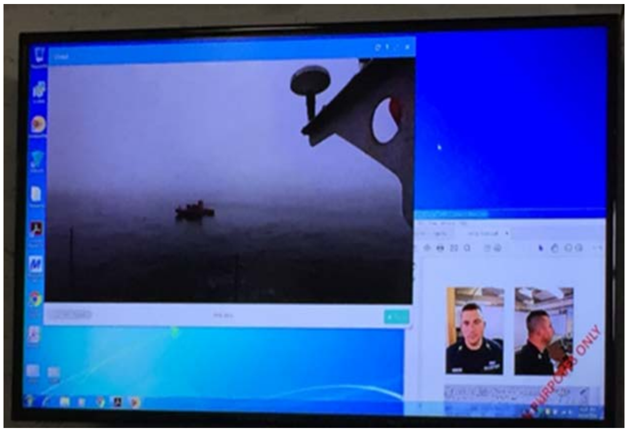

Figure 2-5 Datacasting Display of Video from Boat's Mast Camera and an Alert

3.0 RESULTS

The results are organized into sections by source of input. The experiment accomplished its objectives and has both positive and negative results that should be useful in determining the next steps for these, or similar, technologies. Overall, the technologies successfully allowed interoperable communications across multiple responders and agencies, but are not without perceived obstacles as described below.

3.1 EXPERIMENT ISSUES

Issues identified during the experiment and considered significant are described below. The effect of these issues on the results depended on whether the causes were quickly identified and could be resolved.

- At the start of the experiment, some individuals noted that they had voice communication issues over the Mutualink network. The causes were quickly identified and resolved. Some users had iPhone earbuds and the connected microphones made it difficult to hear them on the network. When these were replaced with better quality headsets, the issue was resolved. Likewise, some users found they had to replace their earpieces with other products to hear the voice communications more clearly.
- At one point, the Mutualink network communication to one boat was intermittent and required a reset of the wireless router.
- Video quality over datacasting was poor at times and inconsistent with the quality available during the prior day's dry run. The primary cause appears to have been a bandwidth issue at the remote server. During the integration and dry run prior to the experiment, datacasting was tested with fewer video inputs and Internet users than during the experiment. On the day of the experiment, the number of concurrent Internet-only users exceeded the available bandwidth and caused performance issues. The video quality varied by the source; those viewing it on WGBH (Boston PBS) reportedly had the poorest image when the video was degraded. There was some ability to recover from this Internet usage overload on the datacasting network by reducing the number of video streams shared at any given time. This meant that rather than sharing multiple videos, command had to decide which one, or possibly two, would be shared at a time instead. As a result of this issue, some users may have given the video quality a poor rating at various times in the experiment, but ultimately most participants thought the technology was useful and felt it has great application for first responders.
- At about 12:15 p.m., control of the UAS was lost; the unit hit the ocean, and could not be recovered. The UAS successfully performed the tasks required for the experiment prior to this. There was no confirmed explanation for what caused the loss of control, but there was some speculation that it may have been frequency interference with other equipment on the boat.

3.2 Scaled Ratings

The participants were asked to rate usefulness and other factors of the technologies. Responses, 14 in total, were received from representatives of every participating federal agency with the exception of CBP. Not all respondents provided a rating for each factor. The results of the ratings are provided below.

The audio and video quality were rated at each discrete sequence in the experiment where activities resulted in either Mutualink or datacasting being used, respectively. Audio quality relates directly to the Mutualink network; the video quality is primarily a result of the datacasting network, while Mutualink carried video from the datacasting network to users as well. These ratings, particularly video quality, varied over the course of the experiment. On a scale of 1 (poor) to 5 (excellent), the audio quality had an average rating of 4.8 and the video had an average rating of 3.7. The audio quality was rated nearly excellent, while the video quality rating varied from poor to excellent as a result of network bandwidth issues.

The results for the set of questions on outcomes show the effect of the addition of technologies in the experiment was definitely positive. The average values for responses for each success metric are shown in Table 3-1. Perceived value and tool's effectiveness metrics were given the highest rating possible; the remaining metrics fell just short of that. This result highlights how adding new communications technologies and capabilities can benefit regular operations.

