Video Datacasting: Houston Pilot After Action Report

First Responders Group

October 2015

Homeland Security

Science and Technology

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Video Datacasting:

Houston Pilot After Action Report

HSHQPM-15-X-00122
October 2015

Prepared for: **Science and Technology Directorate**
First Responders Group
Office for Interoperability and Compatibility by Johns Hopkins University Applied Physics Lab

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Executive Summary

The Johns Hopkins University Applied Physics Laboratory (JHU/APL), under the direction of the Department of Homeland Security (DHS) Science and Technology Directorate (S&T), First Responders Group (FRG), Office for Interoperability and Compatibility (OIC), executed a demonstration and evaluation of a prototype datacasting system installed at the offices of Houston Public Media (Public Broadcasting Station KUHT) and operated by the University of Houston Office of Emergency Management (OEM) in Houston, Texas, on July 20-24, 2015. During the exercise, two potential operational scenarios involving public safety and private sector entities were executed, and the datacasting system was used to broadcast relevant video and other data to test participants. The test team from JHU/APL and subcontractor SpectraRep analyzed the system's technical performance and its operational utility.

Datacasting leverages underutilized capacity in digital television signals to provide secure, targeted broadcasts of data, including voice, text, files, images and video. Data is encoded, encrypted, registered (for access control), and multiplexed with other streams into the digital television signal. Relatively inexpensive datacasting receivers are used to view the encrypted data. Existing digital TV transmission infrastructure (i.e., power, radio frequency equipment, antenna, tower) is used, so datacasting does not add a significant cost to the broadcaster. Using television station infrastructure makes datacasting highly reliable, especially during emergencies.

The July 20-24, 2015, datacasting pilot in Houston was intended both as a demonstration of the technical capabilities of datacasting (coverage, video quality, ease of use) and of its applicability to a number of day-to-day public safety challenges. It was especially important to test video because public safety personnel often use closed circuit television (CCTV) video to prepare and respond to emergency situations. To demonstrate the day-to-day utility of datacasting, two potential law enforcement scenarios were constructed.

The first scenario was executed on July 21 on the University of Houston campus, where two "suspects" were tracked on the school's CCTV surveillance system as they exited a campus dormitory. Live video stream and other information (e.g., dorm roster, floor plans) were forwarded to police officers arriving on the scene. This scenario involved the University of Houston Police Department (UHPD), the University of Houston Office of Emergency Management (OEM) and Houston Public Media. The second scenario was executed on July 23 on the Houston Metro light rail system between NRG Park and the Texas Medical Center. It simulated two "suspects" fleeing an incident at NRG Park and boarding MetroRail to escape. In this scenario, the "suspects" were tracked using Houston Police Department surveillance cameras at NRG Park and MetroRail cameras overlooking the train platforms. This scenario involved operational support from the City of Houston, Houston Police Department, Harris County Sheriff's Office, Texas Medical Center, NRG Park, and the University of Houston, as well as technical support from Houston Public Media.

Actual execution of these demonstrations was the culmination of months of planning in which the organizations identified above worked with JHU/APL and SpectraRep to:

(1) Develop scenarios that would simultaneously emphasize the unique capabilities of datacasting and reflect real-world concerns of the Houston/Harris County public safety community;

(2) Integrate the datacasting transmission capability into Public Television Station KUHT;

(3) Design and implement a low-cost integration concept to enable the participating organizations to input data into the datacasting system; and

(4) Provide participants with receiving equipment and sufficient training to operate the system.

In the days prior to each test, the test team worked to verify system performance and coordinate with the participating organizations to ensure successful execution. These efforts provided additional opportunities to verify the performance and validate the utility of the system.

Both tests met predetermined objectives and provided a clear demonstration of datacasting capability:

(1) All transmissions using the datacasting system – alerts, images, files and video streams – were successfully received by targeted recipients. Members of the test team and/or the participating organizations verified successful receipt.

(2) Through the tests and comprehensive equipment checkout procedures, it was deemed that the system provided extensive coverage throughout the area of responsibility of the participating organizations. Although the datacasting standards do not currently support receipt of data while in a moving vehicle, participating organizations reported the presence of a strong signal in moving vehicles much of the time.

(3) Law enforcement officers participating in the test reported that datacasting provided video and audio quality far exceeding current capability (which is frequently non-existent). One officer referred to the ability of datacasting to support video streaming as potentially lifesaving, and end-user participants made clear their desire to retain the system after completion of the exercise.

(4) All participants commented positively regarding both the ease of installation and ease of use of the particular datacasting system implemented in Houston. Participants in the test were able to use the system effectively with very little hands-on training (actual training was completed virtually).

Equipment used in the July demonstrations was leased for six months; thus, the datacasting capability will remain in place until approximately the end of 2015. At a minimum, it is expected that the University of Houston OEM and UHPD will continue to make use of the capability. Modifications to integrate datacasting into those organizations video systems were more robust and persistent than those for other agencies. However, while the video streaming capabilities of other organizations are limited, they retain full

capability to transmit data – including video clips. JHU/APL is already engaged in discussions with University of Houston OEM to identify ways of collecting additional data regarding system performance and utility while the system remains in use; similar discussions will continue with other participating organizations.

The July demonstrations provided validation of the capability and utility of datacasting for public safety and law enforcement. JHU/APL will continue to collect data and perform additional analysis to better define the potential uses of this capability and how it may be integrated within the broader public safety telecommunications architecture.

1 Introduction

The United States (U.S.) Department of Homeland Security (DHS) is committed to using cutting-edge technologies and scientific talent in its efforts to make America safer. The DHS Science and Technology Directorate (S&T) is tasked with researching and organizing the scientific, engineering and technological resources of the U.S. and leveraging these existing resources to develop technological tools to help protect the nation. The DHS S&T First Responders Group, Office for Interoperability and Compatibility administers the Video Quality in Public Safety (VQiPS) program, which is concerned with all facets of the use of video in the public safety field (i.e., law enforcement, fire, emergency medical technicians and associated entities).

- VQiPS Vision

  The VQiPS Working Group will create a collaborative environment that accelerates the ability of users to specify and deploy video technology solutions that meet user requirements and improve public safety and Homeland Security Enterprise operations.

- VQiPS Mission

  The VQiPS Working Group creates knowledge products, fosters a knowledge-sharing environment and supports research, development, testing, and evaluation for enhanced video quality through measurable, objective, and standards-based solutions across the full spectrum of video-use cases for the public safety community.

- VQiPS Background and Goals

  The VQiPS initiative, which started in 2008, is managed by the VQiPS Working Group made up of a multi-stakeholder partnership between the DHS S&T, the U.S. Department of Commerce's Public Safety Communications Research Program (PSCR), public safety practitioners, the private sector, standards development organizations and the global research community. VQiPS gathers input from practitioners and video experts and delivers unbiased guidance and educational resources that help the first responder community clearly define and communicate its video quality needs. In the beginning, the group sought to accomplish two tasks: educate end users about video system components and provide knowledge tools to help end users define their own use case requirements.

  VQiPS accomplished these goals with multiple technical reports and the development of the VQiPS Web Tool (http://www.pscr.gov/outreach/vqips/vqips_guide/) and the Video Quality Standards Handbook (http://www.firstresponder.gov/TechnologyDocuments/Digital%20Video%20Quality%20Handbook.pdf).

  Moving forward, VQiPS will support the build-out of the Nationwide Public Safety Broadband Network (NPSBN) by developing video-over-broadband materials and

guides, as well as connect to FirstNet to provide technical information and feedback regarding video over LTE.

Identifying and supporting best practices in the efficient distribution of video is consistent with the VQiPS program goals.

1.1 Datacasting Capabilities

The TV broadcast industry recently completed an evolution from analog to digital signal transmission. The digital broadcast signal is composed of time division multiplexing (TDM) or time-division-multiple-access (TDMA) slots, with each time slot containing an Internet Protocol (IP) packet that supports the use of IP networking technology at the entry and destination nodes (i.e., TV station and TV receiver). The signal is transmitted at a constant rate of approximately 19.39 Mbps. However, the TV signal does not consume the total bit rate. Null packets are transmitted in order to maintain the constant bit rate. Those null packets can be replaced with data content not intended for television viewing without degrading the received television signal.

Datacasting takes advantage of the under-utilized bit rate to transmit various digital data types, including voice, streaming video, pictures, messaging, files and documents. The data may be encrypted to provide privacy, registered to enable targeting and may include forward-error protection to enable a high quality of service. While the nature of datacasting is a one-way, wide-area broadcast to all receivers in the coverage area, datacasting allows the user to address specific individuals, groups of individuals or every receiver for receiving and processing data.

A multiplexer is used to integrate the various data types with the TV signal prior to transmission. The multiplexer input is typically provided via a data server that connects to various data sources (e.g., information repositories or databases, closed-circuit TV monitors, voice systems and messaging systems). The server provides the ability to select the data source(s) for transmission over the air. At the receiver end, an antenna and an inexpensive dongle plugged into the Universal Serial Bus (USB) port enables any computer or laptop to receive the TV signal encoded data. Linux-based datacasting software installed on the computer extracts the datacasting information from the rest of the Digital Television (DTV) signal and presents it in a form understandable by the end user.

As with other secure wireless capabilities, transmissions via datacasting are secured via encryption and access control. Datacasting is amenable to a number of encryption and access control implementations. Compliance with Health Insurance Portability and Accountability Act (HIPAA) or other guidelines is achieved via encryption and access control, but was not explicitly addressed in this exercise or in this report.

Because it uses television station infrastructure, datacasting is highly reliable, especially during emergencies. For example, during the 2013 Boston Marathon, cellular and landline communications were saturated and largely unavailable for at least 90 minutes after the bombing [1]. Following the 2011 Mineral Virginia Earthquake, cellular and landline phone communications were saturated for the first 30 minutes [2]. During 2005 Hurricane Katrina [3] and 2012 Superstorm Sandy [4], cellular and Internet communications were

severely affected for an extended time. It should be noted that, during Hurricane Katrina, only about 28 percent of TV stations experienced downtime in the storm zone [5]. Television station downtime could result from damaged transmission towers, flooded transmission equipment or the loss of power for prolonged periods that exceeded back-up generator capabilities. Therefore, as long as the TV station has a source of power with an intact transmission tower and equipment, datacasting should be a reliable means of communicating emergency information to first responders.

Datacasting has the potential to provide significant benefit to first responders, including law enforcement. Potential benefits include the following:

- Because broadcast TV signals are widely geographically available in urban, suburban and rural environments, datacasting coverage typically exceeds that of cellular systems and land-mobile radio. For example, digital TV broadcasts can cover 10,000 square miles or more, which is orders of magnitude greater than cellular coverage. TV broadcasts not only can reach remote areas, but also urban "dead spots" not covered by existing public safety communications systems.

- Because datacasting uses the infrastructure provided by a broadcast TV station, it is a highly reliable and available method of telecommunication. In contrast, cellular coverage is often lost for significant periods of time following emergency events.

- Datacasting is not subject to congestion during emergencies. Unlike other public safety communications systems, datacasting does not share infrastructure or capacity with commercial communication networks.

- Datacasting can be used to multicast data to a large number of users for the same cost as the transmission of data to a single user. Datacasting can make more efficient use of available bandwidth and possibly reduce the cost of commercial service to the agency by reducing the overall demand for bandwidth.

- Datacasting leverages a system designed primarily for the transmission of high quality video and audio streams. Thus, it has the innate ability to address the public safety community's desire for high quality audio and video data transport.

- Datacasting is relatively inexpensive to implement and operate. Many public broadcasting TV stations are already configured to support datacasting. The existing digital TV transmission infrastructure (i.e., power, radio frequency equipment, antenna, tower) is used, so datacasting does not add a significant cost to the broadcaster.

Datacasting has been used by the Clark County School District Police Department in Las Vegas, Nevada,[1] to broadcast video from their extensive closed circuit television video (CCTV) system via the Nevada Public Television Station KLVX. As implemented in Clark County, datacasting is a reliable and useful system that provides operators with ready

[1] See: http://www.spectrarep.com/pr05132010.html.

access to critical data, ensures the timeliness of that data and enables dependable transmission of that data across the entire county – something local cellular networks and land mobile radio (LMR) cannot achieve. In the event of a major event at a school anywhere in Clark County, first responders would have access to critical and current information. In addition, datacasting provides a powerful emergency broadcasting capability that can be leveraged in case of a crisis. SpectraRep is the primary commercial firm that has promoted the use of datacasting. Given the growing interest in datacasting as a distribution method for video the VQiPS program desires to further investigate and study the viability of this technology and potential application to the NPSBN.

For this DHS S&T project, the JHU/APL is leveraging knowledge gained under an existing task with the Department of Justice (DOJ) to explore the technical aspects and value of datacasting as a mechanism to distribute video to multiple users via the public television broadcast spectrum. This includes knowledge gained from a baseline evaluation of the operational use of datacasting in the Clark County school system mentioned above. The goal for the DHS S&T task is to develop a baseline understanding of the datacasting technology from the participants, including understanding the technology installation, the end user perspective on usage and the concept of operations in which it is used.

The first pilot of the datacasting project sponsored by DHS S&T was with the City of Houston, the Harris County Sheriff's Office, Texas Medical Center, NRG Park, University of Houston and KUHT TV (the local public television station). JHU/APL conducted testing and evaluation of their datacasting system, including documenting the technical installation, gathering end user comments on the use/usefulness of the system, gathering system performance measures (to the extent available) and other success factors. Harris County, Texas, has deployed a NPSBN test bed. The Harris County Sheriff's Office, founded in 1837, is the largest sheriff's office in Texas and the third largest in the U.S. The Texas Medical Center opened in 1945 and is the world's largest medical complex. NRG Park is a 350-acre sports complex presenting a variety of sporting events and concerts. The University of Houston was founded in 1927 and enrolls more than 40,000 students in more than 300 undergraduate and graduate degree programs. A professor at the University of Houston, Dr. John Schwarzwalder, established the first public television station in the U.S. in 1953 on the campus of the University of Houston. Now known as Houston Public Media, this station broadcasts on KUHT TV (VHF digital channel 8).

Additional technical details of the datacasting process are provided in Appendix A.

1.2 Goal of this Report

The main goal of this report is to provide an After Action Report for the Datacasting Pilot that took place in Houston, Texas, from July 20-24, 2015. This pilot involved several agencies including Houston Public Media, the University of Houston (UH) Office of Emergency Management and Police Department, the City of Houston Police Department, the Texas Medical Center, NRG Park, the Harris County Sheriff's Office and Houston MetroRail. Two scenarios were used for testing on two different days. The JHU/APL team observed and collected user feedback during these tests. This report documents these tests, including the technical issues and user feedback. Figures 1 and 2 are maps showing the

locations of the exercises. Detailed test plans have been included as Appendices B and C to this report.

The pilots aimed to demonstrate the following:

(1) The technical capabilities of datacasting;

(2) Datacasting's utility to emergency management;

(3) The ability to reliably broadcast large files;

(4) The ability to stream real-time video to multiple users; and

(5) The ability to simultaneously broadcast data to multiple agencies [6].

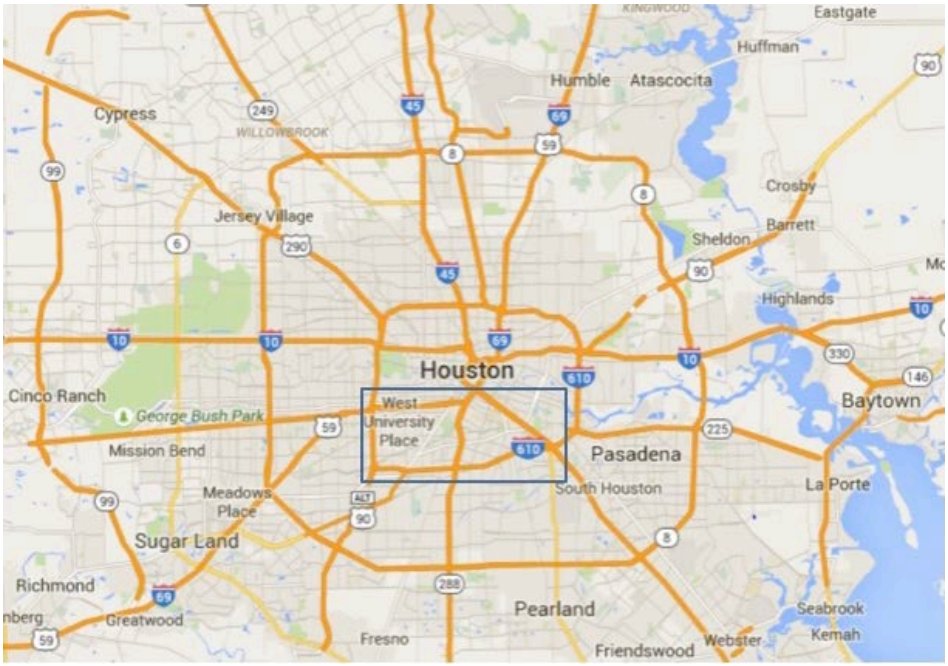


Figure 1: Map of Houston. The blue rectangle contains the scenario locations.