Table 3-1 Average Outcome Success Ratings for a Set of Technology Assessment Metrics

Outcome Success Metric	Average Rating
Operational Contribution	3
Voice Communications	3
Real-time Streaming Video	3
Perceived Value	4
Tools Effectiveness	4
Improvement to Status Quo	3
Outcome success ratings span from: 1 = No aspects of desired outcome achieved 2 = Few aspects achieved 3 = Most aspects achieved 4 = All aspects achieved	

3.3 User Feedback

User feedback was obtained during and after the experiment to help identify whether the technologies in the experiment were helpful, and to gain other user insights on the technologies. This input was categorized into specific topics so that different comments could be more easily consolidated and addressed. The key points raised are listed and sorted below with a designator (+ or —) preceding the comment based on whether it is essentially based on a positive or negative point. In cases where similar comments were made by multiple participants, only one is presented below, and in some cases, the specific comments were summarized.

Mutualink:

- \+ Invitation to the Mutualink events was seamless.
- \+ The voice communication was always clear, text always came through and the video was fairly clear.
- \+ A radio check was conducted without issue.
- \+ Interoperable voice communication was the most effective tool.
- \+ Enabling 'bring your own device' to communicate with operational communications assets provided the greatest benefit out of all technologies tested.
- \+ The technology would be beneficial to streamline communications with other law enforcement assets.
- \+ Mutualink provided benefit primarily with voice communications, which were strong. The video functionality was good, but not user friendly if you needed to jump around, and not of much value.
- – Volume was a little low, but that was a phone issue. Need a way to boost the audio, especially if using a handheld Mutualink asset in a noisy environment.
- – A user was confused because there were two networks running on Mutualink. As described in section 2.2, one incident was administrative (for experiment control) and the other was for operations (for strictly first responder communications).
- – Mutualink should ensure that invites to the incident owner are approved by the leader.

Datacasting:

- \+ Overall video was not bad, perhaps since it was not transmitted through the PBS station.
- \+ Set up was really easy and done within a few minutes.
- \+ The data alerts came in clear. The data files also came in quickly.
- \+ Datacasting, easily displayed on a large screen to multiple viewers, provided good benefit.
- – Operational video must be expandable in case the scenario changes and there is a sudden need for expanded sharing of video. A recommendation to consider technology options that allow surge capability—fiber, microwave or cloud-hosted web services—was provided.[iii]
- – Multiple participants reported streaming video that was intermittent, grainy and had a low refresh rate. Users noted that these issues would clear up at various times.

[iii] In light of the datacasting dashboard congestion as a result of Internet users accessing the videos during the event, the vendor has since upgraded their facility from a local server to a cloud data center. Now, the bandwidth is increased up to 20 fold, and there will be sufficient bandwidth to accommodate any similar Internet traffic demand as the one experienced during the Boston experiment. This will help to preserve the datacasting system's main mission of video distribution using the PBS broadcast network.

- – Poor video quality means you not only lose situational awareness, but it makes it difficult to understand what is going on and becomes a frustration (tied to the aforementioned bandwidth constraint on the remote server).
- – There were not any alerts of additional video feeds being available through datacasting.
- – Multiple participants reported the video network link was dropped and had to be reestablished. Automatically reestablishing the connection was recommended.
- – Drone video was not received. An alert of the drone video feed did not come through datacasting. Users had to search for video under Video Stream.
- – The video was clear enough to see the vessel in the water, but not clear enough to be able to make out any details about the vessel; if this had been an actual event, actual information would be needed for my location/use. The video was fine if just for monitoring purposes.
- – Only one to two videos available at one time.

UAS:

- + The video was extremely choppy, but the target boat was distinguishable.
- + When the drone camera briefly switched to thermal mode, the image was clear.
- + The ability to use a UAV to monitor a situation or search was a big takeaway.
- + The UAS video could be used to remotely view operations in real time or record a practical exercise and provide it for an after action review session, which is not currently available.

Application of Technologies:

- + Several participants commented on how the ability to have real-time information across multiple organizations and see what the responders face at the scene would greatly aid situational awareness and response.
- + The two networks demonstrated interoperability for voice/data and video information sharing.
- + Video of incident is not stored, so live video storage must be managed.
- + Several participants noted desirable use cases for the technology, such as responses to large scale disasters, joint National Special Security Events (NSSEs) or similar events, video for evidence, fisheries, counter narcotics, and training (oversight and review).
- + The ability to streamline communications with other law enforcement assets was a big takeaway.
- + The mast camera had the steadiest image, resulting in better video received than the body or UAV cameras, which have more background movement.
- + Equipment setup was easy and intuitive for both Mutualink and datacasting.
- – The technologies need to be operationally available with all our partners to make the investment worthwhile.

- – Some participants mentioned that while suitable technologies may be available now, they would need to be properly integrated into the mission; not just among the current technologies, but in the training, memorandums of agreement/understanding (MOA/MOU), CONOPS, policies, procedures and the like, which may be a bigger challenge. The added value needs to be compared to impact and cost (fiscal and operational).
- – A couple of participants mentioned that licensing and waivers required to get the technology inside restricted systems is a hurdle.
- – Bridging of operational frequencies needs to be software driven, not manually and physically patched.
- – The offloading communications network needs to be matured in the maritime environment to provide solid backhaul services.
- – Recommendations include reducing this system down to a moderately sized pelican case, bulletproof storage and make system plug and play.
- – There is concern over necessary bandwidth. Participants recommended the system manage bandwidth by identifying bandwidth constraints, tracking congestion and allowing the incident commander to have the ability to add/remove participants to keep video quality.
- – There is a need to address how gear is stored and what would be required to keep it operational.
- – One of the biggest challenges is demonstrating and convincing staff that it improves the operation, but does not require additional time and is easy to use.
- – There is a need to identify several advocates to develop requirements and use cases.
- – Limited budgets to procure technologies may deter its use.

Other:

- + The USCG would be a great unit to perform further testing, as they work very closely with partner agencies, such as CBP and local law enforcement agencies.
- + The experiment was a great way to promote the conversation while introducing technologies and concepts.
- – The call sign naming for the experiment is confusing without referencing the list.

4.0 REFERENCES

U.S. Congress. (2015, February 18). Coast Guard Authorization Act of 2015. *U.S. Public Law 114-120, Section 212 Communications*. Retrieved from https://www.congress.gov/bill/114th-congress/house-bill/4188/text

U.S. Department of Homeland Security. (2016, October). Interoperability Pilot with the Commonwealth of Massachusetts.

5.0 ACRONYMS

BPD	-	Boston Police Department
CBP	-	U.S. Customs and Border Protection
ConOps	-	Concept of Operations
COW	-	communications cell-on-wheels
DHS	-	U.S. Department of Homeland Security
EO	-	electro-optic
FEMA	-	Federal Emergency Management Agency
FLETC	-	Federal Law Enforcement Training Centers
IP	-	Internet Protocol
IR	-	infrared
JITC	-	Joint Interoperability Test Center
JWPMO	-	Joint Wireless Program Management Office
LECC	-	Law Enforcement Command Center
LTE	-	long term evolution
MEMA	-	Massachusetts Emergency Management Agency
MOA/MOU	-	memorandum of agreement/memorandum of understanding
NGFR	-	Next Generation First Responder
NSSEs	-	National Special Security Events
OIC	-	Office for Interoperability and Compatibility
PBS	-	Public Broadcasting System
PL	-	Public Law
S&T	-	Science and Technology Directorate
SWIC	-	Statewide Interoperability Coordinator
TSA	-	U.S .Transportation Security Administration
UAS	-	unmanned aerial system
USB	-	universal serial bus
USCG	-	U.S. Coast Guard