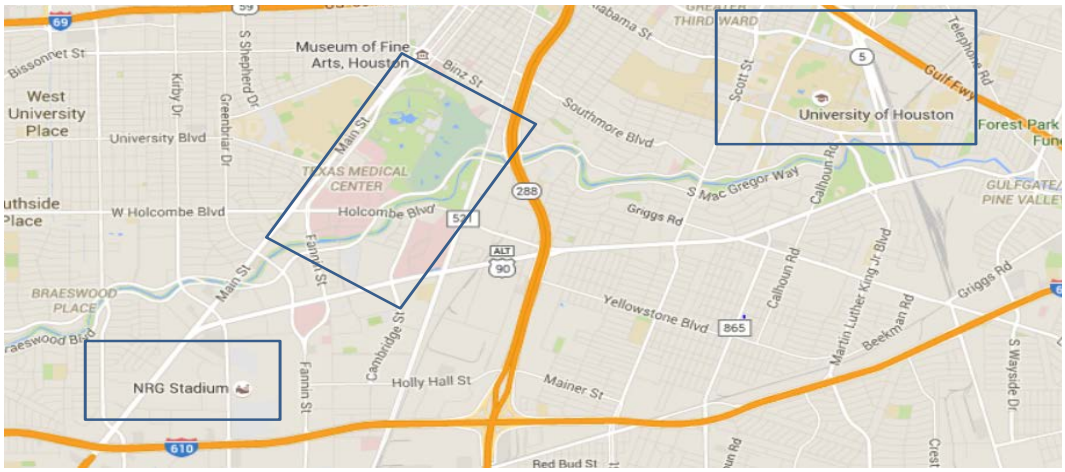


Figure 2: Houston map showing the locations used by the operational scenarios.

2 Houston Datacasting Pilot Demonstrations

2.1 University of Houston Demonstration

2.1.1 Equipment Checkout

Members of the test team arrived July 20, 2015, and performed a series of equipment checkout procedures. These included the following:

1. The test team conducted general verification of datacasting system transmission and receipt capabilities. Although the datacasting system had been extensively exercised in the weeks prior to the test by technical staff at the University of Houston Office of Emergency Management (OEM) and Houston Public Media (KUHT), a final test was performed on July 20 to ensure the system was ready for the formal demonstration. A laptop with datacasting software and an antenna was set up in the University of Houston OEM Emergency Operations Center (EOC). Pre-loaded data was periodically transmitted to the laptop during the day (although only one test was actually needed, there were a number of opportunities to demonstrate the system and to ensure candidate operators were comfortable using the system). All attempts to transmit data via datacasting to the laptop in the EOC were successful.

2. Representatives of the test team inspected and verified the receiver equipment provided to the University of Houston Police Department (UHPD). Test incidents were generated and transmitted to a laptop in the UHPD headquarters and to laptops installed in two UHPD police vehicles. Test data transmitted to the two vehicles were successfully received; however the test team was not able to successfully transmit to the laptop inside the headquarters. On the spot analysis indicated this was a result of poor reception quality due to metallic coating on the windows (the metallic coating acts to reduce heat intake during the summer). Should a permanent datacasting capability be implemented in Houston, this issue could be remedied by installation of an antenna on the roof of the building.

3. Members of the test team and University of Houston OEM staff performed a dry run of the scenario at Cougar Place Residence Hall. The dry run's objective was to verify surveillance camera coverage for the exercise route to confirm the proposed scenario could, in fact, be executed and to facilitate seamless execution of the exercise.

4. A Pilot Demonstration Readiness Review was performed on the morning of July 21, 2015, in the offices of Houston Public Media. Members of the test team reported on steps taken to ensure the success of the exercise to representatives of the DHS, stakeholders and independent reviewers. All in attendance deemed the exercise ready to proceed.

2.1.2 Exercise Description

A technical and operational test and demonstration of the pilot datacasting capability was executed on the campus of the University of Houston on Tuesday July 21, 2015. The primary objective was to demonstrate the technical capabilities of datacasting. Specifically, the test was designed to verify data products, including real-time streamed video, could be "pushed" from the University of Houston OEM EOC computers into the datacasting system, transmitted using the broadcast capability of Public Television Station KUHT and received using police equipment modified to receive and decode/decrypt the datacast signal by members of UHPD. A secondary objective was to validate the utility of the concept. The test was constructed to determine whether the system could be effectively used by members of the public safety operational community and whether data sent using datacasting could have operational utility to public safety.

To achieve these two objectives, a scenario was constructed based upon an anecdotal (but unconfirmed) situation reported to representatives of JHU/APL during a previous evaluation of datacasting. The goal was to simulate two intruders in a UH dormitory captured on security system cameras as they walk through the dormitory (i.e., Cougar Place Residence Hall). Outside, two UHPD officers, each in a vehicle, track the intruders as they move through the dormitory. In the anecdotal version of this exercise, a police officer tracked an intruder in a public school using datacasting-provided video and was able to apprehend the intruder as he exited the building. The police officer never had to enter the school. Figure 3 shows the relative locations of the University of Houston OEM, KUHT, UHPD and Cougar Place Residence Hall.

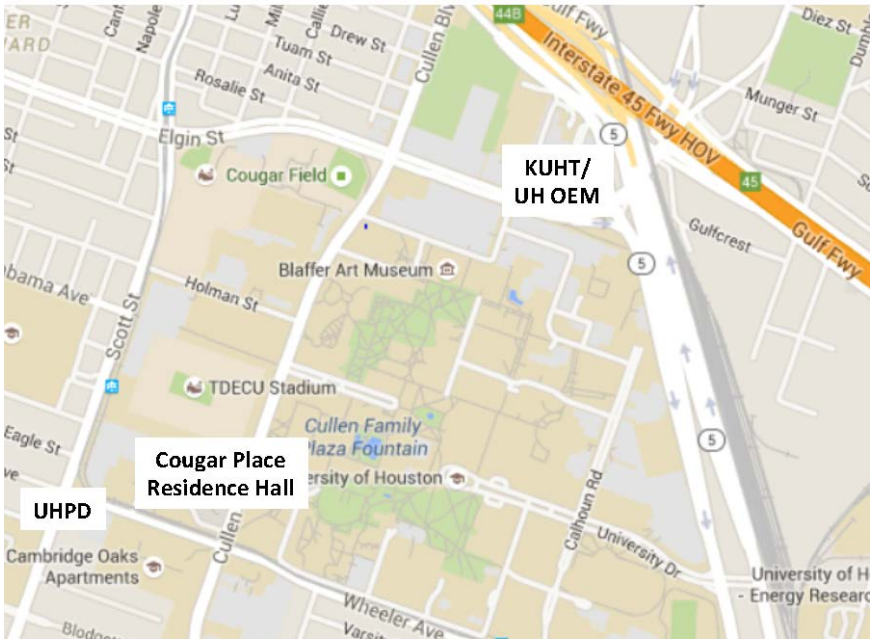


Figure 3: University of Houston campus map showing locations of UHPD, Cougar Place Residence Hall, KUHT and the UH OEM.

This particular case was used as the basis for a scenario for two reasons. First, the execution was relatively low-cost and incurred only minor disruption of University operations. Second, law enforcement experts consulted in previous studies expressed interest in this particular scenario. Intruders in schools represent something of a nightmare scenario for law enforcement because school buildings can be like labyrinths. They are large and offer intruders opportunities for concealment or ambush. They can also be populated after hours by people, like teachers, with legitimate reasons for being there, or by minors, with less legitimate reasons for being there. Either case presents an opportunity for undesired consequences.

2.1.3 Exercise Execution

The following results were achieved during the exercise:

The test was conducted in accordance with the test plan developed and disseminated prior to the test (Appendix B). No substantial deviations were required. Due to other demands on their officers on July 21, 2015, UHPD was only able to provide two police vehicles, both of which were deployed outside Cougar Place Residence Hall. However, in addition, UHPD Lt. Bret Collier observed the test from the University of Houston OEM EOC. Key components of the test included the following:

1. University of Houston OEM representatives exercised operational control of the Datacasting System from within the University of Houston OEM EOC.

2. At approximately noon, two employees of the University of Houston OEM were deployed at Cougar Place Residence Hall on the University of Houston campus. They took up initial positions in the courtyard of the residence hall, within sight of campus security surveillance cameras.

3. A few minutes after noon, two UHPD officers in vehicles deployed to the parking lot directly across from the residence hall. The vehicles were equipped with datacasting compatible antennae and laptops. However, it should be noted that the two officers involved in the test had been provided only brief training on use of the system.

4. Upon arriving at the Cougar Place Residence Hall, the police officers were met by two representatives of JHU/APL whose role was to observe the test and demonstration of datacasting. JHU/APL staff members observed the exercise from the patrol cars (i.e., one staff member in each car).

5. When the patrol cars deployed and the observers entered their respective cars, the University of Houston OEM EOC was alerted that the test could proceed. At a few minutes after twelve, the test officially begun.

6. At test initiation, the OEM officer in the EOC made video of the two OEM employees posing as "suspects" in Cougar Place available to the two patrol cars. Officers in both cars signaled that they could see the suspects loitering in the courtyard of Cougar Place Residence Hall (with the University of Houston Fire Marshall), who was on hand to escort the OEM "suspects" through the building.

7. The OEM officer created an incident using the datacasting system, and an alert was generated containing the following:

    a. A text and voice alert stating: "Test: Shooting at Cougar Place" (Figure 4);

    b. A campus map;

    c. A map of Cougar Place Residence Hall;

    d. An audio file (intended to simulate a recording of an original 9-1-1 call); and

    e. An Excel file containing a list of special needs students (note: this file was fictional in order to protect individual privacy.

8. Both officers at the scene signaled they had received the alert and could observe the attached files.

9. The two suspects in the residence hall were alerted to exit the building. They followed a pre-defined path designed to keep them within sight of University of Houston surveillance cameras.

10. The officers outside the residence hall verified receipt of the video of the two University of Houston OEM representatives walking with the University of Houston Fire Marshall toward the dormitory exit. They also confirmed seeing the two employees leave the building.

11. A second alert was generated at the UHPD EOC. This alert contained two additional attached files: a suspect description and photograph. In order to protect privacy, neither the description nor the photograph was of a real human being.

12. The officers confirmed receipt of the second alert and of the two attached files.

13. All data received by the two University of Houston Police Department officers was confirmed by the accompanying JHU/APL observers.

14. Upon completion of the test, both officers provided their observations to representatives of JHU/APL.

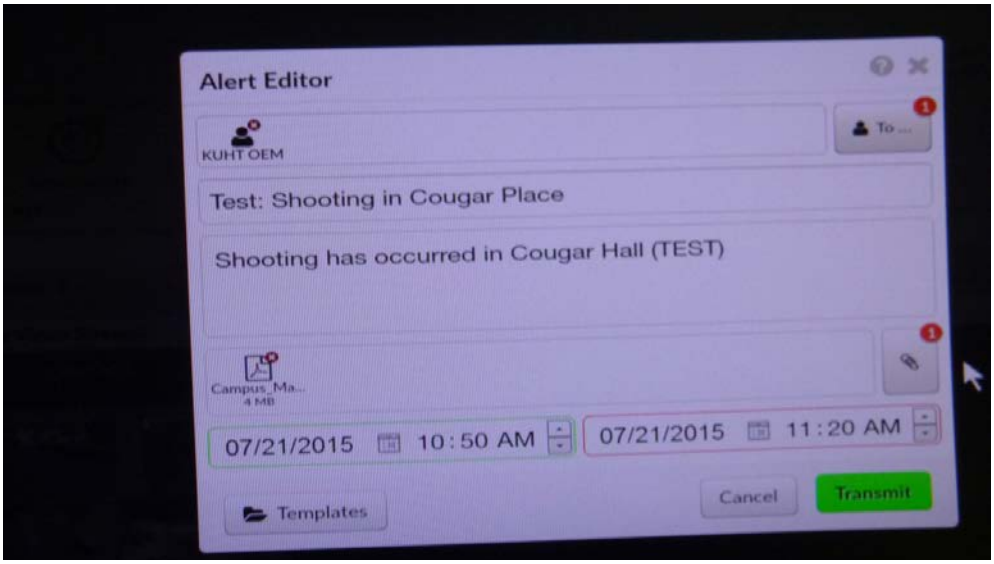


Figure 4: Computer screen showing datacast transmission of alert message.

2.2 Texas Medical Center/NRG Park Demonstration

2.2.1 Exercise Description

The datacasting test team spent Wednesday July 22, 2015, performing an equipment checkout and dry-run prior to the July 23, 2015, exercise at NRG Park, on the Houston MetroRail and at the Texas Medical Center. Specific steps included the following:

On Tuesday, July 21, a representative of the Harris County Sheriff's Office performed a test of the datacasting equipment installed in a Harris County command vehicle. Using the telephone line established to coordinate the datacasting exercise on the University of Houston campus, a representative of Harris County called members of the test team for data. In response, the test team "pushed" an alert with an attached image, which was successfully received. In addition, it was verified that video from the University of Houston OEM EOC was being received using the datacasting system. Due to privacy reasons, the data transmitted from the University of Houston video surveillance system was video of the parking lot at KUHT. In the course of verifying datacasting performance, representatives of the Harris County Sheriff's Office also verified that the system frequently achieved good reception quality in many areas, even though the current datacasting standards are not designed to support reception in rapidly moving vehicles.

Additional tests of the datacasting system were conducted throughout the day on July 22, 2015. To facilitate police officers testing their devices (while continuing to execute their public safety responsibilities), a teleconference line was set up and maintained throughout the day. During the day, representatives of Harris County Sheriff's Office, City of Houston, Texas Medical Center and NRG Park all called in and requested data. A representative of the test team remained by the phones the entire day and "pushed" test messages consisting of alerts, files and video upon request. The few issues that did arise were resolved prior to the day of the test.

Finally, members of the test team worked with the City of Houston and DHS to perform a dry run of the exercise. A representative of JHU/APL traced the proposed route from NRG Park to Texas Medical Center, via light rail, and verified the entire route was within view of an accessible surveillance camera. Practicing the scenario in advance ensured the test would not be repeated due to procedural failures (a major cause of failed tests) and helped facilitate a more realistic evaluation of datacasting (e.g., one not degraded by equipment integration and test execution problems).

2.2.2 Exercise Description

The second scenario, executed on July 23, 2015, simulates the aftermath of a fight at NRG stadium. Two participants in that incident are detected and tracked using NRG Park security cameras as they leave the stadium. Video clips of the "suspects" are captured by the video surveillance system and transmitted to other Houston/Harris County area law enforcement agencies.

After exiting the stadium, the suspects went to the Houston MetroRail station on Fannin Street. While waiting on the platform, they were in view of video surveillance cameras operated by the Houston Police Department and the Houston MetroRail. A video operator with the Houston Police, alerted to the incident at the stadium and having the datacasting video image of the fleeing suspects, was able to positively identify the suspects standing at the Fannin Street station waiting for the train. The operator created an incident using the datacasting system and began streaming video of the suspects to police officers in the vicinity of NRG Park, other light rail stations and partner agencies. Using the streamed datacasting video, these officers observed the suspects board a light rail train.

As the suspects moved north along the light rail system, their movements were tracked using surveillance cameras inside the train, and law enforcement units moved into position to intercept them at light rail stations along the route. A passenger on the train, while browsing the Internet on a cell phone, became aware of the incident at the stadium and, after noting the suspicious appearance of the "suspects," surreptitiously photographed the suspects and transmitted the photograph to a 9-1-1 call center. Additional information, including metro maps and train schedules, were broadcast via datacasting to the responding units. As the suspects exited the light rail train at the Texas Medical Center (TMC) Dryden station, they were apprehended by waiting police officers who recognized them from the disseminated videos. Figure 5 is a map of the scenario showing the suspects' path .

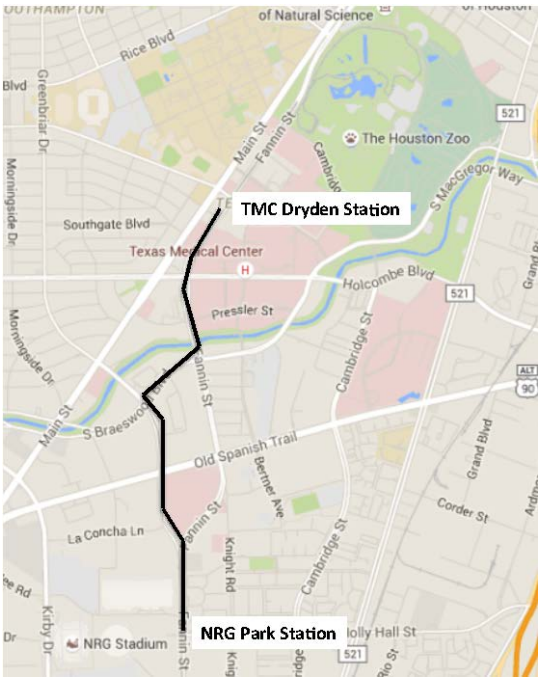


Figure 5: Path taken by the "suspects" using the Houston MetroRail to travel from NRG Park to the TMC.