Appendix A. SEQUENCE OF EVENTS IN EXPERIMENT AS PLANNED IN THE CONOPS

SEQ No	Time	Event	Player	Actions on OPERATIONAL NET	Data Collection Requirements Actions on ADMINISTRATIVE NET
		PREPARATION			
1.	H – 3 Hrs	USCG Incident Command Center Established Mutualink Coordination Incident Created • Ingest Mutualink generated Video in the incident • Text message video feed quality check • Files share "Spiral 2 OPSCON document" • Test Interoperable Radio patch • Create Unsecure "ADMIN NET" • Invite in the following endpoints:	AJM Mutualink		• Create incident Forum **"Admin NET"** • Invite the following into "Admin NET" ○ U.S. GOV - CBP; Boston 1 ○ U.S. GOV - CBP; Boston 2 ○ U.S. GOV - CBP; HQ ○ U.S. GOV - USCG; HQ Samsung ○ U.S. GOV - USCG; HQ Laptop ○ U.S. GOV - DHS SciTech; Griffin ○ U.S. GOV - DHS SciTech; Cotter ○ U.S. GOV - DHS SciTech; User17 ○ U.S. GOV - FEMA FRC1 ○ U.S. GOV - FEMA R2 ○ Mutualink-DHS Exercise ○ Boston Law Enforcement Command Center (B-LECC)
2.	H-2.5 Hrs	Conduct Radio Check on Admin Net	Mutualink		All
3.	H – 1 H	Personnel & Equipment Staged • COW on-line • Datacasting & Mutualink Initiated • Initial Comms Check Conducted	All NIST DC/ML ML	Datacasting Check at EOPPS	
4.	H – 10 min	• Target Vessel in place • Comms Check Complete • Dr. Brothers Arrives EOOPS • Event Introduction	CG MSST Cotter Staffier	Pass-off to Kowdley	MSST Report Target Vessel in place Contestable to MacDonald

SEQ No	Time	Event	Player	Actions on OPERATIONAL NET	Data Collection Requirements Actions on ADMINISTRATIVE NET
			SCENARIO INITIATED		
5.	H Hour	• Boston LECC notifies USCG SEC Boston and other LE agencies of credible information indicating an offshore drug operation. • USCG SEC Boston directs STA Boston to alert asset for deployment.	B-LECC CG Boston	***"A suspect cargo vessel, M/V REZLEG will attempt to bring an unknown amount of illegal drugs into the Port of Boston. Although REZLEG is due offshore on Oct 18th, intel suggests that they will offload the narcotics to a smaller boats that intends to bring the cargo into the inner harbor. Based on this intel, Sector Boston plans to monitor REZLEG's approach to the harbor and intercept the target vessel, working alongside State and local partner agencies."***	All Data collection observers begin recording comms checks per data collection throughout operations
			EXECUTION		
			ESTABLISH INTEROPERABLE COMMUNICATIONS		
6.		• B-LECC requests interoperable comms		B-LECC OPNS MA SWIC (Staffier) BPD COMMS (Surette)	
7.		• B-LECC Activates Mutualink System • B-LECC Creates Mutualink Incident	Mutualink B-LECC	Create **Operational Net** Incident Invite all relevant Endpoints	
8.		• SWIC Authorizes Interoperable Comms	Staffier		
9.		• BPD Radio Shack Executes Comms Patch • B-LECC Request FEMA-1 ingest radio comms patch onto Mutualink	Surette B-LECC Mutualink	Ch 81A UTAC 41 8TAC 91 LE 4	
10.		• B-LECC Integrates EOPSS Into Mutualink	Mutualink	MA EOPSS Monitors via Mutualink	
11.		• Comms Check	Mutualink Datacasting LMR/LTE	USCG, FEMA, FLETC, DHS S&T, BPB, MEMA (CBP, TSA), BPD, MEMA,	Data Collectors annotate voice capabilities
12.			**DEPLOY ASSETS**		
13.		• STA Boston deploys asset – 48' Boat	USCG	NIST 4GLTE COMMS Box Active Ch 81A	Boat 1 up on Admin Net

SEQ No	Time	Event	Player	Actions on OPERATIONAL NET	Data Collection Requirements Actions on ADMINISTRATIVE NET
14.	H + 20 min	Boat departs • Personnel Equipped w/Body Cameras • Mast Equipped w/Camera • Drone on Board B-LECC Ingests Datacast Video into Mutualink	Interdiction Boat Crew Mutualink	Interdiction Vessel reports it is underway;	Validate video on all links & locations using WoZA Application Assessment of Video by Assessment Teams Datacast Video transmitted via Mutualink
15.		• Mast Camera Activated	Datacasting		Transmits to All Assessment of Video by Assessment Teams
16.		• Intel received USCG Sec Boston	IC Boston Datacasting	Transmits Target Vessel Picture to Interdiction Vessel via Datacasting	 Transmit Vessel Photo
USCG ARRIVES AT STANDOFF (3/4 MILE FROM TARGET VESSEL)					
17.		• Target Vessel initiates video on WoZA	Datacasting		Target Vessel Feed
18.		• Interdiction Vessel Launches Drone Surveillance	US SSC Datacasting	• B-LECC conducts analysis on Drone Video • B-LECC identifies drugs & heavy weapons on Board Target vessel	 Drone Feed distributed to All Thermal Feed & Normal Feed Mast Video to all
19.		• LECC Notifies USCG of Drone Feed Analysis – HEAVY WEAPONS IDENTIFIED • USCG continues approach • Target Vessel Flees	Ch 81A USCG Datacasting	• B-LECC Notifies Federal LE Agencies over LE-4 "Be advised, vessel is fleeing and we are tracking vessel"	 Drone Feed and Mast Feed to All

SEQ No	Time	Event	Player	Actions on OPERATIONAL NET	Data Collection Requirements Actions on ADMINISTRATIVE NET
			INTERDICTION		
			PURSUIT		
20.		• USCG Vessel Pursues Advises potential for loss of target • DRONE continues Coverage	B-LECC US SSC Datacasting	Notifies other LE Agencies to prepare to support	Drone and Mast Feed Continue
			INTERCEPT		
21.		• Target Vessel Heaves to ○ USCG Notifies all pursuit has ended ○ USCG Conduct Boarding Assessment ○ USCG Notifies Preparation to Board	USCG Datacasting		Begin Body Camera Feeds
			BOARDING		
22.		• USCG determines suspect vessel is safe to boarding • CG Boarding Team boards vessel	USCG Datacasting US SSC		Video & regular radio checks continue Body Camera Feeds Drone Recovery
			SEARCH/SEIZURE/TOW		
23.		• USCG conducts search • Collection of weapons and drugs • Suspects Arrested	Datacasting		Body Camera Feeds
24.		• Sector Boston authorizes towing suspect vessel & suspects to STA Boston for processing	Ch 81A	SCC Boston	
			ENDEX		

Appendix B. DATA COLLECTION SHEET USED FOR RATING AUDIO AND VIDEO QUALITY

DHS Interoperability Pilot with Commonwealth of Massachusetts

Data Collector Name:

Data Collector Location:

Communication Systems Evaluated:

Phone #:

Email:

Instruction: Use the columns on the right to enter a score of 1 to 5 for video and audio quality, as well as notes or comments during the experiment sequences. A quality of 5 is for communication that is clear, timely, useful and actionable if this were a real world event. If the score isn't 5, please enter a brief comment of why it wasn't excellent. If an evaluation of voice/video during an event sequence is not applicable, enter "NA." If multiple communication systems are evaluated, indicate which for each entry; this can be done with abbreviations such as A (Mutual Link), or B (Datacasting) if the key is recorded on the sheet as well. Use additional pages or locations on these sheets for more detailed observations if necessary.

NEXT GENERATION FIRST RESPONDER Components Communications Experiment H-HOUR SEQUENCE (DRAFT)

Boston, MA | October 17-18, 2016 | Tentative 11:30 a.m. / October 18, 2016

Seq. No.	Time	Event	Players	Received Voice Quality (1-poor, 5-excellent)	Received Video Quality (1-poor, 5-excellent)	Notes/ Comments
PREPARATION						
1.	H – 3 hrs	USCG Incident Command Center Established Mutualink Coordination Incident Created • Ingest Mutualink generated video in the incident • Text message video feed quality check • Files share "Spiral 2 OPSCON document" • Test interoperable radio patch • Create unsecure "ADMIN NET" • Invite in the following endpoints:	Andy MacDonald Mutualink			
2.	H-2.5 hrs	Conduct Radio Check on Admin Net	Mutualink			
3.	H – 1 H	Personnel & Equipment Staged • COW online • Datacasting & Mutualink initiated • Initial comms check conducted	All NIST Datacasting/Mutualink (DC/ML) ML			
4.	H – 10 min	• Target vessel in place • Comms check complete • Dr. Brothers arrives EOOPS • Experiment introduction	CG Maritime Safety and Security Team Cotter Staffier			
SCENARIO INITIATED						
5.	H Hour	Boston LECC notifies USCG SEC Boston and other LE agencies of credible information indicating an offshore drug operation USCG SEC Boston directs STA Boston to alert asset for deployment	B-LECC CG Boston			
EXECUTION						