This particular scenario was selected based upon input from stakeholders within the Houston public safety community. As in the case of the University of Houston scenario, the scenario was designed to be operationally realistic, while also emphasizing the unique contributions of datacasting. NRG stadium was included in the scenario to emphasize datacasting's unique ability to provide high quality video in areas of high cellular use (although nothing in the test actually simulated above average cellular use). In addition, the scenario was intended to demonstrate how the use of datacasting could enhance interoperability between agencies.

Video integration for this test was less robust than was achieved for the University of Houston datacasting. Real-time video was streamed from Houston Police Department and Houston Metro cameras to the University of Houston OEM EOC, where the datacasting equipment was installed, via the Homeland Security Information Network (HSIN). HSIN was used because it provided the required connectivity and met security requirements without the costs of establishing a dedicated connection for this exercise. Frame rates achieved via HSIN were typically significantly lower than those achieved during the University of Houston demonstration. However, this lower frame rate reflects the video quality input available and therefore is not a limitation of the datacasting system. This conclusion was confirmed by test team members and observers in the EOC who had simultaneous access to both the input provided via HSIN and the datacasting output received at a laptop in the EOC. They confirmed that the datacasting output video quality was consistent with the input video quality.

Live portions of the exercise were designed to be low cost and to avoid causing disturbance or alarm. "Suspects" in the exercise were representatives of NRG Park and JHU/APL. At no time did the suspects attempt to simulate aggressive actions (such as a fight or assault at

NRG Park). They merely walked from NRG Park to the Metro, boarded a train and exited the train at the Texas Medical Center.

2.2.3 Exercise Execution

The exercise on the Houston MetroRail System between NRG Park and Texas Medical Center was executed on Thursday July 23 between approximately 1200 and 1300. The test plan (see Appendix C) was disseminated to the participants prior to the test. For the most part, the demonstration was executed in accordance with this test plan; however, a number of significant enhancements and additional participants were incorporated into the test:

1. Members of the test team and stakeholders met at the Texas Medical Center on the morning of July 23 for a Pilot Demonstration Readiness Review. During this review, the test team reported on equipment checkout and informed the team and stakeholders of last minute modifications to the exercise. There was consensus to proceed with the demonstration.

2. A teleconference line was established. The objectives of this line were to (a) enable participants to request data (i.e., to perform their own ad hoc tests of the system as desired) and (b) for test coordination.

3. Between 1000 and 1200, participants dispersed as follows:

    a. Representatives of SpectraRep and the University of Houston OEM deployed to the EOC at Houston Public Media. From there, they managed the system, including creation of incidents and transmission of data products.

    b. City of Houston deployed to their offices from which they load Houston Police and Houston Metro video to HSIN for input into the datacasting system.

    c. Representatives of DHS S&T, JHU/APL, NIJ and the Texas Medical Center (TMC) observed the test from the Texas Medical Center. A Houston Police Department vehicle equipped with datacasting was deployed at the TMC to enable observation of the test from the vantage point of a field unit.

    d. Participants from Houston Police Department, Harris County Sheriff's Office and the City of Houston who had datacasting receive capability in their vehicles deployed to various parts of Houston/Harris County in order to maximize data collection.

    f. The test conductor (JHU/APL) deployed to NRG Park. Based upon execution of the July 21 demonstration at the University of Houston, it was determined that the best vantage point from which to coordinate the test was as a "suspect" tracked during the exercise.

    g. Although not explicitly part of the test, while waiting for the test to begin, the SpectraRep IncidentOne software was loaded on a laptop at NRG Park and that laptop was configured to transmit data during the test. A test alert with an attached file was transmitted from NRG Park. The entire process took less

than 15 minutes, an additional demonstration of the ease of use of the system.

4. At 1200, the "suspects" from NRG Park and JHU/APL took their place upon the Houston MetroRail platform at NRG Park.

5. At approximately 1200, an incident was created indicating there had been a fight at NRG Park and that two suspects were fleeing, one of whom was captured in a video clip taken using NRG Park surveillance system cameras. Along with an alert (Figure 6), the video clip, a map of NRG Park, an aerial view of the stadium and a map of the Houston MetroRail Red Line were transmitted. Participants verified receipt of the alert and attached data.

6. Upon entering the MetroRail platform, the suspects walked toward the designated camera and were detected by a representative of the City of Houston. A video containing the two suspects was then transmitted via HSIN to the University of Houston OEM EOC. Operators within the EOC began streaming the video via datacasting to test participants who confirmed receipt of the video.

7. Upon confirming successful video capture, the suspects boarded the next northbound train. While on the train, one of the suspects began publishing photographs to the City of Houston's Digital Sandbox system (simulating photographs taken by a passerby or police officer and transmitted to a call center). The images were propagated via datacasting, demonstrating the ease with which relevant data can potentially be injected into the system.

8. Upon arriving at the Texas Medical Center on Dryden Street, the suspects exited the train. They are detected using surveillance cameras on and above the rail platform; the video transmitted to the EOC via HSIN and propagated to the participants via datacasting.

9. The suspects traveled once more back to NRG Park and back to the Texas Medical Center on the Houston Metro, providing additional test opportunities.

10. Upon completion of the test, wrap-up sessions were held at the Texas Medical Center and the offices of Houston Public Media to review test results.

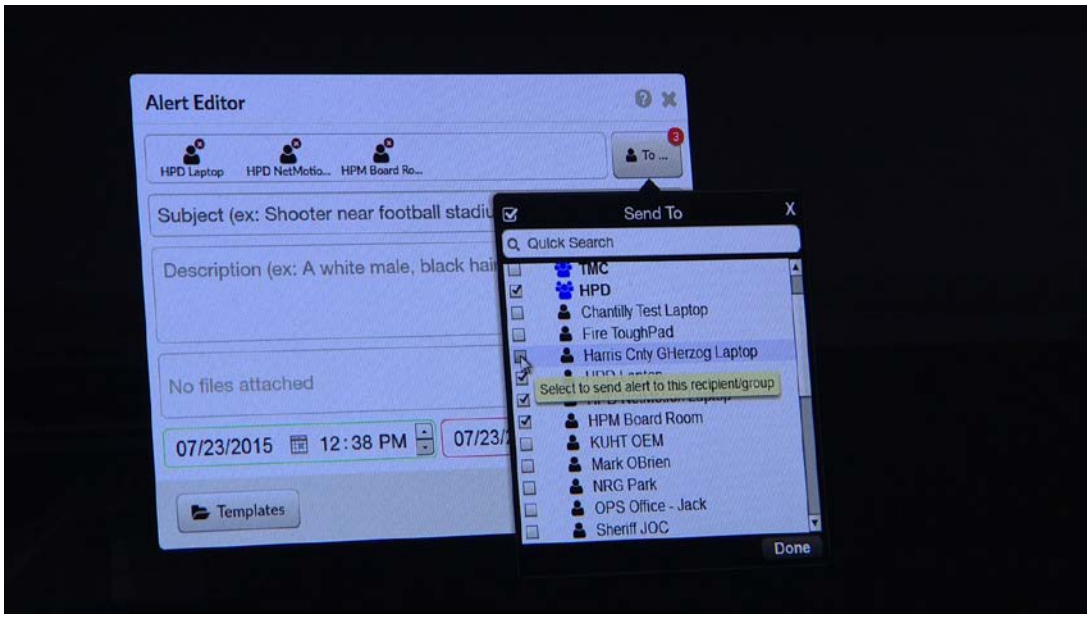


Figure 6: Screen shot of the datacasting Alert Editor.

3 User Feedback and Lessons Learned

The following sections describe the lessons learned and user feedback for the two scenarios.

3.1 University of Houston Feedback and Comments

During the weeks prior to the test, Sidney Knight of Houston Public Media took a laptop equipped with datacasting receiver equipment to various points throughout the University of Houston campus. He reported good coverage across the entire campus and in other parts of Houston, and even achieved good coverage while in a moving car (note: the datacasting system includes an application that measures and presents performance data, including reception signal strength).

Two University of Houston Police Department (UHPD) officers responded to the simulated incident at the University of Houston Cougar Place Residence Hall. Officer Jeremy Nino provided a positive assessment of the datacasting system and indicated it had the potential to facilitate execution of his job. All datacasting information was successfully received. The audio alerts and voice messages were clearly heard. Officer Nino could open all the datacast attachments except for one, which was an Excel file containing the student residence roster. He could not open the Excel file because his laptop's version of Microsoft Office did not include Excel software, so this was not strictly a datacasting limitation. Officer Nino noted the residence hall building floor plan that was sent would be more useful to people not already familiar with the building, such as new officers or those from other jurisdictions. The video was good quality with virtually no jerkiness between frames. Figures 7 and 8 are photographs of the laptop in use during the exercise.

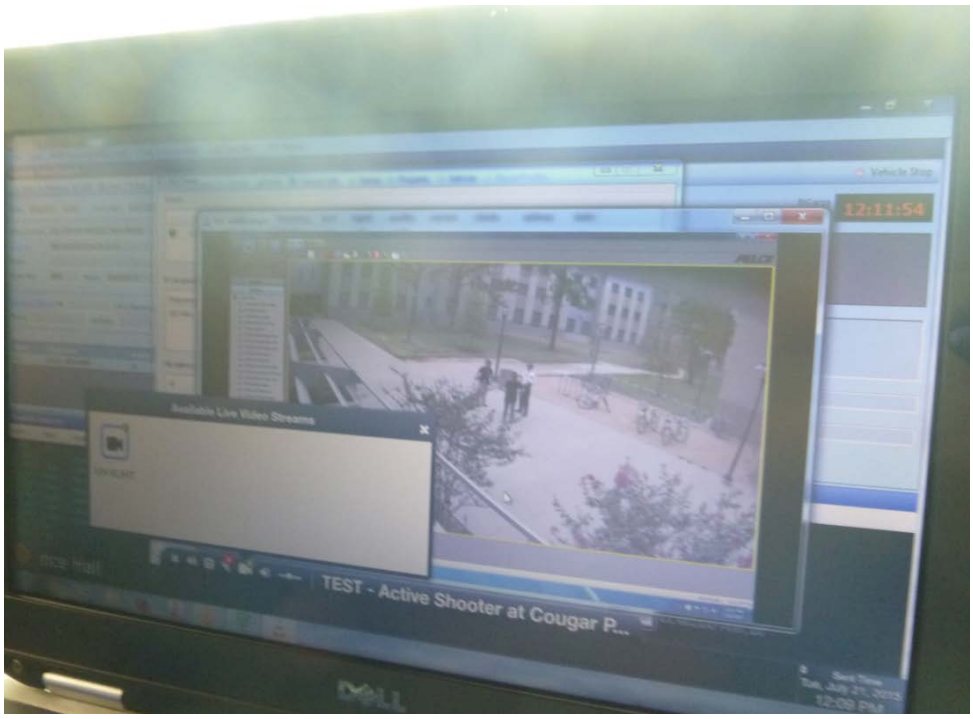


Figure 7: Photograph of a laptop in a UHPD patrol car, as it was used during the exercise.

Figure 8: Photograph of a laptop in a UHPD patrol car, as it was used during the exercise.

Officer Nino offered the following constructive comments regarding ways in which he felt the datacasting capability could be improved:

(1) The lack of screen real estate on his laptop (Figures 7 and 8) made it difficult for him to view multiple files simultaneously. When he opened a new attachment, he had to minimize the other open documents in order to view it. Therefore, he recommended the attachments be consolidated as much as possible. In

particular, he would like to see the text description of the suspect in the same attachment as the image of the suspect.

(2) He mentioned he would like to hear audio while watching video. For example, while watching the suspect on video, it would be useful to hear things, such as the suspect saying "I am going to start shooting in five minutes" or any other telltale noises or conversation. This would only be possible if the CCTV camera had a microphone and the sound was integrated with the video.

(3) When asked what he would like to see that he did not see, he mentioned having some way for the camera to zoom onto the suspect, especially to see if the suspect had a weapon. The CCTV cameras are under control of the camera owner, so this request would have to be relayed to them.

(4) He also mentioned he would like to have a way to send information from his patrol car, such as dash cam video, text messages, audio, etc.

Note that not all of the above would be considered limitations of the existing datacasting capability per se. Overall, Officer Nino found the datacasting system to be very useful and desired to see additional features incorporated into the surrounding architecture. His feedback represents an example of the way in which the introduction of new technology can result in new requirements. As public safety officers are increasingly exposed to the capabilities of communications systems like datacasting, they will identify new and better ways to use these technologies. Integration of data and scalability are important to the acceptance and successful use of such systems.

Officer Ben Garza also provided a positive assessment of the datacasting system, even referring to it as a potentially "life-saving" capability. He provided the following specific feedback:

1. He rated the system very easy to set-up and install.

2. He also rated the system very easy to use. Overall, he stated the system was among the most user-friendly systems he has had the opportunity to use.

3. Officer Garza and the JHU/APL representative confirmed all the data sent was received.

4. Officer Garza rated the quality of the received images very high.

5. Officer Garza rated the quality of the received video very high.

6. Officer Garza rated the timeliness of the received data very high. Overall, Officer Garza commented that the quality of the audio and video far exceeded other systems he had previously used.

7. Officer Garza rated the utility of the received data very high. He stressed the value of having high-quality video and audio data in law enforcement. He considered the ability to receive high-quality video in particular to be a life-saving feature.

8. When asked if he could think of other data he would like to transmit using the system, he returned to the value of the video and the audio.

9. Officer Garza stated the UHPD currently has no capability to disseminate video and audio data to officers in their vehicles. This was consistent with the opinion of other members of the University of Houston OEM.

In addition to the discussion captured above, which reflected Officer Garza's view on the July 21 exercise, there were additional discussions regarding the types of data useful in police work:

1. Officer Garza reiterated the need for high-quality video and audio. He emphasized this was what he desired most.

2. Officer Garza stated that while he could readily exchange information with other UHPD officers, exchanging information with other law enforcement agencies was not easily achieved. He stated the ability to exchange information across agencies is a valuable capability.

3. Officer Garza characterized current (i.e., without datacasting) coverage and capacity within his area of responsibility as poor. There are a significant number of "dead spots" where reception cannot be achieved and, in his experience, there are daily reception failures.

Officer Garza made it clear he would like the datacasting system to be implemented on a permanent basis and expressed some disappointment upon learning the current arrangement only includes a six-month equipment rental.

3.2 Texas Medical Center/NRG Park Feedback and Comments

In this scenario, a member of the test team was allowed to accompany two Harris County Sheriff's Department officers (Deputy Fidel Sanchez and Deputy Kent Rowe) in their Command Vehicle for the duration of the exercise. The officers' role in the exercise was to assess datacasting coverage by seeing how far away from the transmitter they could still receive the datacast signal. The KUHT-TV transmitter is located 1850 feet above average terrain in an antenna farm (29.584444 N, 95.505833 W; near Missouri City in northeastern Fort Bend County, southwest of Houston and about 13 miles from Houston Public Media offices at 4343 Elgin Road). They examined a map and found a point in Crosby, Texas, (see the location northeast of Houston on the map in Figure 1) that was as far away from the transmitter as possible while remaining in Harris County. They drove to the Crosby Volunteer Fire Department station (29.888853 N, 95.059541 W) located at the corner of the US 90 Frontage Road and Kennings Road in Crosby, Texas. Using these latitude and longitude values, this site is approximately 34 miles from the Houston Public Media transmitter. An aerial view is shown in Figure 9, while Figure 10 is a photograph showing where the Command Center vehicle was parked in relation to the Volunteer Fire Department station.

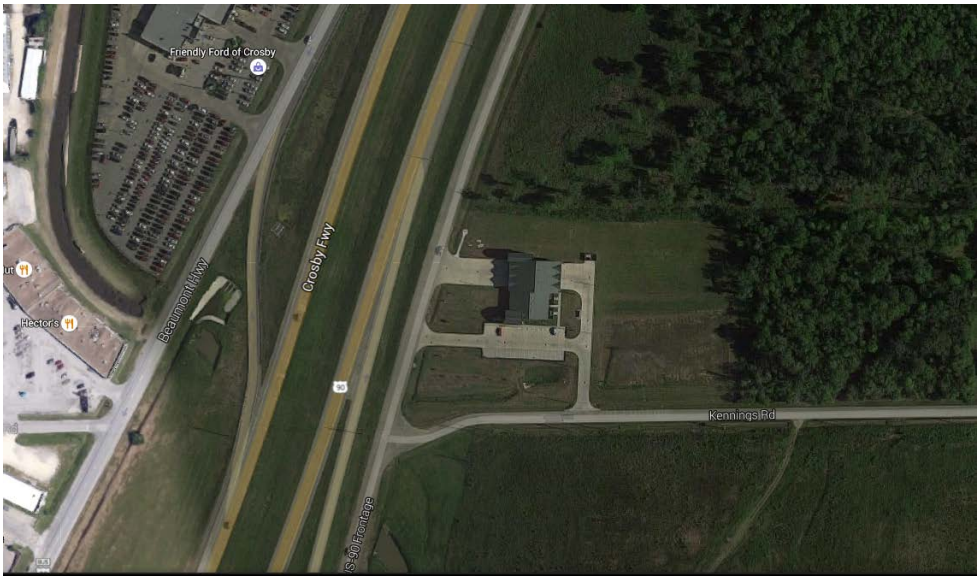


Figure 9: Aerial view (courtesy of Google) of the Crosby Volunteer Fire Department station, which is the building located just to the right of highway US 90.

Figure 10: Photograph of the Harris County Sheriff's Office Command Vehicle (left) in the parking lot of the Crosby, Texas, Volunteer Fire Department (right).

Once on site, they started the SpectraRep software to monitor the signal strength and quality. Figure 11 below shows the signal strength and quality before the mast was raised. The quality scale is unit less and ranges from 0 to 1, reflecting the power received as reported by the USB receiver drive. Note the quality in Figure 11 was 0.88, where 1.0 is the best.

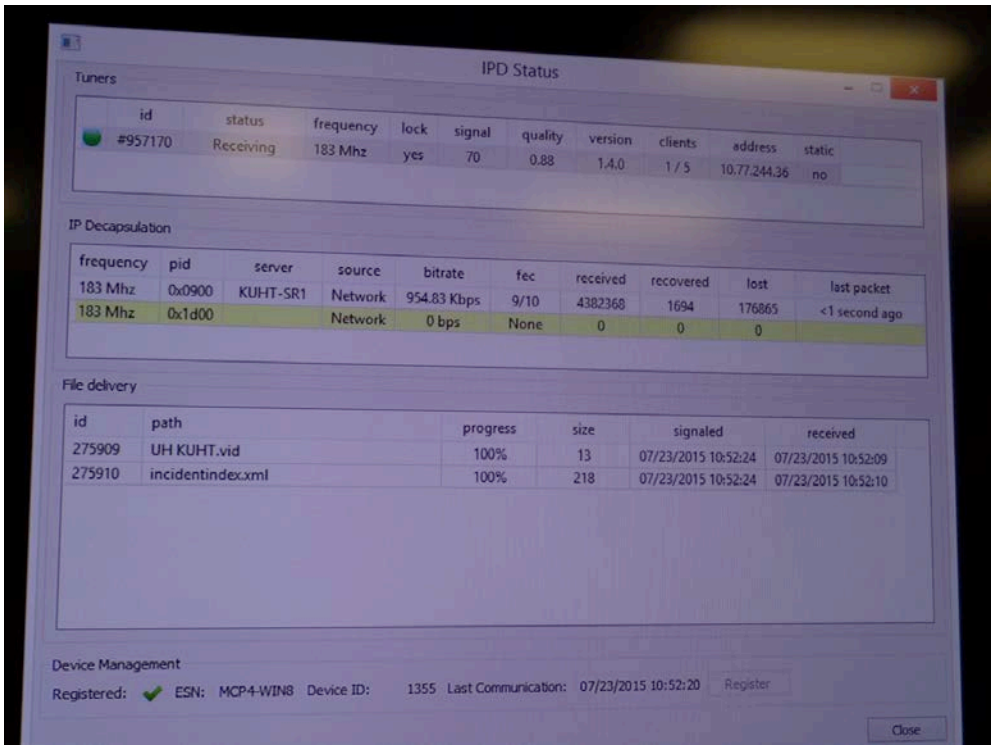


Figure 11: Photograph of the Command Vehicle computer screen before raising the mast. The reception quality is unit less and listed as 0.88, with 1 being the best.

The Sheriff's Department command vehicle (shown in Figures 10 and 12) has a mast containing their transmitter/receiver and a CCTV camera so they can observe around their vehicle. Once the mast is raised, the vehicle must remain stationary. During a real incident, the Command Vehicle typically remains stationary. Therefore, this part of the scenario was not used to test a moving receiver in a vehicle. Figures 10 and 12 show the command vehicle with the mast raised.

Figure 12: Photograph of the Harris County Sheriff's Office Command Vehicle with raised mast on the rear of the vehicle.

The officers raised the mast on the command vehicle, which resulted in improved signal strength, as shown in Figure 13 below. The quality is now 1.00, which is the best possible.

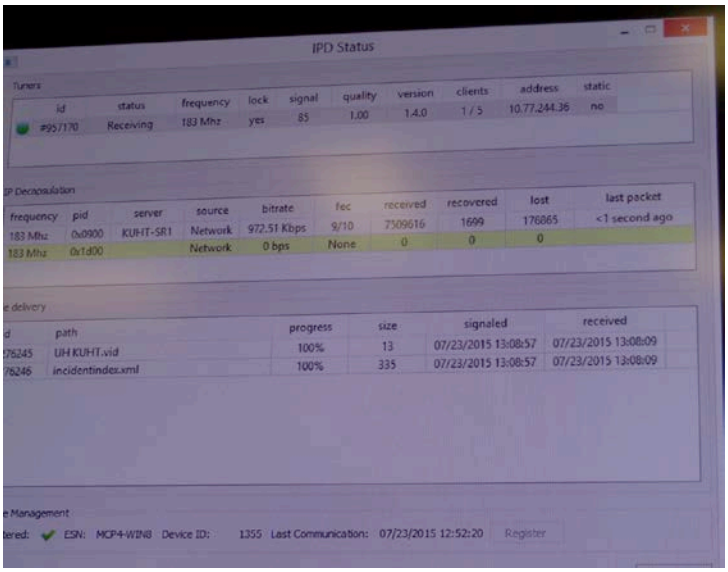


Figure 13: Photograph of Command Vehicle computer screen showing the reception quality is now 1.00 with the mast fully extended.

With the Command Vehicle mast raised, the signal strength and quality were excellent. The alerts were clearly heard and the files were successfully received. The text and image files were easy to view when users clicked on the file icons. Clicking on the audio file resulted in a clearly heard voice message. However, clicking on the video file icon resulted in the Windows operating system failing to open the file because Windows Media Player was not being associated with the .vid file. When the officers used the SpectraRep software menu selection for playing video (instead of double-clicking on the file icon), they were able to view the video file. Therefore, this should be noted in future datacasting training. The video quality was good except for being "jerky," so that there was a time gap between frames. This meant that one might see the suspect in the middle of one frame, but not at all in the next. Specifically, the officers could not always determine the direction of movement of the suspects or follow the suspects as they moved. Although the officers were not aware of it at the time, the jerkiness in the video was a result of using the HSIN to input data into the datacasting system. Because HSIN is a shared resource, video frame rates for this test were lower than they would have been if a more permanent integration had been implemented. Use of HSIN allowed costs for the exercise to be contained at the expense of video quality for the exercise (Note: the video quality achieved during the July 21 demonstration on the University of Houston campus was better because of the dedicated interface implemented within the University of Houston OEM EOC. Data quality achieved during that test is considered more representative of what could be achieved).

The officers made several unsuccessful attempts to call into the conference line to participate in the teleconference because they had an invalid access code. They were finally successful in joining the teleconference once the correct code was provided. Because of this

delay in joining the teleconference, they missed having up-to-date information about the status of the test. However, this was not a limitation of datacasting. They also did not have the problem with computer screen real estate mentioned by the University of Houston Police because the Command Vehicle had a large screen (approximately 4 by 6 feet) covering one of the interior walls. Figure 14 shows the computer screen with four camera views being displayed.

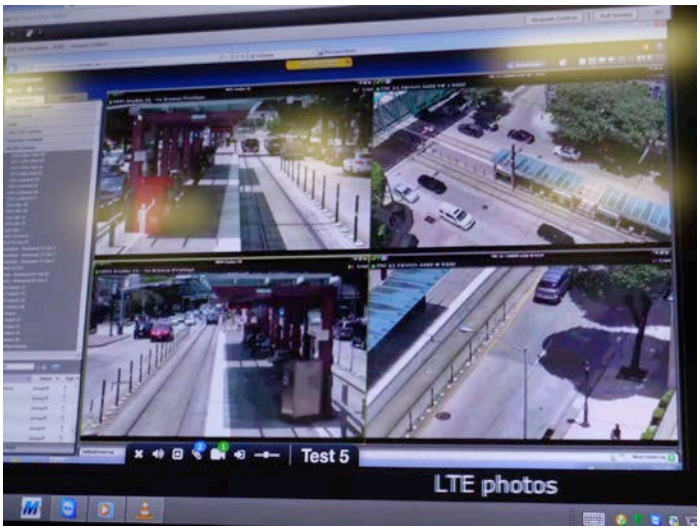
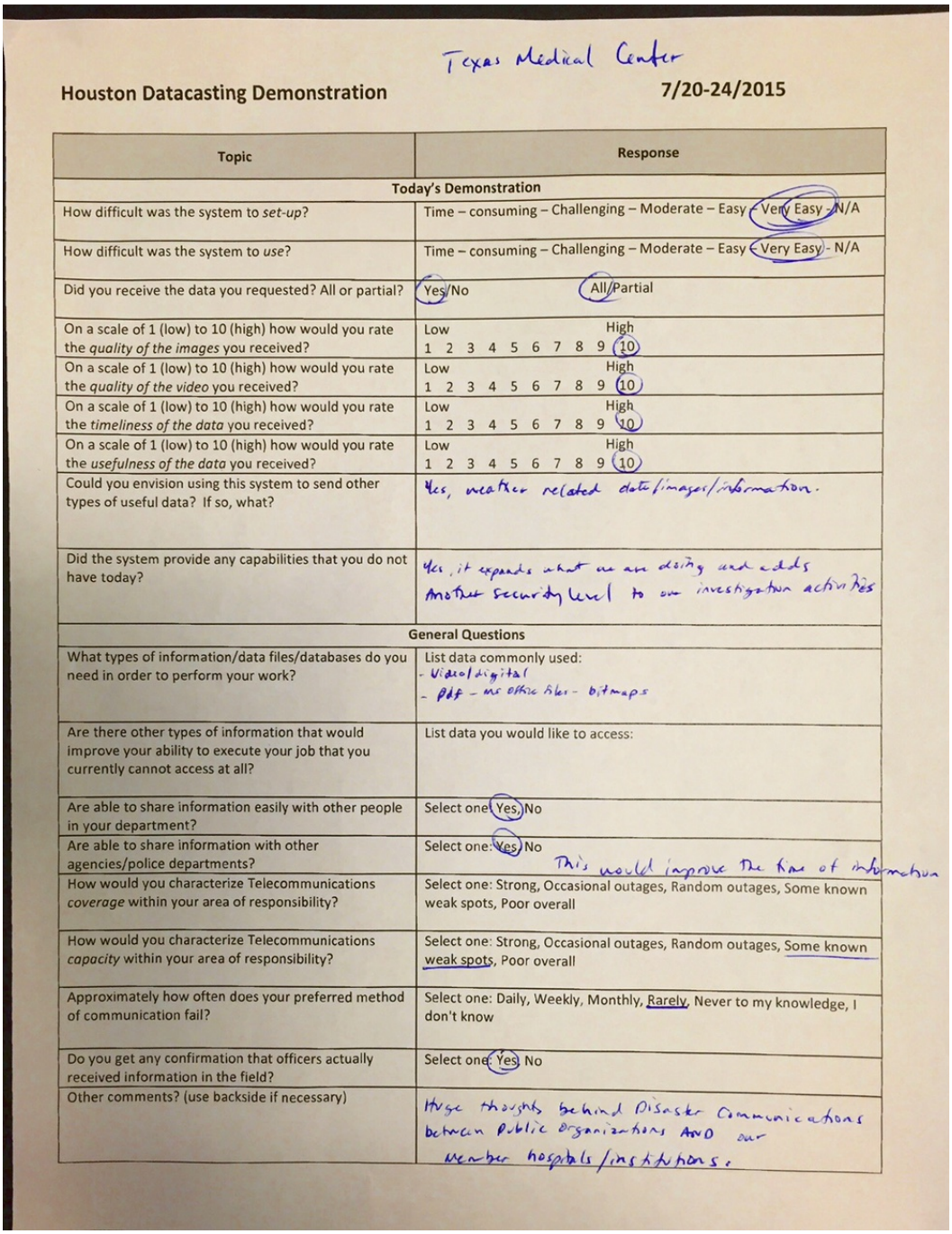


Figure 14: Photograph of the computer screen on the wall of the Harris County Sheriff's Office Command Vehicle.

3.3 Additional Feedback

Each of the stakeholders was provided with a one-page survey as one means of providing feedback. While most of the feedback we received was verbal, Figure 15 shows a sample response from the Texas Medical Center using the survey form.



Texas Medical Center

Houston Datacasting Demonstration 7/20-24/2015

Topic	Response
Today's Demonstration	
How difficult was the system to *set-up*?	Time – consuming – Challenging – Moderate – Easy – Very Easy - N/A
How difficult was the system to *use*?	Time – consuming – Challenging – Moderate – Easy – Very Easy - N/A
Did you receive the data you requested? All or partial?	Yes/No All/Partial
On a scale of 1 (low) to 10 (high) how would you rate the *quality of the images* you received?	Low High 1 2 3 4 5 6 7 8 9 10
On a scale of 1 (low) to 10 (high) how would you rate the *quality of the video* you received?	Low High 1 2 3 4 5 6 7 8 9 10
On a scale of 1 (low) to 10 (high) how would you rate the *timeliness of the data* you received?	Low High 1 2 3 4 5 6 7 8 9 10
On a scale of 1 (low) to 10 (high) how would you rate the *usefulness of the data* you received?	Low High 1 2 3 4 5 6 7 8 9 10
Could you envision using this system to send other types of useful data? If so, what?	Yes, weather related data/images/information.
Did the system provide any capabilities that you do not have today?	Yes, it expands what we are doing and adds another security level to our investigation activities
General Questions	
What types of information/data files/databases do you need in order to perform your work?	List data commonly used: - Video/digital - Pdf – ms office files – bitmaps
Are there other types of information that would improve your ability to execute your job that you currently cannot access at all?	List data you would like to access:
Are able to share information easily with other people in your department?	Select one: Yes, No
Are able to share information with other agencies/police departments?	Select one: Yes, No This would improve the flow of information
How would you characterize Telecommunications *coverage* within your area of responsibility?	Select one: Strong, Occasional outages, Random outages, Some known weak spots, Poor overall
How would you characterize Telecommunications *capacity* within your area of responsibility?	Select one: Strong, Occasional outages, Random outages, Some known weak spots, Poor overall
Approximately how often does your preferred method of communication fail?	Select one: Daily, Weekly, Monthly, Rarely, Never to my knowledge, I don't know
Do you get any confirmation that officers actually received information in the field?	Select one: Yes, No
Other comments? (use backside if necessary)	Huge thoughts behind Disaster Communications between Public organizations AND our member hospitals/institutions.

Figure 15: Example of datacasting feedback using the exercise survey form.

A number of stakeholders and other observers present during the exercise provided additional feedback. Key observations from these stakeholders included the following:

(1) During system checkout in preparation for the July 23 exercise, representatives of the test team attempted to transmit two large video clips (each approximately

20 MB – 160 MB) as attachments to a test message. It took several minutes to complete the transmission because the maximum bandwidth allotted to datacasting for the demonstration was 1 Mbps. Therefore, this could potentially present a problem in an operational implementation, especially one in which multiple organizations had access to the capability. In future applications, it may be necessary to impose file size limits and to implement automated compression techniques.

(2) Stakeholders reiterated the assessment of end-users that the system is indeed easy to install and use.

(3) Like end-users and test members, stakeholders confirmed receipt of all data transmitted. They also rated the quality of video, images and data files as high to very high, and (with one exception) rated the timeliness as high to very high (the dissenting stakeholder rated the data quality as moderately high). Upon follow-up, the observer provided a clarification that larger files took longer to download. This was not observed by other participants or observers. However, this was in part because files selected for the test were limited to those of a certain size. During the equipment checkout, it took minutes to deliver a 40 MB file (datacasting, as implemented for the Houston demonstration, had a maximum capacity of 1 Mbps). No files that large were broadcast during the exercise; however, in an operational environment, a user could conceivably attempt to broadcast a large file. Automated capabilities to limit file size and or to compress large files should be considered as potential future enhancements.

(4) The primary desire was to be able to use datacasting to support the transmission of video and audio data. Currently the participating organizations lack the ability to transmit high quality video data. Except for voice, the desire for video surpasses any other communications needs expressed by test participants and observers. Other needs potentially met by using datacasting include high-quality audio clips, images, maps and geo-location tools. One observer recommended that system be used for broadcasting schematics and engineering diagrams.

(5) Test observers echoed the input of the officers that while they were comfortable with their ability to exchange information within their organizations, they had significantly less confidence in their ability to exchange data with other law enforcement agencies.

Test observers were divided regarding their impressions of existing telecommunications networks. Some of the observers felt the telecommunications systems were highly reliable with few weak spots or outages, while others felt there were weak spots and outages.

4 Summary and Conclusions

Under the direction of the DHS S&T First Responders Group Office for Interoperability and Compatibility, JHU/APL executed a demonstration and evaluation of a prototype datacasting system installed at the offices of Houston Public Media (Public TV Broadcasting Station KUHT) and operated by the University of Houston OEM in Houston,

Texas, from July 20-24, 2015. This exercise was the first in a series designed to demonstrate technical aspects of the datacasting system in an operationally representative context. This report described the preparation, execution and results of this Houston Datacasting Pilot exercise, which involved multiple public safety agencies. Scenarios selected for execution emphasized use of video and inter-agency interoperability. There were two different operational scenarios used for testing: one on the campus of the University of Houston with representatives of the University of Houston OEM, UHPD, Houston Public Media (TV station KUHT) and their Information Technology people; and the other involving the City of Houston, Houston Police Department, Harris County Sheriff's Office, NRG Park, the Houston MetroRail and the Texas Medical Center.

In preparation for the test, representatives of JHU/APL and its sub-contractor SpectraRep (the developer of the datacasting system demonstrated) trained the participants and installed transmission equipment at the television station. A data aggregation and control capability (enabling operators to select data for transmission and forward it to the television station for broadcast) was installed at the University of Houston OEM EOC. Datacasting receiving equipment was installed in UHPD, Houston Police Department, City of Houston, Harris County Sheriff's Office, TMC and NRG Park assets.

The datacasting system broadcast real-time video data from selected University of Houston, Houston Metro and Houston Police Department surveillance cameras. Members of the test team and the participating agencies were able to confirm continuous receipt of high quality data.

The results of this datacasting demonstration were as follows:

(1) The datacasting system is capable of providing high quality video over a wide area of Houston and Harris County.

(2) Although current standards underlying datacasting do not support reception aboard platforms in motion, the test team observed substantial reception in moving vehicles.

(3) All participating organizations agreed datacasting was capable of significantly enhancing their operations. End users observing the system were impressed with its ability to provide data and stream high quality video.

(4) Representatives of the participating agencies were impressed with the ease of set up and use of the datacasting system.

The equipment used in these demonstrations is still in Houston and remains operational. JHU/APL requested participating organizations to continue to use of the equipment so they can collect additional data to measure and document its performance. To enhance the collection of data for more detailed datacasting evaluation, JHU/APL recommends the Incident One datacasting system be upgraded to record and maintain metrics describing system use. Specifically, JHU/APL would recommend that system capabilities be expanded to enable the system to automatically record how many times it was used, to include a description of what was sent (e.g., real-time video, images, maps, records, etc.) and how

many recipients were targeted. There should be no attempt to record content or the identities of recipients. Maintenance of these records would facilitate understanding how often the system is used and how it used, which would facilitate measuring its utility.

5 References

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6. http://www.firstresponder.gov/Pages/Datacasting-Public-Safety-Communication-Over-Broadcast-Television.aspx (Accessed 21 October 2015).

6 APPENDIX A: Technical Details of Datacasting

Television stations transmit aggregate broadcast streams at a constant 19.39 Mbps data rate. Various programs are multiplexed into the aggregate stream. Often television content will not consume the full data rate, or content can be set to use less than the full data rate. When this is the case, null packets are used to fill the unused data rate (see Figure 16). In datacasting, the null packets are replaced with datacasting information that can be received and interpreted by registered recipients with the required equipment.

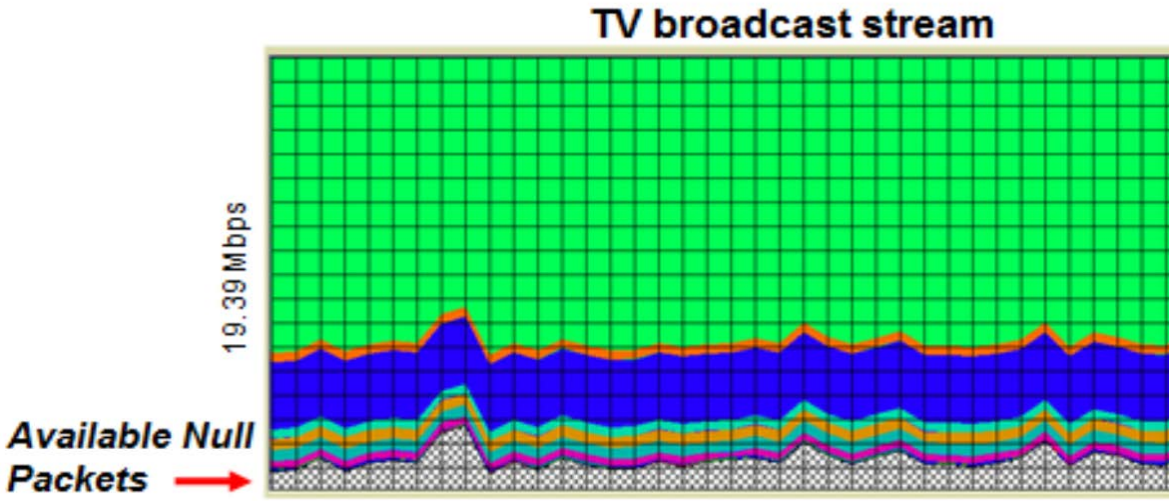

Figure 16: Digital TV Broadcast.

There are three distinct aspects to the datacasting system: (1) information collection and processing; (2) transmission processing; and (3) reception processing (see Figure 17). Optionally, datacasting can be integrated into other systems to create a return path for two-way communication and services. In the prototype system implemented in Houston, information collection and processing, including decisions as to what information to send and to whom, were performed at the University of Houston OEM EOC. Transmission was performed at the Public Broadcast System (PBS) television station KUHT owned and operated by Houston Public Media. Reception equipment was implemented in laptops belonging to the various public safety agencies participating in the demonstration.

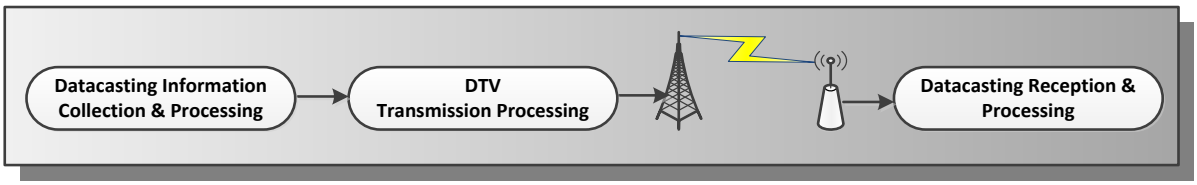

Figure 17: Components of a Datacasting System.

Similar to satellite television providers (such as DirectTV), more than one TV program may be included (i.e., "multiplexed") in one digital television transport stream. Datacasting is an additional program stream in that broadcast channel, but it is not referenced in the Program and System Information Protocol (PSIP), so it does not appear as a "channel" to television sets.

Transport streams are based upon Moving Pictures Experts Group (MPEG)-2 standards. Datacasting information could be embedded within the DTV signal, as represented in Figure 18. In the figure, each packet of the broadcast stream, including the datacasting packet, consists of a 4-byte header and 184 bytes of information.

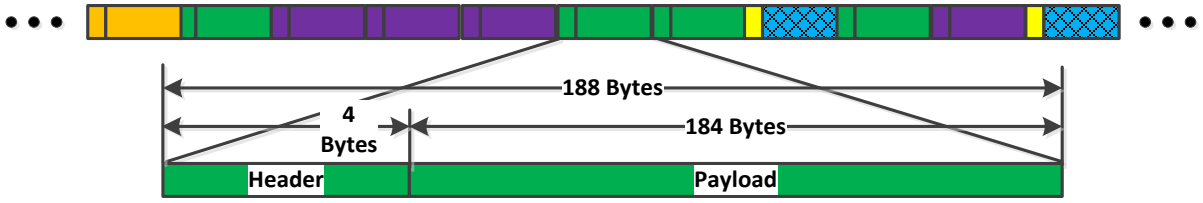

Figure 18: Datacasting within a DTV Stream.

The header consists of 32 bits, including a 13-bit Packet Identifier (PID), as shown in Figure 19.

Sync	Error Indicator	Payload Unit Start Indicator	Transport Priority	PID	Transport Scrambling Control	Adaptation Field Control	Continuity Counter
8 Bits	1 Bit	1 Bit	1 Bit	13 Bits	2 Bits	2 Bits	4 Bits

Figure 19: DTV Broadcast Stream Header Format.

Figure 20 illustrates the DTV transport components. The transport consists of services (i.e., television channels), which are made up of events (i.e., television programs) that each have their own elementary service streams (i.e., packetized MPEG 2 streams consisting of video, audio, metadata and service information as examples).

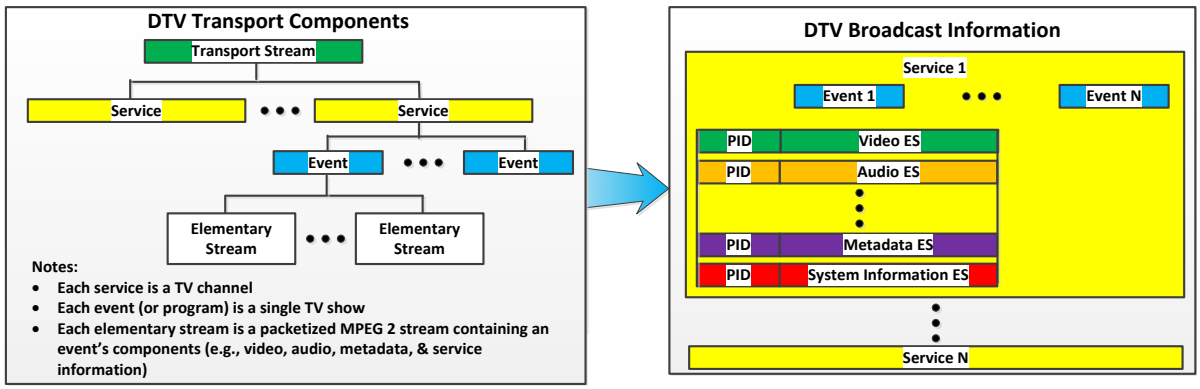

Figure 20: DTV Transport Components.

The elementary service System Information contains various tables, including:

- Program Association;
- Program Map;

- Network Information;
- Service Description;
- Event Information;
- Conditional Access;
- Bouquet Association;
- Time and Date; and
- Time Offset.

System Information tables include Packet Identifier (PID) assignments to elementary streams, events and services. System Information packets are assigned pre-determined PIDs.

Figure 21 contains a representation of the Datacasting Transport information, which is different than the regular television transport. Datacasting does not use the System Information tables and PIDs are pre-assigned to datacasting. PIDs are not included in the System Information tables to prevent DTV receivers from searching for a "ghost" service, event or elementary stream. Datacasting uses "Access Control" to identify PID Assignments, Receiver Assignments, Receiver Group Assignments, Protocol Assignments (e.g., video, file, and messaging assigned to individual and/or group receivers) and key list assignments (for encryption/decryption). Access Control is transmitted on a regular periodic interval.

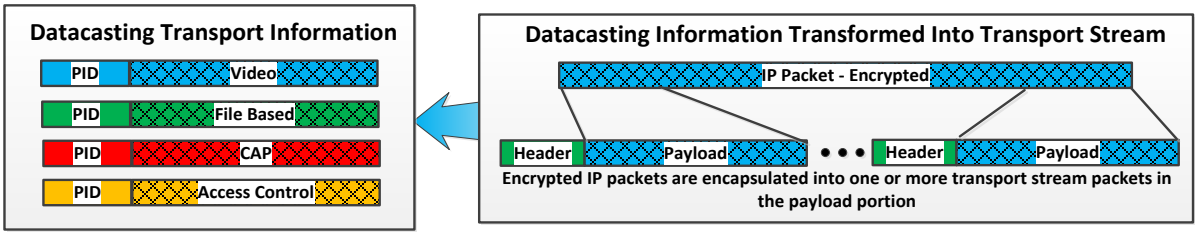

Figure 21: Datacasting Transport Stream.

Datacasting Information Collection and Processing

In general, the datacasting system is configured to incorporate four types of data into the datacasting transport stream as shown in Figure 22:

Real-Time Streamed Data (blue in Figures 21 & 22): Typically, the streamed data may consist of video information such as from a Closed-Circuit Television (CCTV) system. Other streamed data such as audio, weather information and news broadcasts can also be incorporated.

File-Based Information (green in Figures 21 & 22): This information includes documents, images, audio and video clips. It can include other types of digital information, including

software. Forward error correction (FEC) and carouselling are used to assure all packets are received, even in degraded reception environments.

Message Based Information (red in Figures 21 & 22): Generally, the messages are Common Alerting Protocol (CAP) compliant messaging, allowing messages and notifications to be processed by any CAP compliant alerting platform.

Access Control Information (yellow in Figures 21 & 22): File-based data is used to control registration and access. This information includes receiver registration, receiver group assignments, protocol assignments, key list assignments and PID assignments.

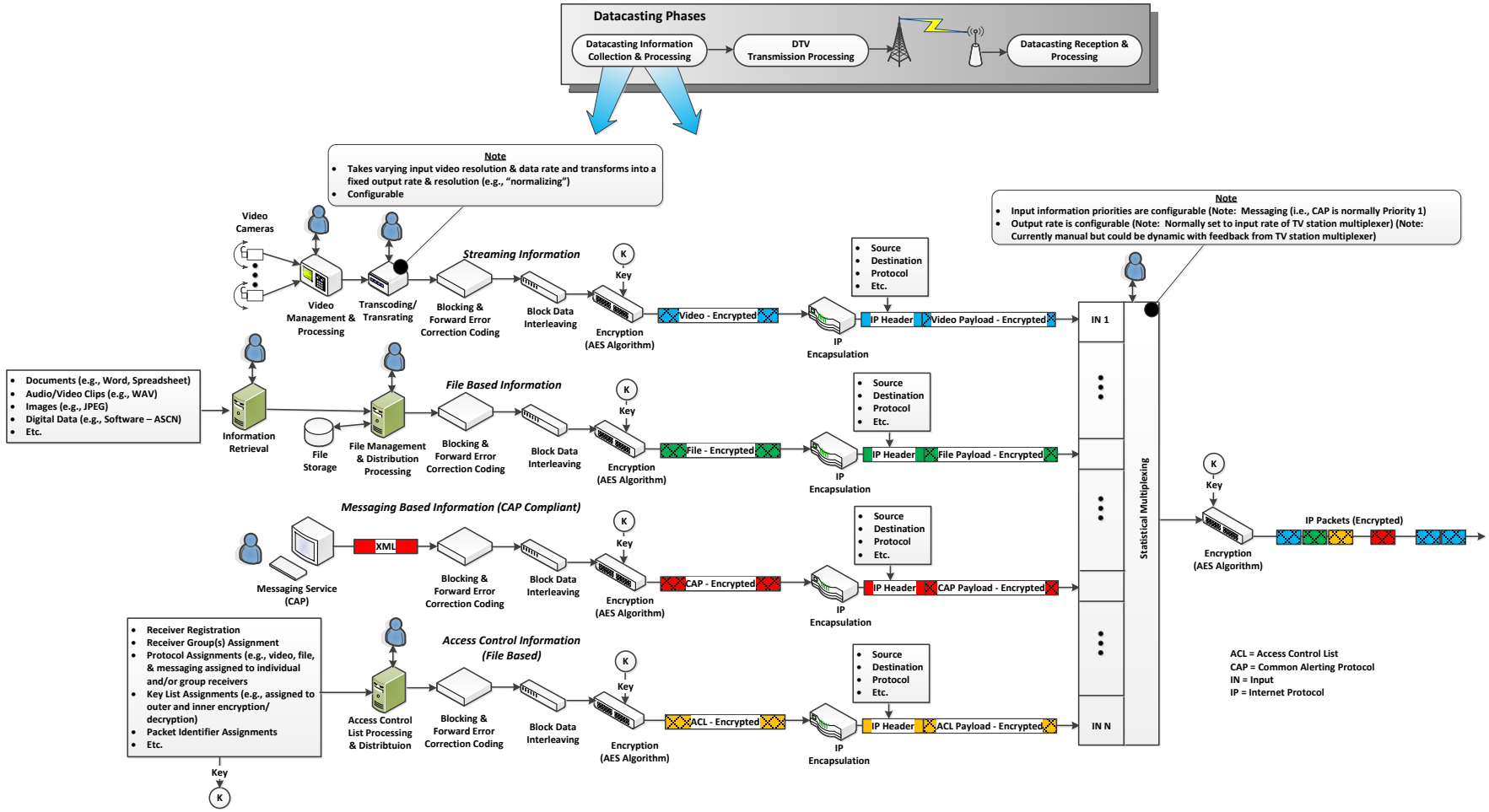

Figure 22: Datacasting Information Collection and Processing.

Some portions of the data preparation process are common for all information types. Data are blocked and forward-error correction[2] is applied. The blocked data are interleaved and encrypted. Encrypted data are encapsulated using IP encapsulation into the MPEG transport packets. Source, destination and protocol data are packaged into the header. The datacasting packets are multiplexed to form a stream that is further encrypted using AES-256.

Transmission Processing

Transmission processing (see Figure 23) consists of merging (multiplexing) the datacasting data stream with the television programming stream(s) as depicted in Figure 24. Prior to the merging, the datacasting stream is processed into DTV transport packets and each transport packet is assigned a PID.

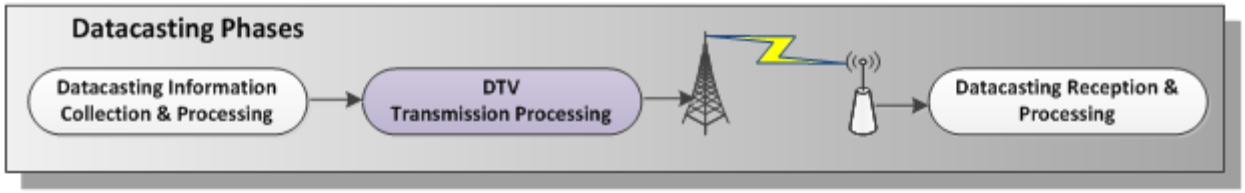

Figure 23: Transmission Processing.

[2] Forward Error Correction is an encoding technique that protects the transmission and reception integrity of the data. It is used to detect and correct "bit-errors," technical problems that cause an occasional bit in a data stream to be misinterpreted. Provided the rate of errors in a data stream remains below a threshold, the Forward Error Correction Code can correct errors in the data stream. Forward Error Correction is a ubiquitous technique; it has no encryption value.

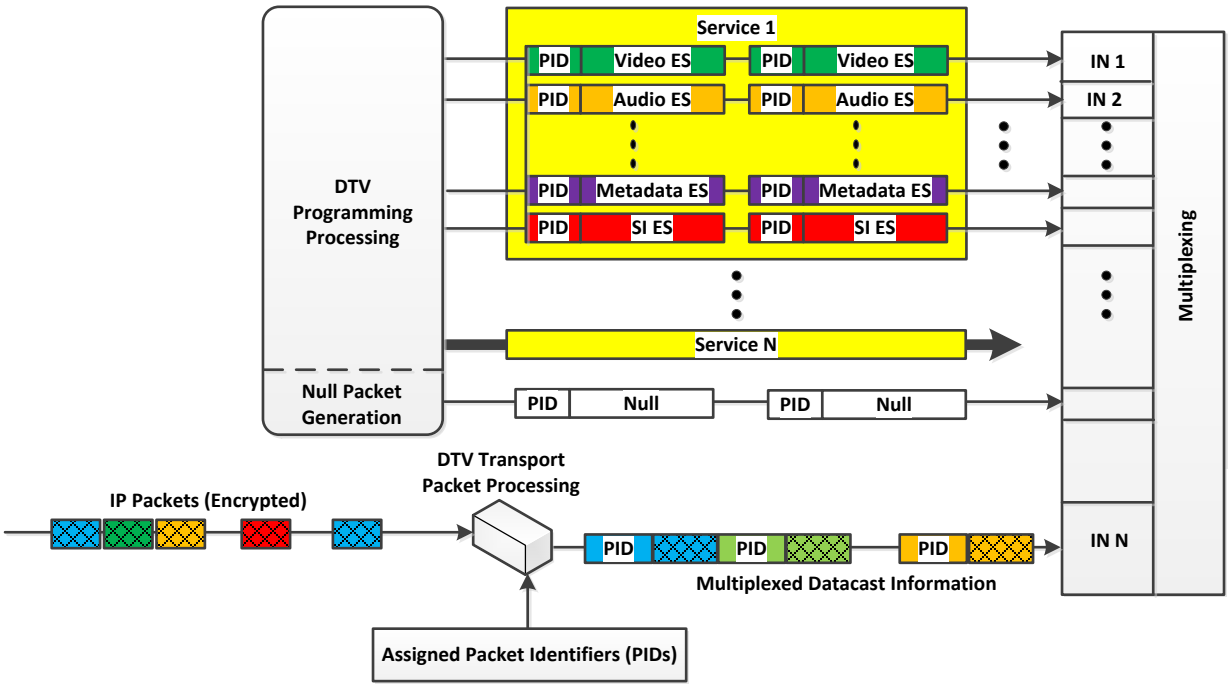

Figure 24: Multiplexing Datacasting and Television Streams.

The overall output rate of the resulting merged stream (including datacasting and programming information) is 19.39 Mbps. Bit rate allocations are configurable. However, under normal conditions, there will be approximately 1-2 Mbps available for datacasting. This bit rate can be increased should conditions warrant it. Maximum bit rate is currently set manually. In the future, it may be possible to enter the information electronically into the information collection statistical multiplexor, which would enable the system to dynamically re-allocate the bit rate.

Null packets are required to maintain a constant 19.39 Mbps bit rate.

Figure 25 depicts the functions performed on the multiplexed signal through transmission. The signal is modulated using 8 level vestigial sideband modulation (8-VSB) and transmitted.

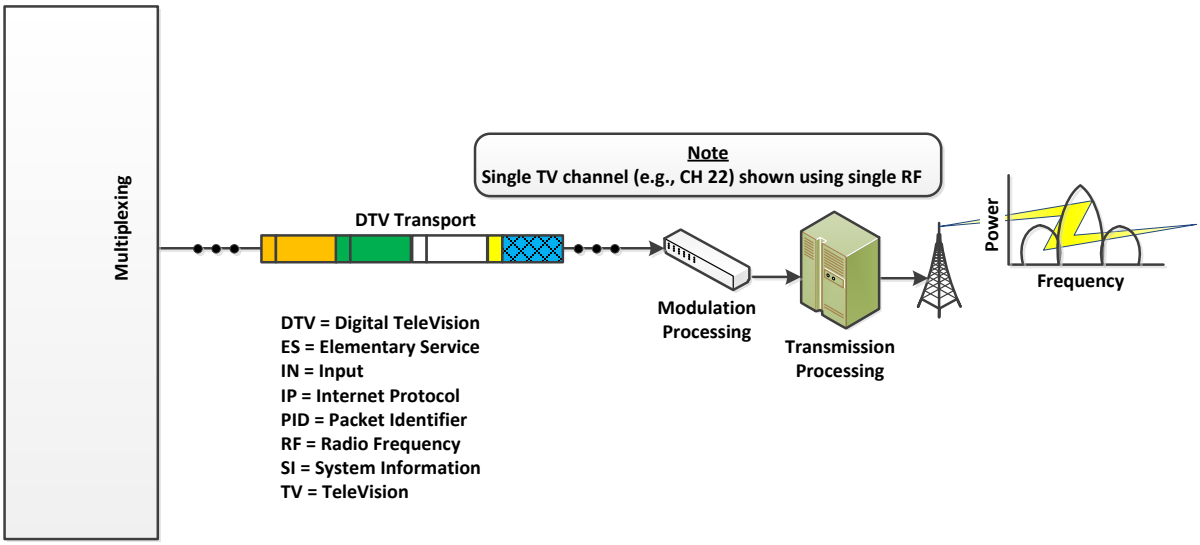

Figure 25: Transmission of Multiplexed Data.

Datacasting Reception and Processing

Datacasting reception (see Figure 26) begins with reception of the signal by a receiver connected to a computing device, not a television set. The receiver can be a USB "dongle", or Linux based appliance. Any UHF or VHF antenna will capture the signal. However, only devices with the required software, decryption, and registration will actually be able to convert the signal into useful information. Upon receipt of a signal, the datacasting system demodulates the signal and identifies the packets directed to the device according to the assigned PIDs. A device can be designated as the unique registered recipient or as part of a group registration.

When a device is authorized to receive data, the encrypted IP packets are decrypted for processing by the appropriate application software in the device. Figure 27 depicts the process.

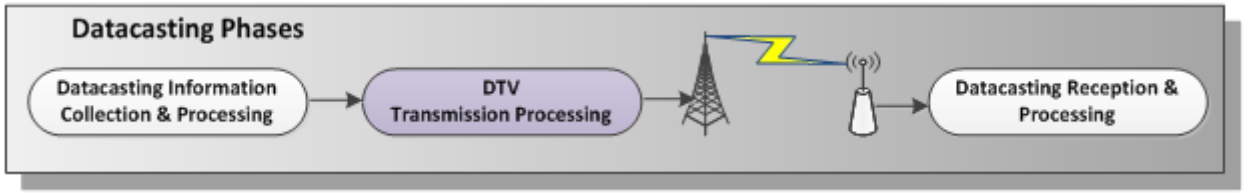

Figure 26: Datacasting Reception and Processing.

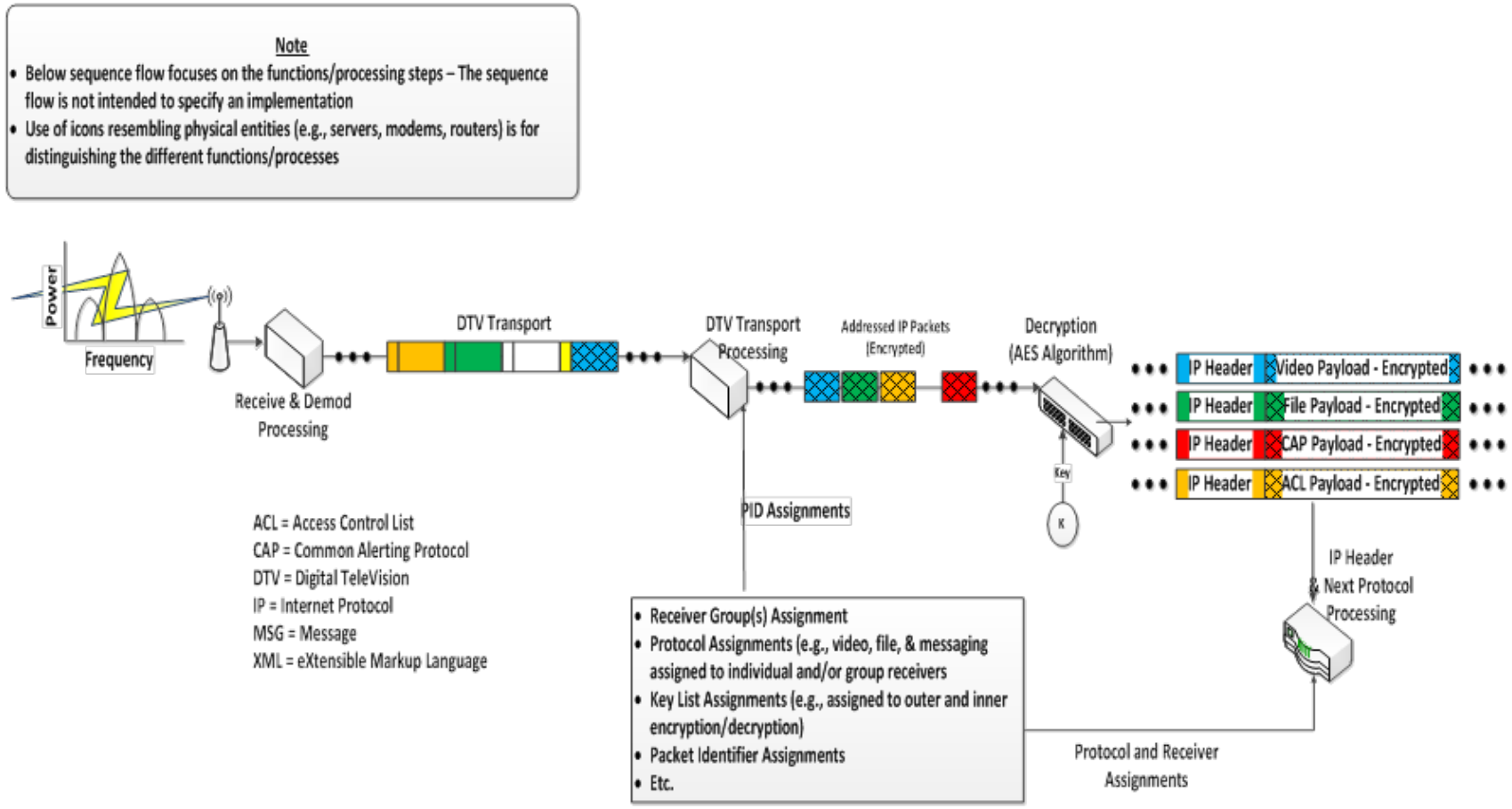

Figure 27: Datacasting Receipt.

Finally, IP packets are processed according to type (streamed data, files, messages and access control) as shown in Figure 28. The further processing of data type is contingent on the access control list that identifies the encryption keys and receiver assignments to be used for each data type processed by this receiver.

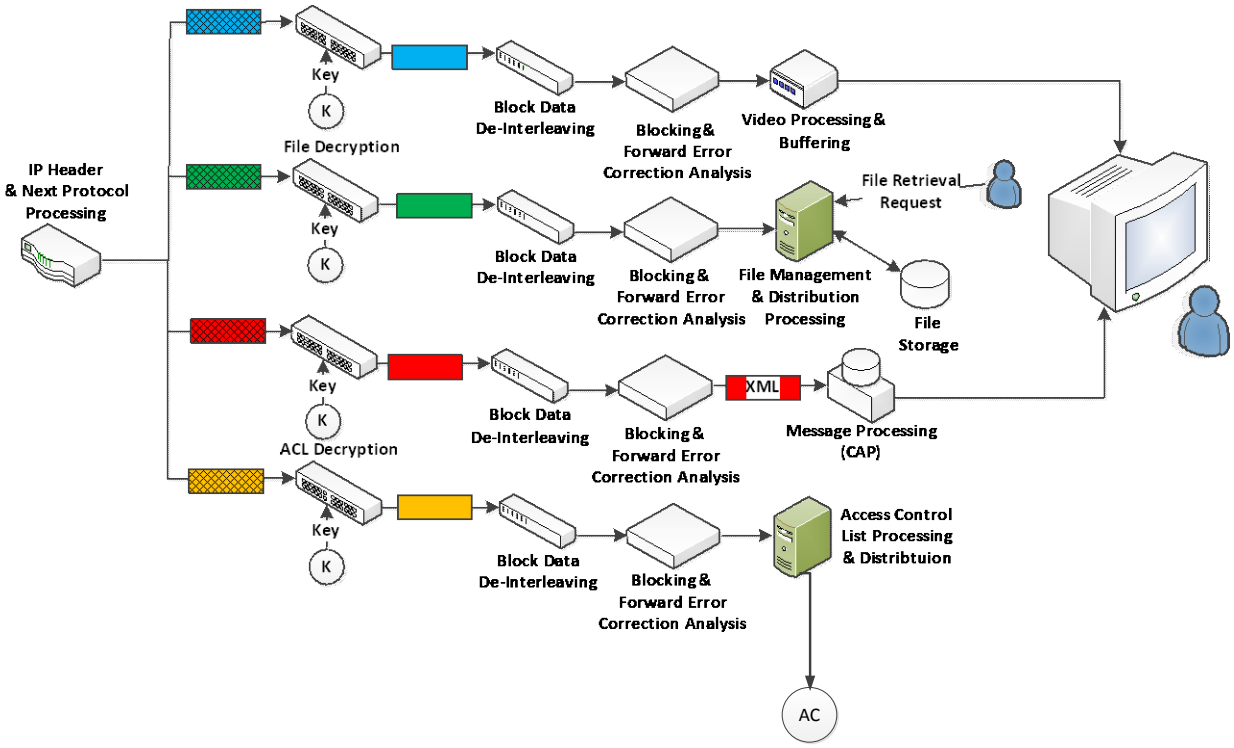

Figure 28: Processing Received Datacasting Information.

7 APPENDIX B: Test Plan for the University of Houston Cougar Place Residence Hall

The following test plan was distributed to the participants prior to the exercise:

Test Objectives:

The demonstration has the following objectives:

1. The primary objective is to demonstrate the technical capabilities of datacasting
2. The secondary objective is to demonstrate that datacasting has utility to emergency management
3. Detailed test objectives include the following:
    a. Demonstrate the ability to reliably broadcast large files containing data useful to first responders via datacasting
    b. Demonstrate the ability to stream real-time video to multiple users via datacasting
    c. Demonstrate the ability to simultaneously broadcast data to multiple agencies using datacasting technology (i.e. to demonstrate the potential for datacasting to increase interagency coordination during emergencies).

Test Location:

The Test will be conducted on the campus of the University of Houston (UH). Portions of the test will be conducted at Cougar Place Residence Hall, at television station KUHT, and at the University of Houston Office of Emergency Management (OEM) Emergency Operations Center (EOC). In addition, additional test procedures will be executed from the University of Houston Police Department (UHPD) Dispatch.

Specific actions at each location include:

1. A simulated "event" will be conducted at Cougar Place Residence Hall.
2. Data and video will be selected for transmission, and designated for datacasting by OEM Staff at the University of Houston EOC.
3. Data will be selected for transmission, and designated for datacasting by dispatch operators at the UHPD Dispatch.
4. Actual datacasting broadcasts will occur at KUHT.
5. Locations of persons/organizations receiving datacast messages are TBD. Technically, they could be positioned anywhere within the KUHT broadcast volume.

However, they should be stationary (i.e. not driving) for the duration of the test. Update: UHPD was able to provide two vehicles and two officers. They received the datacast information while parked across the street from Cougar Place Residence Hall. In addition, a laptop with datacasting software and receive hardware was maintained in the University of Houston OEM EOC and observed by OEM staff and observers.

Participants/Responsibilities:

The following organizations will participate in the demonstration and will have the following responsibilities:

1. DHS S&T: DHS S&T is the authority for this demonstration.

2. City of Houston Government: City of Houston is a critical stakeholder.

3. University of Houston: University of Houston will host the demonstration. As host, the University of Houston will provide the following support:

    a. Input into test planning: The University of Houston OEM will provide input into the design of test procedures and objectives. They also have the authority to accept or reject any test procedures executed on the campus of the University of Houston or involving university personnel or property.
    b. Broadcast infrastructure (KUHT): KUHT will provide access to unused portions of its broadcast signal to transmit encoded data in support of the demonstration and prior to the demonstration to enable testing of the test architecture. It will also provide physical access to its equipment to SpectraRep to install equipment necessary to integrate KUHT broadcast equipment with the University of Houston EOC. Representatives of KUHT will work with SpectraRep to define the integration requirements for the demonstration.
    c. OEM Personnel: The University of Houston EOC will provide a staff member to "push" designated information and video to the datacasting capability installed at KUHT.
    d. Test "subjects": The University of Houston will provide test subjects. Their only responsibility will be to walk through Cougar Place Residence Hall and allow themselves to be observed by the university surveillance system.

4. UHPD: The UHPD will participate in the demonstration in the following ways:

    a. Dispatch: The UHPD Dispatch will provide a trained dispatch officer to "push" designated information to the datacasting capability installed at KUHT.

b. Police Officers: The UHPD will provide TBD officers to receive data from the datacasting system. The officers will have the equipment required to receive datacasts, and will provide observations at the end of the demonstration. The officers will be stationed in TBD locations where they will await reception of information from the datacasting system. Update: UHPD was able to provide two vehicles and two officers. They received the datacast information while parked across the street from Cougar Place Residence Hall.

5. JHU/APL: JHU/APL is DHS S&T's technical authority for this test; its responsibilities include:

   a. Test Design: JHU/APL will coordinate stakeholders in designing of a test that meets the objectives of the stakeholders. JHU/APL will develop required test plans and procedures.
   b. Test Preparation: JHU/APL has sub-contracted SpectraRep to provide and install required test equipment; JHU/APL has responsibility for overseeing SpectraRep during this process.
   c. Test Execution: Although representatives of the University of Houston OEM and UHPD will execute the test, JHU/APL is responsible for ensuring that participants understand their roles and can perform them.
   d. Test Analysis: JHU/APL is responsible for test analysis.

6. SpectraRep: SpectraRep is under contract to JHU/APL to support demonstration of the datacasting system in Houston. This task includes:

   a. Planning – SpectraRep will support planning of the event in Houston. This includes working with the University of Houston DPS Public Safety Systems department to develop integration requirements for the test.
   b. Provision of equipment – SpectraRep will provide the necessary equipment to enable datacast information transmission from KUHT and receipt by test participants.
   c. Installation – SpectraRep will install and integrate the equipment in Houston.
   d. Maintenance – SpectraRep will be responsible for maintenance to ensure that the datacasting system equipment is functional throughout the demonstration.

Dates/Duration:

The actual test will occur on 21 July 2015. This demonstration is expected to last no longer than one day. The actual test will be completed in approximately one hour; however, a full day is assigned to execute dry run and other pre-tests of equipment. Time is allotted to run the test a second time if desired.

Test Preparation:

Preparation for this demonstration consists of the following steps:

1. Test Planning: Test planning was completed the week of 18-22 May.

2. System Integration: Equipment for transmission was installed at KUHT during the week of 18-22 May.

3. Test Procedures: Draft test procedures were developed and disseminated for review by stakeholders during the week of 18-22 May.

4. Test Equipment: Equipment for reception of datacasting data was mailed to test participants during the week of 6-10 July.

5. Equipment Checkout: Members of the test team from JHU/APL and SpectraRep will arrive in Houston on Monday 20 July to perform final tests on the equipment to be used during the test.

Set-up Procedures:

The following represents a sequential description of the steps required for system checkout on 20 July 2015; times are approximate and will be modified to accommodate police officer duties:

1. 0500 – 1100: Travel Time. Technical representatives from JHU/APL will travel from the Washington DC – Baltimore MD area to Houston Texas in order to perform a system checkout prior to a 21 July demonstration of a pilot datacasting system.

2. 1100 – 1400 (approximate): General test of datacasting system is performed:

    a. Verification that data and video can be transmitted from the University of Houston OEM EOC to datacasting receivers using the KUHT digital television system.
    b. Verification that fictional data prepared for the test is loaded and ready for the test. Specifically, the test team will verify that the following is available at the University of Houston OEM EOC:
        i. PDF Campus map of the University of Houston
        ii. PDF Building Plan for Cougar Place Residence Hall
        iii. Pre-recorded MPEG audio file simulating a 911 call describing a shooting on the campus of the University of Houston.
        iv. Excel file containing a list of students and staff (proxy: no list of real students or faculty will be transmitted during this test in order to protect privacy)
        v. Excel file containing a list of special needs students (proxy: no list of real will be transmitted during this test in order to protect privacy)
    c. Verification that the UHPD communications center can transmit data

3. 1300 – 1700: Checkout of receivers. A teleconference line will be established. Representatives of the University of Houston Police Department with receivers are encouraged to call the test team during this window, and the test team will push test material. Receipt of the material will represent a successful system check. The objective is to perform a test of every receiver distributed and to correct any problems encountered.

4. 1500 – 1700: Exercise Dry Run. A representative of JHU/APL will perform a dry run of the scenario to be executed at Cougar Place Residence Hall.

5. 1700 – 1800: Checkout Review Meeting: SpectraRep and JHU/APL will meet to assess the results of checkout and additional efforts required (if any).

Test summary:

The demonstration of the datacasting system at the University of Houston is intended to simulate the data dissemination capabilities of the system in the case of shooting on the campus. One to two test support staff, dressed in clothing that makes them readily discernable from other persons in around the test location, will enter Cougar Place Residence Hall and walk to a designated location within the Hall, where they will await the beginning of the test. The designated location must be in view of a campus surveillance camera. At the beginning of test, they will linger in the designated location for approximately five minutes (during which time, if they were real shooters, they would be engaged in shooting). During this time, they will move around the room. At some point, they should face the surveillance camera in a way that enables it to capture their faces. Approximately one minute into the test, calls are made to the UHPD Dispatch (call will be pre-recorded; no call will be made to an actual 911 system). Immediately after the call, the representative at the University of Houston EOC will activate the datacasting system and transmit the information stored there for Cougar Place Residence Hall. Shortly after that, the UH EOC representative (UH OEM staff member) will identify the shooters on the video system, select the video and broadcast it via datacasting. Shortly afterward, dispatch operators at the UHPD will broadcast suspect photos and records.

After approximately five minutes, the test subjects will begin to leave Cougar Place Residence Hall, following a pre-defined path in the view of surveillance cameras. The EOC operator at the University of Houston will update the video feed as the suspects move from one camera field of view to the next. A police officer or officers outside Cougar Place Residence Hall will observe the suspects exiting the building.

Test Procedures:

On 21 July 2015, the following test procedures will be executed in the sequence described below:

1. 0900 – 1000: Pilot Demonstration Readiness Review. Representatives of the test team, key stakeholders, and test participants will meet to review readiness to proceed. JHU/APL and SpectraRep will present the results of the 20 July checkout. The review will be held at the offices of KUHT.

2. 1030 – 1430: A teleconference line will be set up to enable participants with receivers to contact the core test team. Although the fully live demonstration is scheduled for noon, participants with receivers may request data at any time of the day. This open line helps achieve two objectives: (1) it mitigates the risk of a police officer needing to respond to a real-life incident coincident with the test and (2) it provides opportunities for participants to make multiple requests from different locations thus increasing the sample size.

3. 1030 – 1200: Participants with datacasting receivers will deploy to the locations identified by their respective organizations. A critical objective of the exercise is to demonstrate datacasting coverage even into areas in which coverage with other communications technologies is limited; organizations are encouraged to deploy receivers to locations of interest to them. There is no implication intended that police officers would be supporting the demonstration for ninety minutes; the implication is that the core test team will be able to "push" data ninety minutes prior to the live exercise.

4. 1145 – 1200: Test participants with receivers will inform the core test team (stationed at KUHT) that they are deployed and ready to support the test. Ideally, this would be done via the open teleconference line set up for this purpose. Note: it is understood that the availability of operational personnel cannot be guaranteed for the duration or any part of the test.

5. 1145 – 1200: Test participants simulating "assailants" exiting Cougar Place Residence Hall take their positions in the residence hall.

6. 1200: Representative in University of Houston EOC initiates use of the datacasting system:

    a. EOC representative activates datacasting capability
    b. EOC representative inputs a text message: "ALERT: Shooting at University of Houston: Cougar Place Residence Hall".
    c. EOC representative creates an incident entitled "shooting in Cougar Place Residence Hall". Duration is set to 24 hours to enable test engineers to retrieve data from laptops after incident.
    d. EOC representative locates folder entitled "Cougar Place Residence Hall" and opens it.
    e. EOC representative selects all the data in folder and then "clicks" on transmit
    f. Datacasting system transmits the following:
        i. Campus map
        ii. Cougar Place Residence Hall Building Plan
        iii. List of Students and Faculty
        iv. List of special Needs Student
        v. Audio file of 911 call

7. 1200 – 1205: Test participants with datacasting receivers observe receipt of information indicated above.

8. 1200 -- 1210: EOC representative in University of Houston EOC identifies the "assailants" in Cougar Place Residence Hall using video from the school's surveillance cameras.

9. 1200 – 1210: Officer in University of Houston EOC initiates streaming of video of "assailants" using datacasting

10. 1200 -- 1210: Test participants with datacasting receivers observe receipt video from Cougar Place Residence Hall.

11. 1200 – 1210: A dispatch officer at the UHPD Emergency Operations Center transmits additional pre-prepared data via datacasting; test participants with datacasting receivers observe receipt of this data.

12. 1210: The representative in the University of Houston EOC contacts the "assailants" in Cougar Place Residence Hall to inform them that video of them is being disseminated; the "shooters" begin to exit the building via a pre-defined course. This pre-defined course will ensure that they are within the field of view of a campus surveillance camera at all times.

13. 1210 – 1215: "Assailants" exit Cougar Place Residence Hall; they are observed by at least one officer on the scene who has been observing them via datacast surveillance camera video.

14. 1200 – 1400: Review. The teleconference line will remain open. Test participants with datacasting receivers may request transmission of additional data via the datacasting system. Participants are encouraged to exercise the system as frequently as possible from as many locations as possible in order to achieve a richer sample.

15. 1400 – 1600 Review: JHU/APL will inspect laptops.

16. 1400 – 1900 Review: JHU/APL will analyze data. Specifically, JHU/APL will verify receipt of all data transmitted on each piece of receiving equipment.

Measurements:

The following data collection will be performed:

1. At the completion of the test, JHU/APL and SpectraRep will collect the laptops and dongles and verify the receipt of all messages transmitted on each laptop.

2. Members of JHU/APL will query officers participating in the test regarding the utility of the information provided, and their ability to follow the events simulated in the exercise using just the datacast information.

Post-Test:

JHU/APL will perform post-test analysis and develop a final report documenting the results of this test.

8 APPENDIX C: Test Plan for NRG Park and Texas Medical Center

The following test plan was distributed to the participants prior to the exercise:

Test Objectives:

The demonstration has the following objectives:

1. The primary objective is to demonstrate the technical capabilities of datacasting
2. The secondary objective is to demonstrate datacasting has utility to emergency management
3. Detailed test objectives include the following
    a. Demonstrate the ability to reliably broadcast large files containing data useful to first responders via datacasting
    b. Demonstrate the ability to stream real-time video to multiple users via datacasting
    c. Demonstrate the ability to simultaneously broadcast data to multiple agencies using datacasting technology (i.e. to demonstrate the potential for datacasting to increase interagency coordination during emergencies).

Test Location:

The test will be conducted at a number of sites around the City of Houston, with technical support provided by Houston Public Media (KUHT). Portions of the test will be conducted at NRG Park, the Texas Medical Center (TMC), and on the Houston MetroRail. Additional technical support will be provided from television station KUHT, and from the Emergency Operations Center operated by the University of Houston Office of Emergency Management (OEM). Specific actions at each location include:

1. A simulated "event" (intended to simulate a fight in the stands) will begin at NRG Park (Figure C1). Participants from NRG Park will allow themselves to be captured on video while exiting the stadium and walking toward the NRG Park Metro station located on Fannin Street. This video will be generated prior to the test, and input to the datacasting system for broadcast during the test.
2. Participants from NRG Park (or another participating organization) will board the Houston Metro and ride at least as far as the TMC Metro station, where they will leave the train.
3. Video from the Houston Metro will be "pushed" onto the datacasting system by a representative of the City of Houston or Houston Police Department.

4. Actual datacasting broadcasts will occur at KUHT. Data and video will be transmitted from NRG Park and the Houston Metro Communications Center to the television station where it will be multiplexed into the Digital Television signal. Real-time video and other data will be published to an Internet Protocol (IP) address (identified using a Uniform Resource Locator (URL)) on the Homeland Security Information Network. The data will be retrieved for broadcast at KUHT.

5. Receivers will be provided to the following participants: City of Houston, Houston Police, Harris County, Harris County Sheriff's Office, NRG Park, Texas Medical Center and Houston Metro. These organizations will distribute the receivers at various sites around Houston.

Figure C1: NRG Park with the stadium and the Astrodome (foreground).

Participants/Responsibilities:

The following organizations will participate in the demonstration and will have the following responsibilities:

1. DHS S&T: DHS S&T is the authority for this demonstration. They will also act as observers for the test.

2. City of Houston Government: City of Houston is a critical stakeholder. They will observe the test and record of observations. In addition:

    a. City of Houston will publish real-time video to an Internet Protocol (IP) address (identified using a Uniform Resource Locator (URL)) on the

Homeland Security Information Network, which will be accessible by the datacasting equipment at KUHT.

b. City of Houston will receive datacast data using a datacasting receiver and provide observations.

3. University of Houston: University of Houston will host technical equipment in support of the demonstration. As host, the University of Houston will provide the following support:

   c. Input into test planning: The University of Houston OEM will provide input into the design of test procedures and objectives.

   d. Broadcast infrastructure (KUHT): KUHT will provide access to unused portions of its broadcast signal for the purpose of transmitting encoded datacast data in support of the demonstration and prior to the demonstration to enable testing of the pilot architecture. It will also provide physical access to its equipment to SpectraRep for the purpose of installing equipment necessary to integrate KUHT broadcast equipment with the University of Houston EOC. Representatives of KUHT will work with SpectraRep to define the integration requirements for the demonstration.

4. NRG Park: NRG Park will host a portion of the test and provide data and video in support of the demonstration.

   a. NRG Park will make its spaces available to Test Subjects who will "simulate" a fight in the stands during a sporting event. For purposes of the test, a designated participant or participants will be captured on video camera walking from stadium seating to an appropriate exit and from there to the Houston Metro station on Fannin Street. The participant(s) will be filmed using the stadium surveillance system, and the film will be recorded prior to the test. Update: During the actual test, a security representative from NRG Park and the JHU/APL test conductor performed this role. As a result of the exercise dry-run, it was assessed that the best perspective from which to control test was the test's subjects.)

   b. A designated member of the NRG Park staff will initiate transmission of designated data and the recorded video of the "brawlers" to KUHT for broadcast via datacasting. Video will be "pushed to KUHT via a Virtual Private Network tunnel. Real-time video and other data will also be published to an Internet Protocol (IP) address (identified using a Uniform Resource Locator (URL)) on the Homeland Security Information Network, which will be accessible by the datacasting equipment at KUHT.

   c. A designated member of the NRG Park staff, equipped with datacasting receiver equipment, will observe the exercise and provide feedback upon completion.

5. Houston Metro Police

    a. Houston Metro/Metro Police will make its spaces available to Test Subjects (provided by TBD) who will "simulate" suspects fleeing a sporting event. (Note: test subjects will be required to do nothing more than dress in a readily distinguishable manner that enables them to be continuously tracked using video surveillance systems, walk from the stadium to the Houston MetroRail, and board and exit a train. At no time will they be required to do anything that would arouse suspicion or cause alarm to passersby or train passengers). Update: During the actual test, a security representative from NRG Park and the JHU/APL test conductor performed this role. As a result of the exercise dry-run, it was assessed that the best perspective from which to control test was the test's subjects.)

    b. A designated member of the Houston Metro Police staff will initiate transmission of designated data and video to KUHT for broadcast via datacasting.

    c. Designated members of the Houston Metro Police, equipped with datacasting receiver equipment, will observe the exercise and provide feedback upon completion.

6. Texas Medical Center

    a. TMC will make its spaces available to Test Subjects (provided by TBD), who will "simulate" a fight in the stands during a sporting event. (Note: test subjects will be required to do nothing more than dress in a readily distinguishable manner that enables them to be continuously tracked using video surveillance systems, walk from the stadium to the Houston MetroRail, and board and exit a train. At no time will they be required to do anything that would arouse suspicion or cause alarm to passersby or train passengers). Update: During the actual test, a security representative from NRG Park and the JHU/APL test conductor performed this role. As a result of the exercise dry-run, it was assessed that the best perspective from which to control test was that of the test's subjects. It should be noted that sufficient data was collected by the time the time the test subjects reached the train platform; TMC did not need to open its spaces for execution of this test.

    b. A designated member of the TMC Security staff will initiate transmission of designated data and video to KUHT for broadcast via datacasting (Note: there is currently no plan for TMC to transmit in this exercise).

    c. Designated members of the TMC Security staff, equipped with datacasting receiver equipment, will observe the exercise and provide feedback upon completion.

7. Houston Police Department:

a. Police Officers: The Houston Police Department will provide two officers to receive data from the datacasting system. The officers will be provided the equipment required to receive datacasts, and will provide observations at the end of the demonstration. The officers will be stationed in TBD locations where they will await reception of information from the datacasting system. Upon completion of the exercise, officers carrying dongles will be requested to provide feedback. Update: The Houston Police Department representatives observed the test from a laptop in their offices and from a vehicle stationed in front of the TMC.

8. Harris County Sheriff:

   a. Police Officers: The Harris County Police Department will provide two officers to receive data from the datacasting system. The officers will be provided the equipment required to receive datacasts, and will provide observations at the end of the demonstration. The officers will be stationed in TBD locations where they will await reception of information from the datacasting system. Upon completion of the exercise, officers carrying dongles will be requested to provide feedback. Update: As discussed previously, Harris County Sheriff installed datacasting in a single vehicle (with two officers) and drove to the location specified during the discussion of test execution and results.

9. JHU/APL: JHU/APL is DHS S&T's technical authority for this test; its responsibilities include:

   a. Test Design: JHU/APL will coordinate stakeholders in designing of a test that meets the objectives of the stakeholders. JHU/APL will develop required test plans and procedures.

   b. Test Preparation: JHU/APL has sub-contracted SpectraRep to provide and install required test equipment; JHU/APL has responsibility for overseeing SpectraRep during this process.

   c. Test Execution: JHU/APL is responsible for ensuring that participants understand their roles during the exercise and can perform them.

   d. Test Analysis: JHU/APL is responsible for test analysis.

10. SpectraRep: SpectraRep is under contract to JHU/APL to support demonstration of the datacasting system in Houston. This task includes:

    a. Planning – SpectraRep will support planning of the event in Houston. This includes working with all the participants to develop integration requirements for the test.

b. Provision of equipment – SpectraRep will provide the necessary equipment to enable datacast information to be transmitted from KUHT and to be received by test participants.

c. Installation – SpectraRep will install and integrate the equipment in Houston.

d. Maintenance – SpectraRep will be responsible for maintenance to ensure that the datacasting system equipment is functional throughout the demonstration.

Dates/Duration:

The actual test is currently scheduled to occur on Thursday 23 July 2015. This demonstration is expected to last no longer than one day. The actual test will be completed in approximately one hour; however, a full day is assigned to execute dry run and other pre-tests of equipment and post-test analyses. Time has also been allotted to run the test a second time if desired.

Test Preparation:

Preparation for this demonstration consists of the following steps:

1. Test Planning: An integration working group will be set up to define integration issues related to provision of desired data from NRG Park, Houston Metro Communications Center, and TMC (and any other participants who desire both transmit and receive capability during this test) to KUHT. In addition the working group will identify and resolve any integration requirements associated with installation of datacasting receiver equipment.

2. System Integration: Equipment for transmission was installed at KUHT during the week of 18-22 May. Data connections between organizations wishing to transmit data during the exercise will be established and tested no later than TBD. Update: The connection with HISN was verified the week of 6 July.

3. Test Procedures: Draft test procedures were developed and disseminated for review by stakeholders during the week of 25-29 May.

4. Test Equipment: Equipment for reception of datacasting data was mailed to test participants during the week of 6-10 July.

5. Equipment Checkout: Members of the test team from JHU/APL and SpectraRep will arrive in Houston on Monday 20 July to perform final tests on the equipment used during the test.

6. Tests of HSIN connectivity: Two tests of the HSIN were performed. During the second of these tests, real-time data was "pushed" from the Houston Police EOC to KUHT and transmitted via datacasting.

Set-up Procedures:

The following represents a sequential description of procedures to be executed the day before the demonstration, 22 July 2015:

1. 0900 – 1100: Day One Review: A review of results from the 21 July 2015 demonstration on the campus of the University of Houston will be reviewed. Participants in this review will include core test team, invited stakeholders and participants in the demonstration. Objectives of this meeting are:

    a. Identify and resolve issues from day one that could jeopardize the test at NRG Park

    b. Collect data from operational personnel participating in the demonstration. This feedback is an important aspect of test analysis.

2. 1100 – 1500: A Teleconference line will be set up. During that time the following tests will be performed:

    a. Every prospective test participant with a receiver will call in and request data. A test message and additional data will be transmitted upon request and the participant will verify receipt.

    b. Every provider of data and video (NRG Park, Houston Police, Texas Medical Center) will demonstrate their ability to transmit data to KUHT and the datacasting team will verify that that data is input to the datacasting system.

3. 1100 – 1900: Representatives of JHU/APL and SpectraRep will "troubleshoot" all receivers failing their final checkout.

4. 1300 – 1700: Dry run of live exercise. JHU/APL will perform a dry run of the live exercise tracing the expected track of test "suspects" on 23 July.

5. 1700 – 1900: JHU/APL will review checkout results and verify readiness to proceed.

6. 22 July TBD: Designated operators at NRG Park, TMC and Houston Police Department load the following data to be used in the test:

    a. Maps of NRG Park

    b. Maps of the Houston Metro

    c. Fictional "Rap Sheets" or other criminal records, developed specifically for this test

    d. Traffic maps – Ideally, traffic maps could be accessed, captured using a screen shot, and transmitted as part of the test. However, as an alternate solution, "canned" traffic maps might be generated prior to the test.

e. JPEG photographs of suspects – for privacy reasons, these should not be photographs of real suspects. Update: All data was loaded the day before the test.

Test summary:

During an International Friendly soccer match at NRG stadium, an argument and then a fight begins involving a group of a half dozen gang members attending the match and other spectators. The gang members have managed to smuggle arms into the stadium, and there are injuries in the stadium. Following the fight, the gang members flee the stadium. As they exit the stadium, they assault and seriously injure two guards. They then flee toward the Metro Station at Fannin Street and board a northbound train in the direction of the Medical Center. For purposes of this demonstration, there will be no attempt to simulate an actual fight; test personnel will simulate the assailants leaving the stadium and walking toward the Metro. Test personnel will not engage in any activities that would alarm or worry observers.

During the fight, surveillance cameras capture video of the assailants. In addition, cameras outside the stadium capture video of the assailants boarding a northbound train. However, while authorities are aware that the assailants have boarded a train and are headed north, they are unaware of their ultimate destination. Police are dispatched to multiple stations along the Metro line in order to apprehend them, and warnings are transmitted to various law enforcement organizations located along the train route, including security at the Texas Medical Center. There is significant concern regarding the violent intent of the gang members. Again, test personnel will only simulate the gang members and boarding the train; they will do nothing to alarm or worry passengers on the Metro. Similarly, police officers supporting the exercise need not actually be dispatched; they can observe the exercise remotely from selected locations.

Emergency Medical Services are dispatched to the stadium to care for the wounded. Video from the fight, providing some information on the extent of the injuries, is forwarded to arriving medics and to the hospitals to which the wounded are being transported. In addition, security personnel arriving at the scene capture images of any information allowing an assessment of the number of wounded, their condition and, if possible, their identity (e.g. images of driver's licenses). This information is forwarded to appropriate government agencies and used to retrieve and transmit medical records of the wounded to emergency and hospital staff. For purposes of this test, there is no need to actually access any government databases; fictional suspect histories will be developed, loaded in advance and transmitted via datacasting.

During the fight, two of the assailants suffered severe injuries. They disembark the train at the Texas Medical Center seeking treatment. Security and police at the center have the video, and they immediately apprehend the assailants.

The remaining assailants exit the train at another station further north; they are immediately apprehended by police officers who are waiting for them and can identify them from the disseminated video. (This step is optional. It can be achieved by having test

personnel remain on the train and continue to monitor and transmit Metro surveillance video.)

Apprehension and emergency medical services are complicated by the presence of civilians fleeing the stadium. Traffic reports are continuously updated to first responders to enable them to navigate to the stadium, hospitals and apprehension points.

Test Procedures:

The following test procedures will be executed on 23 July 2015.

1. 0900: A Pilot Demonstration Readiness Review will be held at the Texas Medical Center (2450 Holcombe Blvd Suite #1 Houston TX 77021). The test team will brief stakeholders on the results of equipment distribution and checkout.

2. 1000: A teleconference line will be set up to enable participants with receivers to contact the core test team. Although the fully live demonstration is scheduled for noon, participants with receivers may request data at any time of the day. This open line helps achieve two objectives: (1) it mitigates the risk of a police officer needing to respond to a real-life incident coincident with the test and (2) it provides opportunities for participants to make multiple requests from different locations thus increasing the sample size.

3. 1000 – 1200: Participants with datacasting receivers will deploy to the locations identified by their respective organizations. A critical objective of the exercise is to demonstrate datacasting coverage even into areas in which coverage with other communications technologies is limited; organizations are encouraged to deploy receivers to locations of interest to them. There is no implication intended that police officers would be supporting the demonstration for two full hours; the implication is that the core test team will be able to "push" data two hours prior to the live exercise.

4. 1145 – 1200: Test participants with receivers will inform the core test team (stationed at NRG Park Communications Center and at KUHT) that they are deployed and ready to support the test. Ideally, this would be done via the open teleconference line set up for this purpose. Note: it is understood that the availability of operational personnel cannot be guaranteed for the duration or any part of the test.

5. 1200: An operator at the NRG Park Communications Center creates an incident using the datacasting system:

    a. Dispatch officer activates datacasting capability

    b. Dispatch officer inputs a text message: "ALERT: Fight and Injuries at NRG Park".

c. Dispatch officer creates an incident entitled "Brawl at NRG Park". Duration is set to 24 hours to enable test engineers to retrieve data from laptops after incident.

d. Dispatch officer locates folder entitled "Datacasting Demonstration" and opens it.

e. Dispatch officer selects all the data in folder and then "clicks" on transmit

f. Datacasting system transmits the following:

   i. Stadium Map

   ii. Map of local area

   iii. Audio file of 911 call

   iv. Video clip of "fight" and exit – A pre-recorded video of NRG Park personnel walking from the stadium to the NRG Park Metro Station on Fannin Street.

6. 1200-1205: Officers with datacasting receivers and dispatch personnel at the TMC, Houston Police Department, Harris County, Harris County Sheriff and Houston Metro observe receipt of information indicated above.

7. 1210: The dispatch officer in the NRG Park communication center contacts the "assailants" in NRG Park to inform them that video of them is being disseminated; the "assailants" begin to exit the building via a pre-defined course toward the Reliant Park Metro Station on Fannin Street. This pre-defined course will ensure that they are within the field of view either of the stadium or the Houston Metro surveillance camera at all times.

8. 1210 – 1220: A dispatch operator with access to video from Houston Metro surveillance cameras will search video from the NRG Park MetroRail Station (Figure C2). Upon identifying the tracked subject/subjects at the station, the dispatch operator will begin streaming video of the "suspects" waiting at the station. Officers with datacasting receivers and dispatch personnel at the TMC, Houston Police Department, Harris County, Harris County Sheriff and Houston Metro observe receipt of the video.

9. 1210 -- 1220: Upon identifying the "suspect(s)" at the station, the dispatch operator will alert one of the suspects that they can now board a train; the suspect(s) will board the next available train.

10. 1200 – 1230: A dispatch operator with access to video from Houston Metro surveillance cameras will begin streaming video of the "suspects" on the train. As in other phases of the demonstration, the "assailants" will be readily observable and identifiable by security personnel observing surveillance video; however the

"assailants" will not engage in any behavior that would cause alarm to other train passengers. Officers with datacasting receivers and dispatch personnel at the TMC, Houston Police Department, Harris County, Harris County Sheriff and Houston Metro observe receipt of the video.

11. 1215 – 1230 (optional): A dispatch officer at a second communications center will push additional data related to the assailants (note: as this is not real-time video, the pushed data will be "fictional" in order to ensure protection of privacy).

12. 12:30: The "suspects" exit the train at the Dryden Texas Medical Center Stop, walk toward the Texas Medical center, and enter a building. As they do so, they are captured on video by TMC surveillance cameras. An operator at the TMC distributes video of the suspects via datacasting. Officers with datacasting receivers and dispatch personnel at the TMC, Houston Police Department, Harris County, Harris County Sheriff and Houston Metro observe receipt of TMC video. This marks the end of the test.

13. 1200 – 1400: The teleconference line will continue to be manned by the core test team until 1400. Any test participant with a receiver may continue to request data until then.

14. 1400 – 1700 (locations to be determined based upon police officer availability): JHU/APL and SpectraRep will inspect receivers and laptops.

15. 1400 – 1900: JHU/APL will analyze data. Specifically, JHU/APL will verify receipt of all data transmitted on each piece of receiving equipment.

16. 17:00 – 19:00: End of Day Review

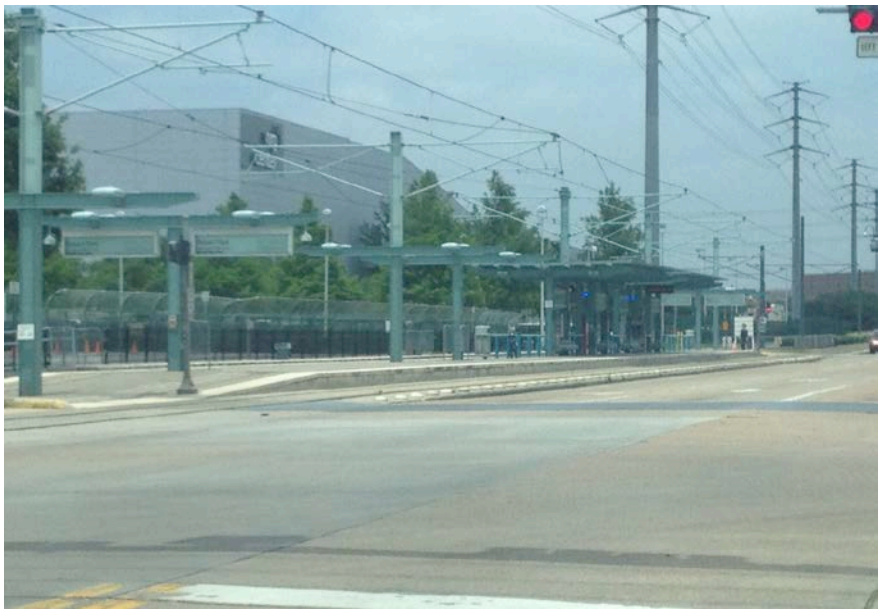

Figure C2: NRG Park MetroRail Station, as viewed from Fannin Street.

Measurements:

The following data collection will be performed:

1. At the completion of the test, JHU/APL and SpectraRep will inspect the laptops and dongles and verify the receipt of all messages transmitted on each laptop.

2. Members of JHU/APL will query officers participating in the test regarding the utility of the information provided, and their ability to follow the events simulated in the exercise using just the datacast information.

Post-Test:

JHU/APL will perform post-test analysis and develop a final report documenting the results of this test. A quick-look analysis will be performed on the evening of 23 July and morning of 24 July.