Seq. No.	Time	Event	Players	Received Voice Quality (1-poor, 5-excellent)	Received Video Quality (1-poor, 5-excellent)	Notes/ Comments
ESTABLISH INTEROPERABLE COMMUNICATIONS						
6.		B-LECC requests interoperable comms				
7.		B-LECC activates Mutualink system B-LECC creates Mutualink incident				
		SWIC authorizes interoperable comms				
		BPD radio shack executes comms patch B-LECC request FEMA-1 ingest radio comms patch onto Mutualink				
		B-LECC integrates EOPSS into Mutualink				
		Comms check				
8.		B-LECC requests interoperable comms				
DEPLOY ASSETS						
9.		STA Boston deploys asset – 48' boat	USCG			
10.	H + 20 min	Boat departs Personnel equipped w/ body cameras Mast equipped w/ camera Drone on board B-LECC ingests data cast video into Mutualink	Interdiction Boat Crew Mutualink			
11.		Mast camera activated	Datacasting			
12.		Intel received USCG Sec Boston	IC Boston Datacasting			
USCG Arrives at Standoff						
13.		Target vessel initiates video on WowZA	Datacasting			
14.		Interdiction vessel launches drone surveillance	US SSC Datacasting			

Seq. No.	Time	Event	Players	Received Voice Quality (1-poor, 5-excellent)	Received Video Quality (1-poor, 5-excellent)	Notes/ Comments
15.		LECC notifies USCG of drone feed analysis – HEAVY WEAPONS IDENTIFIED USCG continues approach Target vessel flees	Ch 81A USCG Datacasting			
INTERDICTION						
PURSUIT						
16.		USCG vessel pursues Advises potential for loss of target Drone continues coverage	B-LECC US SSC Datacasting			
INTERCEPT						
17.		Target vessel heaves to ○ USCG notifies all pursuit has ended ○ USCG conducts boarding assessment ○ USCG notifies preparation to board	USCG Datacasting			
BOARDING						
18.		USCG determines suspect vessel is safe to boarding CG Boarding Team boards vessel	USCG Datacasting US SSC			
SEARCH/SEIZURE/TOW						
19.		USCG conducts search Collection of weapons and drugs Suspects arrested	Datacasting			
20.		Sector Boston authorizes towing suspect vessel & suspects to STA Boston for processing	Ch 81A			
END EXERCISE						

Appendix C. DATA COLLECTION SHEET USED TO EVALUATE OUTCOME METRICS

Boston OpEx_Interoperability Pilot Feedback			
Description of desired outcome:	Outcome success rating:*	Reason for success rating:	Additional Comments**:
Operational Contribution Did the technologies observed during this pilot demonstration enhance your ability to interoperate with other agency partners in execution of this mission? Why or why not?			
Voice Comms Were you able to use **your** operating frequency to talk with local, state and federal response partners in executing this mission? Share your experience.			
Comms Partners Who did you need to talk with? Why?	N/A		
Real-time streaming video Did you receive the video necessary to meet your mission objectives?			
Perceived Value How do you perceive the value of the capabilities and tools used during this mission?			
Tools effectiveness What was the most valuable tool used to execute this mission? Are there any tools missing?			
Improvement to status quo Did the implementation of technologies employed provide a positive or negative contribution to your mission objectives?			
Planning take-aways What planning and preparation performed for this pilot demonstration would not be feasible during an actual event?	N/A		

Boston OpEx_Interoperability Pilot Feedback			
Description of desired outcome:	Outcome success rating:*	Reason for success rating:	Additional Comments**:
Follow-on recommendations If developmental equipment observed during this mission helped you to perform your duties, please explain whether such technology should be further developed and adopted for your agency's use.	N/A		
What is your operational role?***	N/A		
* Outcome success ratings span from: 1 = No aspects of desired outcome achieved, 2= Few aspects achieved, 3= most aspects achieved, 4= All aspects achieved			
** The "Additional Comments" section provides space to list relevant details such as location, time, lessons learned, etc...			
*** User roles include: boat crew, dispatch, command center, watchstander at specific unit, etc...			
Additional / role specific observations or risks not captured above:	Outcome success rating:*	Reason for success rating:	Additional Comments**: