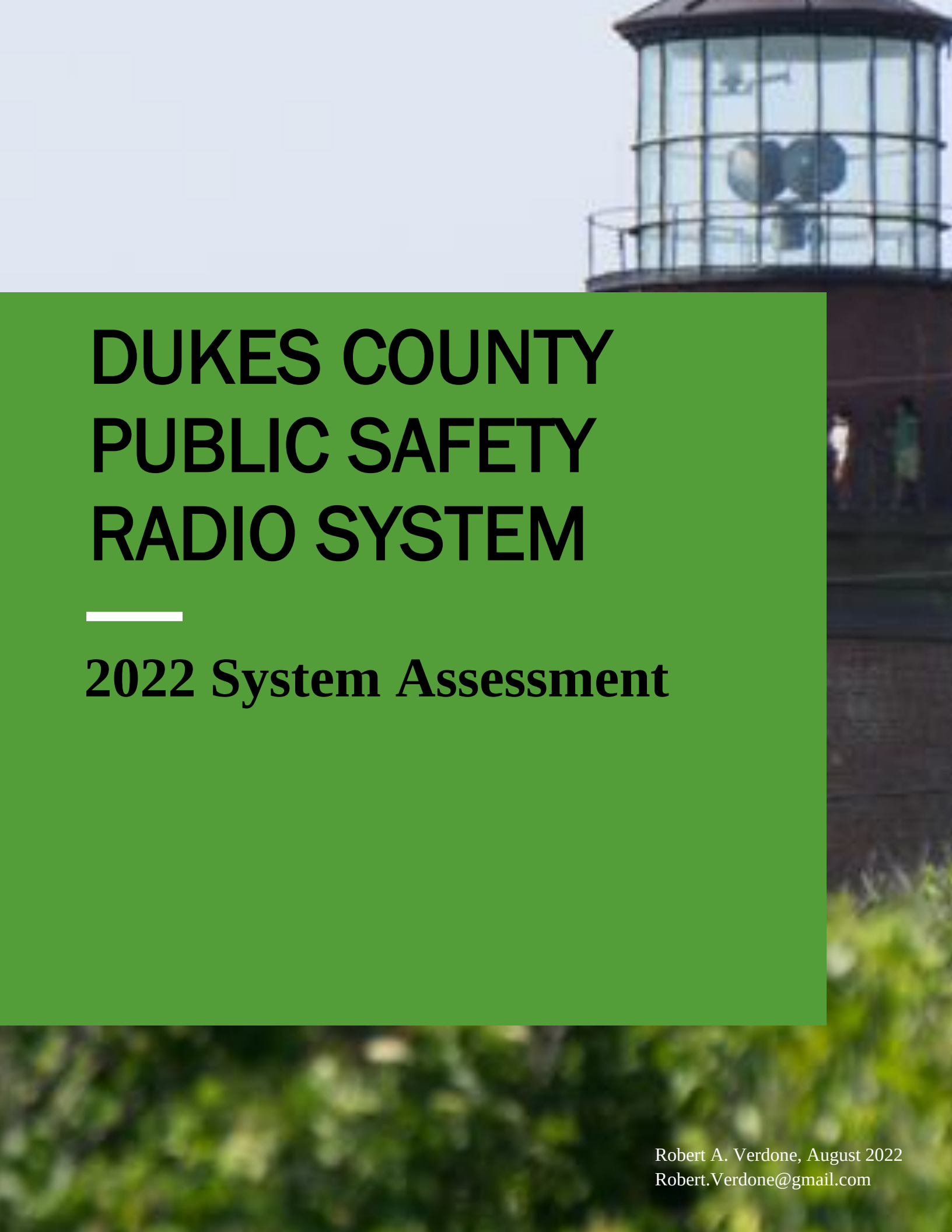

DUKES COUNTY PUBLIC SAFETY RADIO SYSTEM

2022 System Assessment

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Executive Summary

The Dukes County Sheriff's Office commissioned this assessment of the Martha's Vineyard Public Safety Communications System (MVPSCS) as an independent review and assessment of its current design and operations within public safety communications compared to the previous network. The scope of this assessment includes a detailed look at the radio system components, system layout, network design, subscriber configuration, dispatch consoles, and radio channel configuration**.** This assessment is limited to reviewing the programmatic and schematic design of the MVPSC and does not attempt to certify compliance with any standard or technical performance of any equipment. Nothing in this document may be considered to make any warranty, expressed or implied, or assume any legal liability or responsibility for the accuracy or completeness, or usefulness of any information, apparatus, product, or process disclosed. Reference herein to any specific commercial product, process, or service by name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement, recommendation, or preference.

The public safety radio system in Dukes County has a long and documented history of initially leading the way in cooperative interoperable communications, but over several decades falling behind modernization and upkeep, eventually falling into near disrepair. As the system further degraded, the demand on the system increased, and the projected cost to replace it grew to unattainable figures. Several studies were conducted to assess the state of the system and the options for stabilizing the system's health. Each study, conducted by independent assessors, concurred that a major system overhaul was due; however, the urgency of each recommendation rapidly built as the years progressed.

During the term of the current Sheriff, Robert Ogden, a clear priority was set for the DCSO administration to overhaul the infrastructure of the radio system and promulgate governance, best practices, and a sustainable management and maintenance program. Aggressively pursuing grant funding through the Massachusetts State 911 Department's Regional Emergency Communications Center Development Grant program, a competitive statewide grant, the DCSO was able to secure the funding needed to make the multi-million-dollar investment into the MVPSCS project. That project ushered in a new era of advanced communications, resistant subsystems, and a complete replacement of infrastructure and subscriber equipment.

Post modernization, the MVPSCS system is leaps and bounds ahead of the legacy radio system in all program areas. Although there are still areas of the system in which further investments should be made, the new MVPSCS closely aligns with national best practices, standards, and use. The success of this program is noteworthy and should be lauded.

Introduction

Where it started:

Martha's Vineyard public safety agencies, whether born of necessity or by intentional design, have long embodied some of the most difficult to attain best practices in communications system design and interoperability. The Island's use of a consolidated and shared radio system, as well as the establishment and operation of a regional emergency communications center and PSAP, were decades ahead of their time. As a framework, these models built a foundation on which the communities and public safety agencies of Martha's Vineyard had the potential to build a truly standard-setting system. Early iterations of the communications systems on Martha's Vineyards were designed around the available technology for infrastructure and subscriber units to support the day's common operational culture. Built as a collection of simplex channels, the former radio network was designed for police, fire, and EMS operations which relied on mobile (vehicle-mounted) radios in order to talk back to the communications center with limited availability or reliance on portable (handheld) radios. Peer-to-peer radio communications were possible within the limited range of individual mobile or portable radios, and communications that extended beyond the effective range of portable and mobile radios were relayed through the communications center. Over the years, the technology used to build out the various communications networks was quickly outpaced by the state-of-the-industry.

The Problem:

Rapid evolutions and miniaturization of communications technology: Research and development for the adaptation of new and miniaturized radio components into portable, battery-powered radios produced a surge of more affordable portable (handheld) radios. As more and more police and fire agencies adopted the use of portable radios, their limited range and reduced power resulted in coverage gaps.

The rapid increase in the workload and data load placed on the communications center and field units: In the early 90's, Massachusetts implemented the statewide 9-1-1 system. This represented the beginning of another rapid evolution of the public safety ecosystem on Martha's Vineyard. 9-1-1 calls at the time were almost exclusively from landline phones as cell phones were not widely adopted. As 9-1-1 matured into E9-1-1 and as the general public began to shift from landlines and payphones to cellular phones, the 9-1-1 system saw a steady increase in use. Further, this evolution sparked a nationwide effort to promulgate 9-1-1 center standards of care, certification and training requirements, and key performance indicator thresholds. In Massachusetts, the adoption of emergency medical dispatch (EMD) protocol regulations required that every public safety answering point (PSAP) implement an EMD protocol or program. These new regulations along with the ever-increasing adoption of cellular phones, meant that PSAPs across the Commonwealth were seeing higher call volumes of dynamic, mobile, and transient calls that now required additional time to provide pre-arrival instructions. Also, the introduction of additional data such as NCIC, CJIS, and responsibilities such as police, fire, and ems schedule tracking increased the demand on the staff of communications centers and the time required to do it. This was no different in Dukes County. Fast forward to recent

years, and the 9-1-1 system statewide is seeing the majority of calls originating from cellular devices and the constant evolution of available data streams required to be handled by the communications center and field units.

An increase in data, demand for rapid communications, and more time required to do it: The cumulative effect of the natural but incredibly fast evolution of the 9-1-1 system, the public safety programs, the way public safety was administered, and the tools used to do it is the shift toward a more distributed approach to business. Tasks requiring computer use were not exclusively required to be done at the communications center anymore. A fire chief could pull a map of where fire hydrants are and the preplan for a building, on the fly, on mobile devices. The radio system on Martha's Vineyard also saw the adoption of a distributed communication culture; however, the system was never designed for it. The system's original design was for local area direct communications and limited wide-area communications confined to vehicle-mounted mobile radios. Unfortunately, attempts to communicate longer distances to coordinate between officer to officer or ems unit to ems unit were often unsuccessful.

Backhaul: Any solution deployed to enhance radio coverage requires backhaul. Backhaul connects the remote site, such as a tower in a town, and the communications center or to the system's core. These connections often take the form of telephone lines, microwave networks, or fiberoptic networks. At the time of implementation, leased dedicated telephone lines were the most cost-effective, very reliable, and the industry standard for radio backhaul. However, telephone lines are no longer supported by most modern radio systems and have been end-of-lifed by the telephone carriers. With no commercially available leased alternative, the backhaul requirement to move into a new system can be very costly and complicated to implement. Until the backhaul issue was resolved, the Island's communications system was forced to remain on legacy technological solutions.

Narrow banding: The Federal Communications Commission to implement the provisions of sections 309(j) and 337 of the Communications Act of 1934 as amended, issued order 19 FCC Rcd 25045 (31)[1] requiring the conversion of all land mobile radios from 25Khz channel spacing to 12.5Khz channel spacing, known as "Narrow banding." The effect of narrow banding was an observed degradation of operational range. The NTIA's study[2] of narrow banding in marine radios in a similar frequency range to the Dukes County system indicates a 7-10% loss of effective operational range upon narrow banding. This compounded already pervasive issues.

The Solution:

Plug the holes: As mentioned earlier, the radio system saw a shift from the exclusive use of high-powered vehicle radios with roof-mounted antennas to the wide adoption of portable handheld radios with integrated antennas and a tenth of the power. Besides the struggle for wide-area peer-to-peer communications, the communications center was also experiencing trouble hearing units once they

[1] 19 FCC Rcd 25045 (31) (see https://docs.fcc.gov/public/attachments/FCC-04-292A1.pdf)
[2] Assessment of Compatibility Between 25 and 12.5 kHz Channelized Marine VHF Radios, NTIA TR 97-343

departed their vehicle. The solution implemented, at first, was to deploy receive sites throughout the Island. This allowed better reception from the field to the communications center. These sites were deployed in various tower locations based on availability. As the system grew in size, the cost of the system grew as well. To manage costs and still have the ability to deploy and expand, lower-tier equipment was implemented, equipment designed more for commercial applications such as taxi-livery dispatch or other non-mission-critical functions. This was effective in broadening the range of in-bound radio traffic to the communications center.

Adapting new from old: The need and demand for a modern radio system that would allow for peer-to-peer communications natively was identified. Reviews of the old system as-built revealed significant barriers to a quick and affordable renovation. The system, as deployed, would not support the demanding requirements of transitioning from a receive-only site to a receive and transmit site. Implementing a system-based repeated radio network meant that a system component failure would or could result in a complete system failure. The simplex "walkie-talkie" style system initially deployed only relied on the radio-in-hand to operate. The simplex model had a natural resilience at the expense of operating range.

Furthermore, due to the low risk associated with a singular receive site failure, the sites utilized for the original system could meet much lower standards to be acceptable. When inspected for use and adoption into a repeated system, many sites were deficient for this purpose. Finally, the backhaul between the sites was not compatible or adaptable for conversion to a modern system. Modern public safety grade radio systems require IP connectivity between all sites; the telephone line backhaul could not carry IP traffic. Due to the receive-only nature of most remote sites, the backhaul in place was almost universally one-way, only able to pass audio from the site to the communications center but not back to the site. The moratorium[3] on leased telephone lines precluded upgrading these circuits to a 2-way line. An innovative solution for transmitting site shifting and multi-cast split frequency channel planning offered some relief but proved burdensome to maintain and introduced considerable complexity into the daily operations of Martha's Vineyard public safety agencies.

Redesign and rebuild: The radio system as-built proved to be deficient[4] from end to end when considered for adaptation to a modern system. Further, most of the equipment in place was at the end of life or past end of life. Aside from the operational issues observed, coverage was described as "marginal at best"[5] as described in a study conducted in 2006 by the NLECTC; the backbone of the entire system was degraded, unrepairable, and required to be turned off by August 2022. The findings of NLECTC echo the findings of the study completed in 2003 by PSComm, LLC[6] , which described the radio system issues as:

1. Units are not able to hear each other's transmissions.
2. Dispatchers are unable to receive units from all locations at all times (dead spots)
3. Units are not able to receive the dispatcher from all locations at all times (talk out dead spots)

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[3] FCC-19-72 (see https://docs.fcc.gov/public/attachments/FCC-19-72A1_Rcd.pdf)
[4] NLECTC Technical Memorandum 06-001, CaptureNet ID: 58899, 2006
[5] *Id at p.13*
[6] Dukes County Radio Study, PSComm, LLC, 2003

4. During peak times, the single dispatch channel becomes very congested
5. The EMS channel and police dispatch channel cannot be used at the same time by the dispatcher
6. There is no encryption for the radio system, and there is a large number of citizens who monitor the police radio system.
7. Backup systems are non-existent or inadequate.
8. The same CTCSS/PL tone is used on all channels
9. The console is a Zetron 4000 series that is 12+(2003) years old and needs to be replaced.
10. Much of the base station equipment is old, some approaching 40 years old.
11. The voting comparator is not a commercial land mobile radio product; expansion is not feasible.
12. Many of the portables are old and outdated
13. There are many different portable radios by several manufacturers, which limits features
14. There are few towers on the Island and little hope of constructing a new large one
15. Users if the radio system periodically experiences interference from "pirate" users.

Also identified in the NLECTC and reconfirmed in other studies was the Island's lack of backup capabilities and the inability of the majority of both infrastructure and subscriber equipment to comply with the APCO Project 25 standards[7]. This left the entire radio system unable to meet the operational needs of first responders, unsustainable, unmaintainable, and facing assured failure come August of 2022. Deliberate and rapid action was clearly indicated, but initial project estimates were in the $2M to $6M range. Considerations for adaption of the State's 800Mhz trunking radio system were contemplated, but based on the State's implementation roadmap, this did not seem feasible for this phase. As a multi-town PSAP the Dukes County Emergency Communications Center is designated as a "Regional Emergency Communications Center"[8] and thusly eligible for certain grant programs administered through the State 911 Department. A successful competitive application into the Development Grant program overcame the enduring, monumental task of funding the redesign, modernization, and rebuilding of the Martha's Vineyard Public Safety Communications System and is certainly laudable.

[7] APCO Project 25 (ANSI/TIA/EIA-102)
[8] MGL c.6A §18A (see https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter6A/Section18A)

Assessment

The Martha's Vineyard Public Safety Communications System (MVPSC) has been assessed against previous observations, assessments and recommendations adapted to the modern equivalent standard. Further, the system has been assessed against new standards and published best practices that may not have been available at the time of previous assessments.

The assessment of the MVPSC system was approached from the perspective of a historical review of the previous system, its faults and success, and the various studies, reviews, and resulting recommended actions. These historical faults and recommended actions are adjusted for modern standards and then compared against the results of the efforts recently undertaken to modernize the system. Through this review, we endeavor to capture if meaningful progress has been made, what the system's state is, whether the new system aligns with modern standards and priorities as well as attempting to identify area where additional investments and improvements could be made if funding is made available through state funding or other sources.

Standards, Priorities, Best Practices and Concepts

Standards and Best Practices

- Project 25 TIA-102 Documentation Suite Overview
- APCO / NPSTC 1.104.2-2017 Standard Channel Nomenclature for the Public Safety Interoperability Channels
- US DOJ LAW ENFORCEMENT TECH GUIDE FOR COMMUNICATIONS INTEROPERABILITY
- SHARED COMMUNICATION SYSTEMS AND INFRASTRUCTURE (SCSI) FOR PUBLIC SAFETY COMMUNICATIONS
- DHS Interoperability Continuum
- DHS Communications Interoperability Performance Measurement Guide
- DHS Creating a Charter for a Multi-Agency Communications Interoperability Committee
- U.S. Fire Administration Voice Radio Communications Guide for the Fire Service (2016)
- IAFF Fire Ground Survival (FGS) Program
- NFPA 1221: *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems.*
- NFPA 1561: *Standard on Emergency Services Incident Management System and Command Safety.*
- NFPA 1802: *Standard on Personal Portable (Hand-Held) Two-Way Radio Communications Devices for Use by Emergency Services Personnel in the Hazard Zone.*
- NIST Technical Note 1477: Testing of Portable Radios in a Firefighting Environment
- NIST Technical Note 1850: Performance of Portable Radios Exposed to Elevated Temperatures.

National Priorities

Title XVIII of the Homeland Security Act of 2002, as amended, requires that the Cybersecurity and Infrastructure Security Agency (CISA) develop the NECP to "**provide recommendations regarding how the United States should support and promote the ability of emergency response providers and relevant government officials to continue to communicate in the event of disasters and to ensure, accelerate, and attain interoperable emergency communications nationwide.**" The law also directs CISA to develop and periodically update the NECP in coordination with federal, state, local, territorial, tribal, and private sector stakeholders.[9]

Published DHS priorities:

- Enhance effective governance among partners with a stake in emergency communications, embracing a shared responsibility of the whole community from traditional emergency responders and supporting entities to the citizens served
- Address interoperability challenges posed by rapid technology advancements and increased information sharing, ensuring the most critical information gets to the right people at the right time
- Build resilient and secure emergency communications systems to reduce cybersecurity threats and vulnerabilities

[9] https://www.cisa.gov/necp

Governance and Leadership: 

Develop and maintain effective emergency communications governance and leadership across the Emergency Communications Ecosystem

Planning and Procedures: 

Develop and update comprehensive emergency communications plans and procedures that address the evolution of risks, capabilities, and technologies across the Emergency Communications Ecosystem

Training, Exercises, and Evaluation: 

Develop and deliver training, exercise, and evaluation programs that enhance knowledge of and target gaps in all available emergency communications technologies

Communications Coordination: 

Improve effective coordination of available operable and interoperable public safety communications capabilities for incidents and planned events

Technology and Infrastructure: 

Improve lifecycle management of the systems and equipment that enable emergency responders and public safety officials to share information efficiently and securely

Cybersecurity: 

Strengthen the cybersecurity posture of the Emergency Communications Ecosystem

Interoperable Communications

Interoperable emergency communications don't just happen because a piece of equipment is in a police officer's or firefighter's hand. It happens because the emergency response community has developed relationships, invested significant funds, and expended countless time and effort to ensure communication is there when they need it and know how to use it in any emergency.[10]

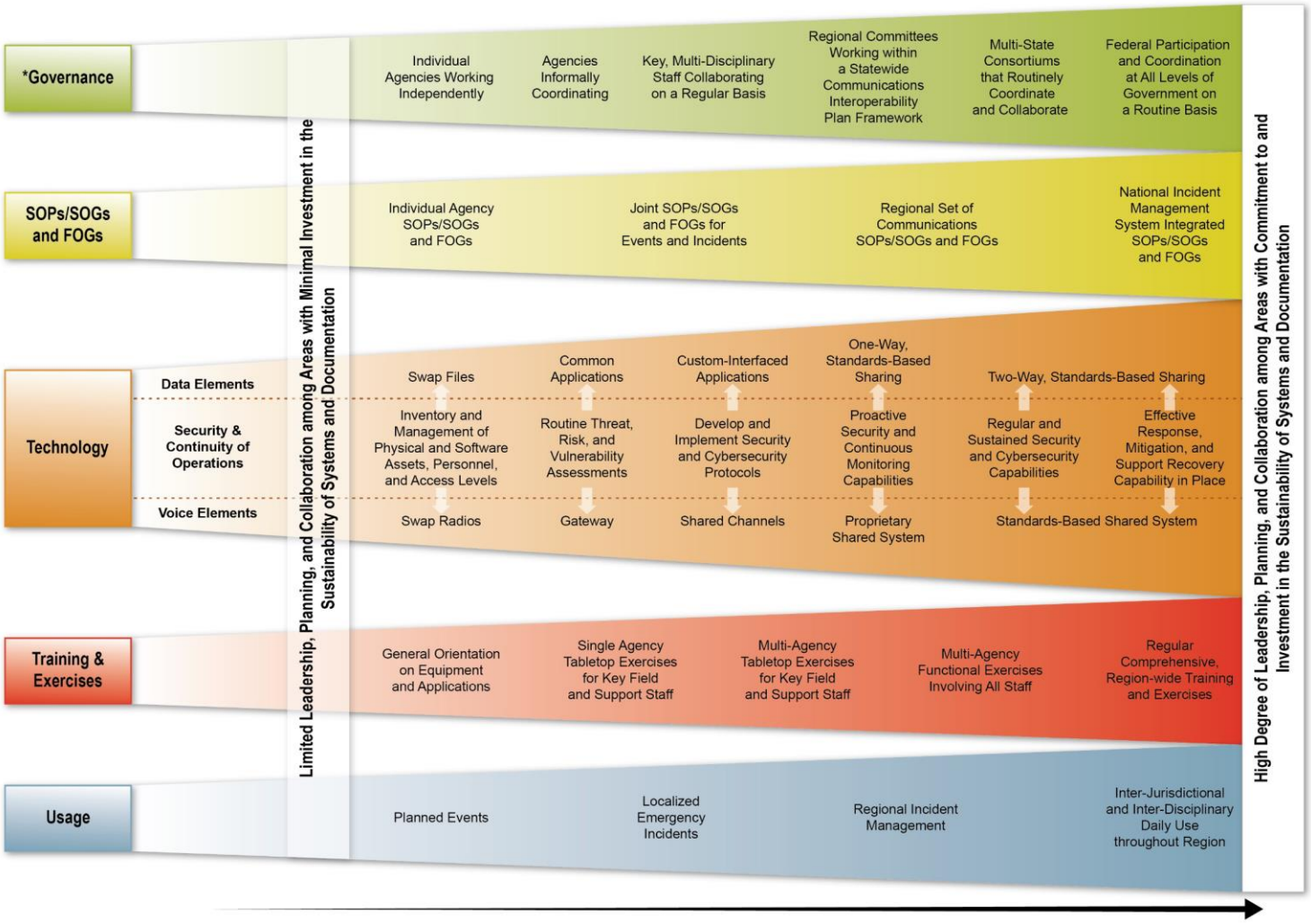
Interoperability is an evolving, multi-dimensional challenge. To gain a true picture of a localities' interoperability, progress in each of the five interdependent elements must be evaluated. For example, when an agency procures new equipment, that agency should plan and conduct training and exercises to make the best use of that equipment.

Optimal interoperability is contingent upon an agency's and jurisdiction's needs. The Continuum is designed as a guide for disciplines, agencies, and jurisdictions that are pursuing interoperable solutions based on changing needs or additional resources.[11]

To drive progress along the five elements of the Continuum and improve interoperability - public safety and as necessary public services and NGOs - should observe the following principles:

- Gain leadership commitment from all disciplines and jurisdictions
- Foster collaboration across disciplines through leadership support
- Interface with policymakers to gain leadership commitment and resource support, which includes funding and sustainment
- Use interoperability solutions routinely
- Plan and budget for updates to systems, procedures, documentation, and technology

[10] CISA /DHS Interoperability Elevator Pitch
[11] CISA/DHS Interoperability Continuum



*Brochure text updated to include information on Lifecycle Funding within the Governance Section

System Review

Previous system(s)

The previous radio system and its iterations have been reviewed several times over the past two decades and consistently showed little progress toward a whole-system improvement, and in the most liberal assessment, it would limit the observed system improvements to only the work required to respond to a failure or plug holes. Three separate studies over almost 20 years (PSComm, 2003, NLECTC, 2006, Verdone & Staffier, 2017) concurred that public safety radio system deployed in Dukes County was severely deficient for these reasons:

- The pervasive use of consumer and commercial-grade infrastructure which is inappropriate for mission-critical and life safety operations.
- The use of a simplex configuration for primary operations
- The profound empirical evidence of coverage deficiencies
- The inadequacy of in-place backhaul
- The lack of backup and contingency systems
- The political turbulence of the governance, management, and maintenance of the system
- Subscriber unit salient standards and standard configuration
- System funding for maintenance
- Lack of compliance with P25 standards

Other issues identified:

- Lack of adoption of MDC-1200 or other subscriber identification system
- Faulty grounding
- Lack of National Interoperability Channels programmed
- Failure to properly license channels and sites
- Channel naming conventions
- Use of 10-codes

This assessment will not attempt to reassess the quality of the previous systems and will rely on the available data and literature to establish that there is sufficient evidence to assume that the previous system was deficient in several aspects.

Current System (2022)

The Dukes County Sheriff's Office, through the successful application(s) into the highly competitive State 911 Department RECC and Regional PSAP Development Grant, was able to subsidize the DCSO's efforts to modernize into an effective, safe and resilient radio system that has been called for, for over 20 years.

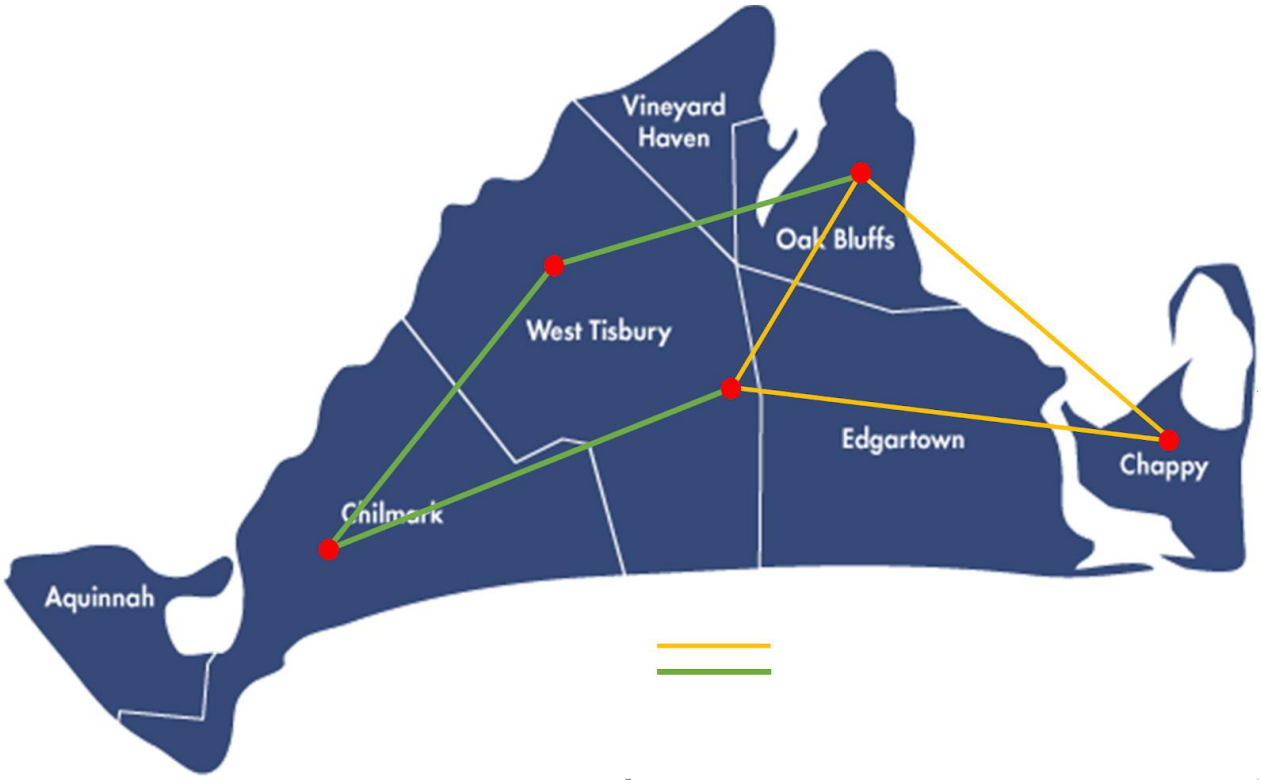
Through demonstrated considerable effort, the DCSO team has achieved a wide spectrum of programmatic, technical, and administrative tasks to attain high compliance with the recommended actions, best practices, and standards.

The Dukes County radio system is now a P25, public safety grade, duplex simulcast VHF land mobile radio system.

Backhaul:

As mentioned, several times across this document and the several studies conducted, backhaul is amongst the most essential element of successful system implementation. The need to replace the legacy copper telephone circuits used in the previous system was required to implement a modern IP-based network and urgently required to avoid the end-of-life termination of those circuits in the coming months.

The MVPSCS implementation utilized a hybrid of private fixed wireless licensed microwave and fiberoptic connections to link the various sites.



Green- Fixed Wireless Microwave
Yellow- Fiberoptic

This model of backhaul deployment appears to be an exceptional use of available resources and achieves a physical network topology capable of supporting diverse path routing, a best practice to ensure highly available network presence at all sites.

The MVPSCS network configuration employs quality of service rules or, in other words invokes a "reserve" of bandwidth for radio traffic and can prioritize bandwidth utilization for other services. This is a critical practice to implement to ensure that radio traffic always has a path. The MVPSCS is almost assured to eventually have other networks or services traversing the physical infrastructure built. This measure is forward-looking and well indicated. The MVPSCS network appears to be well planned and implemented into logically separated sub-networks.

The MVPSCS is a considerable improvement over the phone line circuits previously used. The new network is physically capable of diverse path routing and with additional investments into the network – diverse path topology could easily be achieved. The network appears to retain the ability to utilize diverse paths and will enjoy the disaster recovery capabilities that this presents, but the MVPSCS network team should continue to endeavor to automate that process. Additionally, the MVPSCS fiber network is dependent on a commercial carrier. It may be in the best interest of the system to replace or overlay certain legs or the entire commercial carrier-based fiber network with private fiber or microwave.

Radio Infrastructure

Spectrum and channel use:

The MVPSCS reorganized the available VHF spectrum into wide-area simulcast channels utilizing multiple transmit sites and several receive-only sites. The new channels are separated into wide-area operations/dispatch channels and tactical channels based on discipline with overlayed geographically designated cross-discipline tactical channels.

Fire Dispatch	*Daily dispatch/ops*	*PD Dispatch*	*Daily dispatch/ops*
Fire Tac	*Assignable tac*	*PD Tac*	*Assignable tac*
OPS ED	*Cross-Discipline TAC*	*OPS ED*	*Cross-Discipline TAC*
OPS DN	*Cross-Discipline TAC*	*OPS DN*	*Cross-Discipline TAC*
OPS UP	*Cross-Discipline TAC*	*OPS UP*	*Cross-Discipline TAC*
FG1	*Fire Ground*		
FG2	*Fire Ground*		
FG3	*Fire Ground*	*JAIL*	*Jail ops*
FG4	*Fire Ground*	*TRIBE*	*Tribal Gov. Ops*
FD OPS UP	*Assignable tac (geo)*	*PD OPS UP*	*Assignable tac (geo)*
FD OPS DN	*Assignable tac (geo)*	*PD OPS DN*	*Assignable tac (geo)*
FD OPS ED	*Assignable tac (geo)*	*PD OPS ED*	*Assignable tac (geo)*
VFIRE21	*National interop*	*VLAW31*	*National interop*
VFIRE22	*National interop*	*CLAW32*	*National interop*
PAGER	*Quick call paging*	*PAGER*	*Quick call paging*
FD DISPATCH	*Daily dispatch/ops*	*PD DISPATCH*	*Daily dispatch/ops*

APCO Project 25 Digital Use (P25)

Project 25 is a public-private partnership established in 1989 by government entities and the Association of Public-Safety Communications Officials – International (APCO) for the primary purpose of realizing the benefits of digital narrowband land mobile radio (LMR) technologies for public safety practitioners and other users. Public safety, government, and manufacturer representatives participate in the P25 process to develop voluntary consensus standards with the support of the American National Standards Institute (ANSI)-accredited Telecommunications Industry Association (TIA). The goal of P25 is to specify formal standards for interfaces between the various components of an LMR system, commonly used by emergency responders, to enable easy interoperability of radios and other components, regardless of manufacturer.[12]

Radios that use P25 enhance the usable range and intelligibility of radio transmissions, maximizing the coverage and use of a radio system. Further, P25 systems offer advanced features such as AES encryption and subsystem interface standards.

[12] NTIA Report 13-495

P25 utilizes software in the radio to digitally process and transmit voice traffic using a vocoder. The result is a standardized, manufacturer agnostic vocoder standard that enhances interoperability as the land mobile radio industry moves towards digitizing radio traffic.

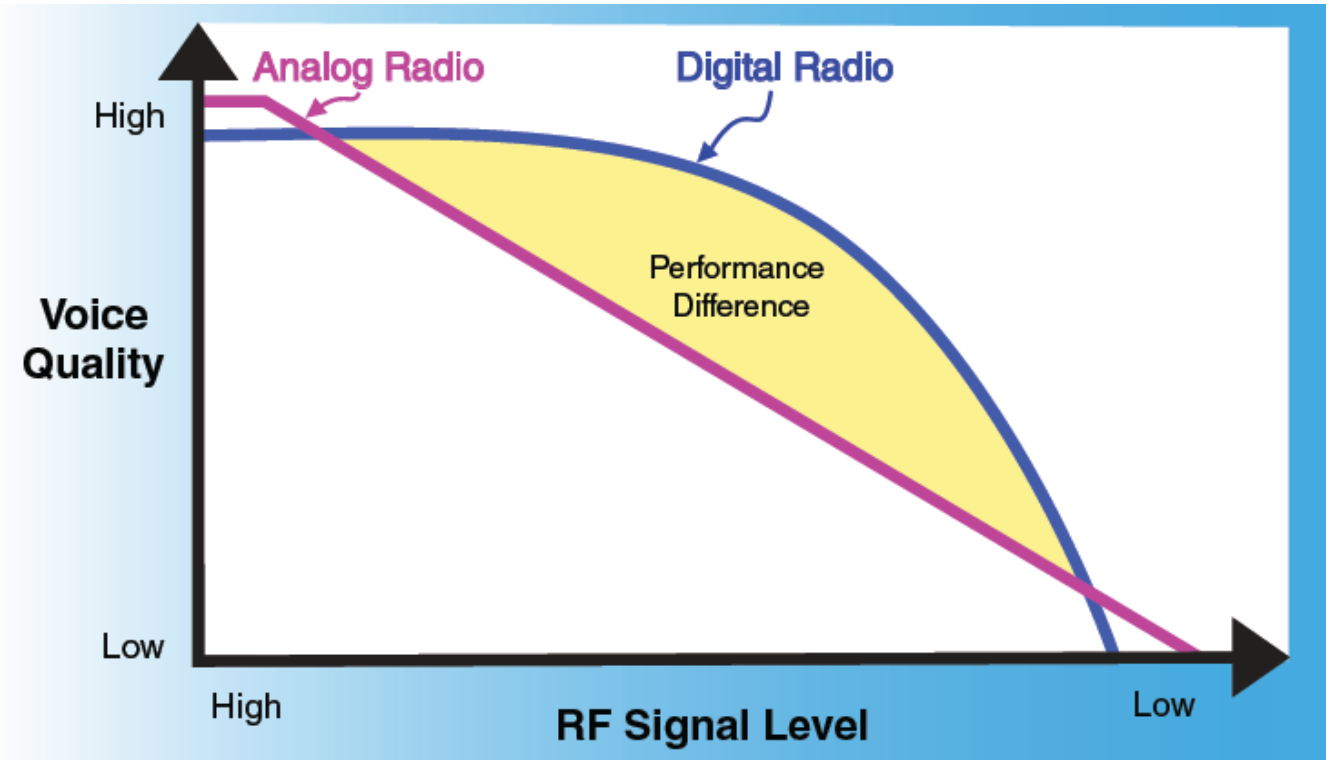
A radio's ability to communicate utilizing P25 channels is a best practice and is often a strict requirement of grant-funded equipment. The use of P25 for day-to-day radio systems is encouraged and is often found to relieve coverage and reception quality issues.

P25 Training

The use of a P25 radio channel is very similar to an analog (as the former Dukes system was) radio system. However, there are important performance factors that all users should be trained to understand and recognize such as coverage area limits and the effect of simultaneous transmissions.

P25 Coverage

P25 radios do not change the actual coverage area that a system covers; however, the usability of the covered area does change considerably. P25 radios use packets of data to communicate – if the packets arrive at the receiving radio, the audio is heard; if not, there is often nothing heard at all. This is a stark contrast to analog radios, which will become scratchy as the coverage decreases. Although this does yield a tremendous operational advantage, training should focus on the issue raised by this phenomenon where a user's radio may go from strong coverage to no coverage without the tell-tail 'warning' of static. Although digital radios provide a larger range of usable signal levels, the lack of advanced indication of signal level decrease allows users to get closer to complete loss of communication with less warning than analog radio.



Fire Service Use of P25

The ability to understand the digital radio transmissions has been a focus of many fire departments. After implementation of P25 digital systems, it was discovered that digital audio was not the same as analog, and the performance differences were most prevalent during fire operations. One of the most significant differences was attempting communications with a vibrating low air alarm or a PASS device alarming.

In 2007, the International Association of Fire Chiefs (IAFC) formed a working group to address potential problems with P25 digital radio. The working group consisted of fire service personnel, other public safety representatives, wireless radio manufacturers, manufacturers of fire apparatus and equipment, and consultants to address potential problems found in digital radios in the presence of loud background noise. This effort was funded jointly by the DHS Office of Interoperability and Compatibility, the National Institute of Standards and Technology (NIST) Office of Law Enforcement Standards, and the Federal Partnership for Interoperable Communications (FPIC). As a result of the findings of the IAFC workgroup, the National Telecommunications and Information Administration (NTIA) allocated resources to perform testing of the P25 vocoders in the firefighting environment. NTIA TR-08-453[13] was released in 2008. The report identified performance differences between digital and analog radios. As we move forward in time, technology continues to advance. Emerging technologies and new vocoders, such as the ones used in cellphone technology (4G Long Term Evolution (LTE)), required testing. In response to emerging digital voice technologies, additional testing was performed by the NTIA. NTIA report 13-495[14]documents the performance of the different technologies in the firefighting environment.

When P25 is used in settings where the background noise level is within limits set in the P25 standard, it provides usable audio. However, the P25 vocoder was not designed to operate in the high-background-noise environments encountered on the fireground. When the P25 vocoder was being developed, the designers tested the intelligibility of the digital audio with high ambient noise levels at the receiving radio. The P25 vocoder is unable to differentiate the spoken voice from the high background noise and assigns a digital value that does not accurately represent the voice. The result is unintelligible audio or broken audio with digitized noise artifact. Users of P25 radios have been affected by many common fireground noises. The SCBA alerting systems for low air or inactivity and PASS devices have made the audio transmitted from digital radios unusable. P25 radios transmitting from high-noise environments do not perform to the same levels as analog radios.

The effect of SCBA masks on the human voice was published by the Institute of Electrical and Electronics Engineers (IEEE) Communications Magazine. The testing in the IEEE article documents the effects of the SCBA system on voice intelligibility. Based on the testing, the conclusion was that "SCBA systems are frequently used by firefighters and other public service personnel who rely on

[13] NTIA Technical Report TR-08-453 Intelligibility of Selected Radio Systems in the Presence of Fireground Noise: Test Plan and Results,
[14] http://www.its.bldrdoc.gov/publications/2720.aspx.

speech radio communications to perform their work. The SCBA mask acoustically distorts speech, and the breathing system produces noises that can detrimentally affect speech communications, especially when a digital speech codec is used in the communications link. Both speech intelligibility and speech quality are detrimentally affected by SCBA equipment use."[15]

When on the fireground, communications are often very fast, and many users are trying to communicate simultaneously. This can result in simultaneous transmissions. Simultaneous transmissions can be a hindrance to fireground communications, and there is a difference between analog and digital. In simultaneous analog transmissions, the result is a warble-like tone behind the voice. The technical term for this is heterodyning or mixing of frequencies. In analog, the receivers can hear that two units are transmitting and can ask for a repeat of the transmission. In digital, if the two signals are equal in strength, the receiver may quiet due to a corruption of the data stream. This can occur in any digital simplex/direct or digital repeated system where access is not controlled.

Fire departments and other emergency service agencies have successfully implemented digital radio systems. However, fire departments around the country have reported difficulties with digital radios. Each instance must be analyzed individually for the cause. It is essential to understand the cause of the communications problem and either design it out of the system or avoid use of the technology when it does not meet operational requirements. This analysis should be done for any technology employed on the fireground. Studies performed by NIST, IAFC and portable radio manufacturers have supported the findings from the field users. When researching new communications systems, fire departments need to consider the performance differences between digital and analog technologies.

This is supported by NFPA 1221, Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems, (2013 edition). It requires a tactical analog channel for on-scene communications.

> 9.3.1.3 A communications radio channel, separate from the radio dispatch channel, shall be provided for on-scene communications.
> 9.3.1.4 At a minimum, the tactical communications channel identified in 9.3.1.3 shall be capable of analog simplex mode

When fireground noise of high amplitude is introduced, the voice translation ability of the P25 radio decreases and generates poor or unintelligible audio. These problems worsen when the firefighter speaks into the portable radio through an SCBA facepiece. Bone microphones, throat microphones and microphones in the facepiece minimize the interference caused by background noise by isolating the transmitted voice from background noise. Speaker microphones are subject to the same problems that are found with the microphone on the portable radio.

The configuration of the P25 vocoder is limited in its capability to translate the human voice in the presence of common fireground noise or through a facepiece. The studies performed by NIST and IEEE illustrate that digital radio intelligibility when talking through an SCBA facepiece is degraded.

[15] http://blog.tcomeng.com/index.php/digital-trunked-radio-system-problems/

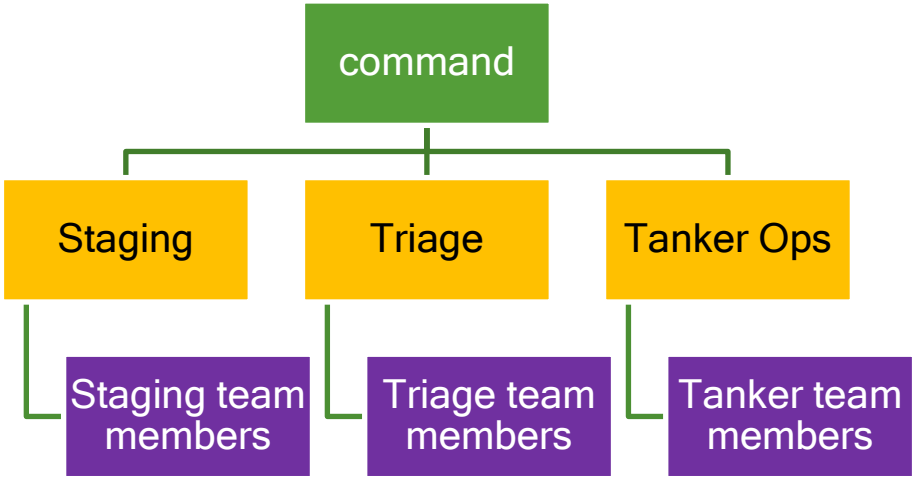
This can pose a safety hazard for fireground operations. To maintain safety, fire departments should consider using portable radios that incorporate analog modulation for operations where the firefighter is using an SCBA.

Radios using the P25 digital technology have performed well for other fire service functions, such as on emergency medical incidents and support functions on the fireground where an SCBA is not required, as well as law enforcement operations. The difficulties presented by the inability of P25 radios to produce intelligible voice messages in the presence of fireground noise is a significant safety concern and should be considered seriously by public safety radio system designers and users

Expanding, Critical, and Fireground Operations

Any operation that has expanded beyond an operation that is adequately handled by a single unit or more overtly utilizes the expanded set of incident command system roles should utilize a multi-channel communications plan to efficiently coordinate the response. These types of incidents should be preplanned where able and the focus of drills and training. A COML and COMT should be assigned as part of the planned response for any major incident.

No responder should routinely be expected to utilize more than 2 radio channels to operate in their positions. Each radio channel assigned to a role must have a dedicated radio – a radio's scan feature is not an adequate solution for monitoring multiple radio channels. Incident command positions should be able to communicate with the element they are responsible for and to the next higher command position. For example, suppose an incident is divided into multiple branches, divisions, or groups (divisions for the purposes of this example) where the individual division's radio traffic will exceed or interfere with the total operation. In that case, that division should be assigned its own channel. The division leader should be able to communicate on the radio channel assigned to the command network and to their division members.



Command	Radio 1: Command channel	Radio 2: Dispatch channel
Staging Officer	Radio 1: Command channel	Radio 2: Staging channel
Staging team	Radio 1: Staging channel	
Triage Officer	Radio 1: Command channel	Radio 2: Triage channel
Triage team	Radio 1: Triage channel	
Water Supl. Officer	Radio 1: Command channel	Radio 2: SAR channel
Tanker team	Radio 1: SAR channel	

The MVPSCS plan aligns with this best practice methodology.

Fireground Operations

Fireground operations are unique in their challenges, both operationally and technically. Each time a fire department operates on the interior of a fire building, the environment, firefighter position (generally horizontally positioned and crawling and the protective equipment worn, such as an SCBA mask, dictate and demand a special approach to communications planning.

Using simplex communications maintains positive communications between the IC, exterior on-scene, and interior units without relying on exterior communications systems. Maintaining positive communications is especially important in "mayday" situations. When users on simplex radios are deployed to the interior of a structure, they create a radio receiver network. As more and more radios move into the structure, the strength of the network increases. If Engine 1 calls mayday, the probability of another radio on the interior receiving the transmission is high. If the mayday is not heard by the IC, another radio operator on the interior can act as a human repeater to repeat the message to the IC. In addition, the number of radios in a structure creates redundancy, whereas reliance on a single repeater

or trunked system creates a single point of failure. Simplex communications allow direct communications with the initiator of the mayday and other crews on the fireground.
This means that no infrastructure is required to support receiving and transporting the fireground communications to the dispatch center, and without remote transmitters, the dispatch center cannot transmit to the fireground. When the radios involved in direct communication are portable radios, the communication distance typically is limited to a few miles; for mobile radios the distance can be 50 to 100 miles. Often referred to as "line-of-sight communication," which makes direct/ simplex radio communication most suitable for fireground use by units on an incident scene. The use of a simplex/direct fireground channel requires the use of a separate command channel. In this type of system, the dispatch center monitors the command channel, and the incident commander relays the relevant information received on the direct/simplex channel onto the command channel.

NFPA 1221 Standard for fireground operations:

> 9.3.1.3 A communications radio channel, separate from the radio dispatch channel, shall be provided for on-scene communications.
> 9.3.1.4 At a minimum, the tactical communications channel identified in 9.3.1.3 shall be capable of analog simplex mode

The MVPSCS plan is exceptionally well laid out to support routine daily operations and expand critical and fire incidents. Tactical repeated channels and simplex, analog assignable fire ground channels are available separate from the routine dispatch channel. These channels should be used as a matter of practice, and when multiple channels are used, multiple radios should also be used. Fireground channels should be assigned and used for most fires and closely coordinated with an on-scene COML familiar with the nuance of structural firefighting and other public safety operations to ensure the best plan and use of channels is safely implemented. The use of the dispatch channel for fire or critical incident tactical operations is discouraged.
Channel Use

The channel plan is well aligned with the best practices promulgated for police and fire/EMS operations.

Call signs (hailing)

The MVPSCS project promulgated the adoption of the general and universal use of "Control" when referencing the communications center to replace a legacy use of callsigns derived from the last 3 digits of the original FCC callsigns per discipline. I.E. 252 for fire dispatch and 860 for police dispatch. This better aligns with the national best practice of utilizing "plain language", especially where the MVPSCS operational plan now is dependent on the routine use of multiple channels. The use of control is conventionally used throughout New England and across the United States as a common name hailing call sign for the dispatch operations communications center for a jurisdiction.

Automatic Identification System (radio IDs)

A significant gap in the previous Dukes County system was the assignment and use of automated radio ID numbers. Radio IDs allow for the identification of radio during each transmission, and this enables radio users to be identified as well as other advanced features such as automated radio checks, radio stun, call alerting and emergency alerting.

The MVPSCS team has implemented a well-organized ID scheme for the P25 and analog network (MDC1200).

Emergency Button

There are many schools of thought regarding the use of radio emergency buttons. The position that the MVPSCS takes should contemplate effectiveness, training, technological barriers, and other environmental and operational challenges.

Fire, EMS, and Police Dispatch use of "Control"

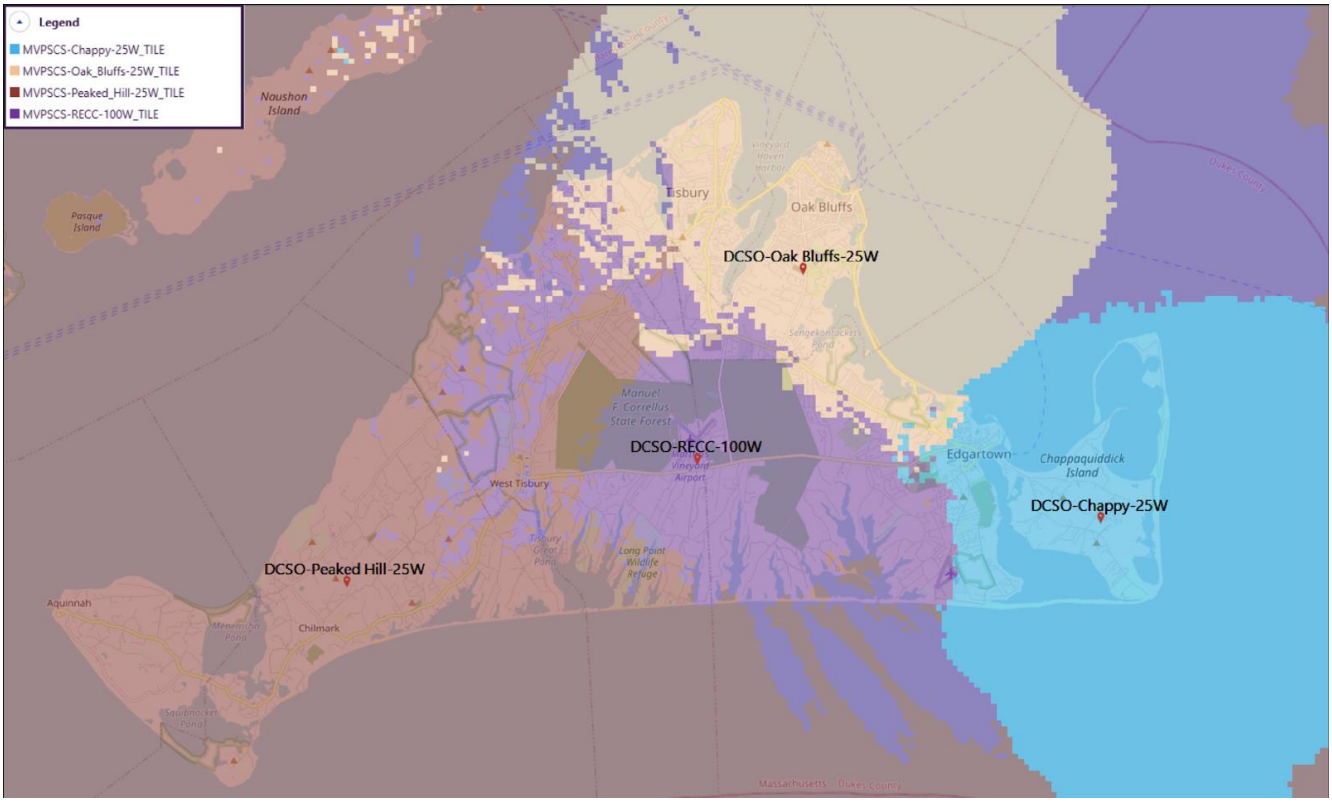
Although it is acceptable to use a singular hailing callsign for all disciplines, this practice can create a challenge in the communications center to easily aurally parse fire, EMS, and police radio traffic. If this is the case, the MVPSCS policy authority should consider changing the hailing call sign of fire/EMS operations and even perhaps Fire and EMS operations into separate callsigns. Commonly used callsigns include "fire alarm", "firecom", "medcom", or "Dukes Fire". Fire alarm is commonly used across the Commonwealth.

Equipment

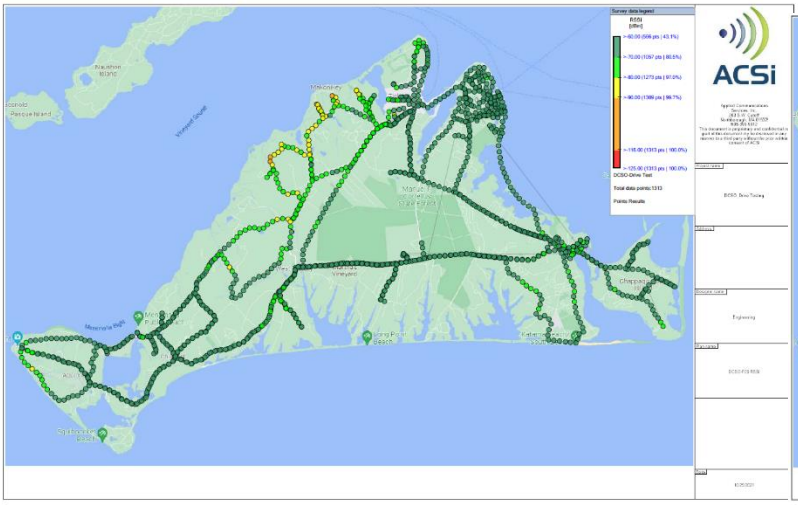
The MVPSCS system has been built utilizing public safety grade equipment and backhauled utilizing carrier-class microwave and fiberoptic networks. The system as-built enjoys a laudable level of redundancy and resilient design; however, the MVPSCS team should continue to endeavor towards full N+1 redundancy and diverse-path network topology. It is a best practice to utilize diverse network backhaul methods to all critical sites i.e., microwave and fiberoptic cable.

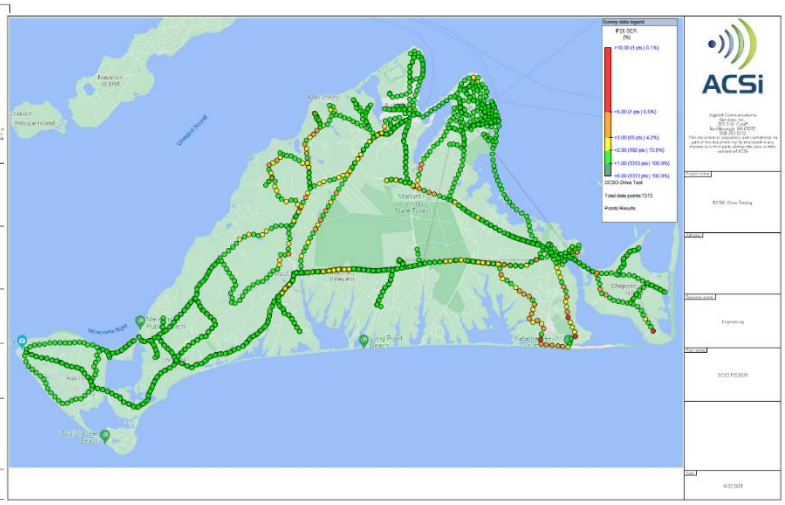
Deployment

The MVPSCS cannot be expected to have 100% coverage of 100% of the jurisdiction. The system design has exceptional theoretical and tested coverage. Theoretical coverage shows a considerable island-wide saturation for Martha's Vineyard, Cuttyhunk, Pasque, Penikese, and Naushon Islands.

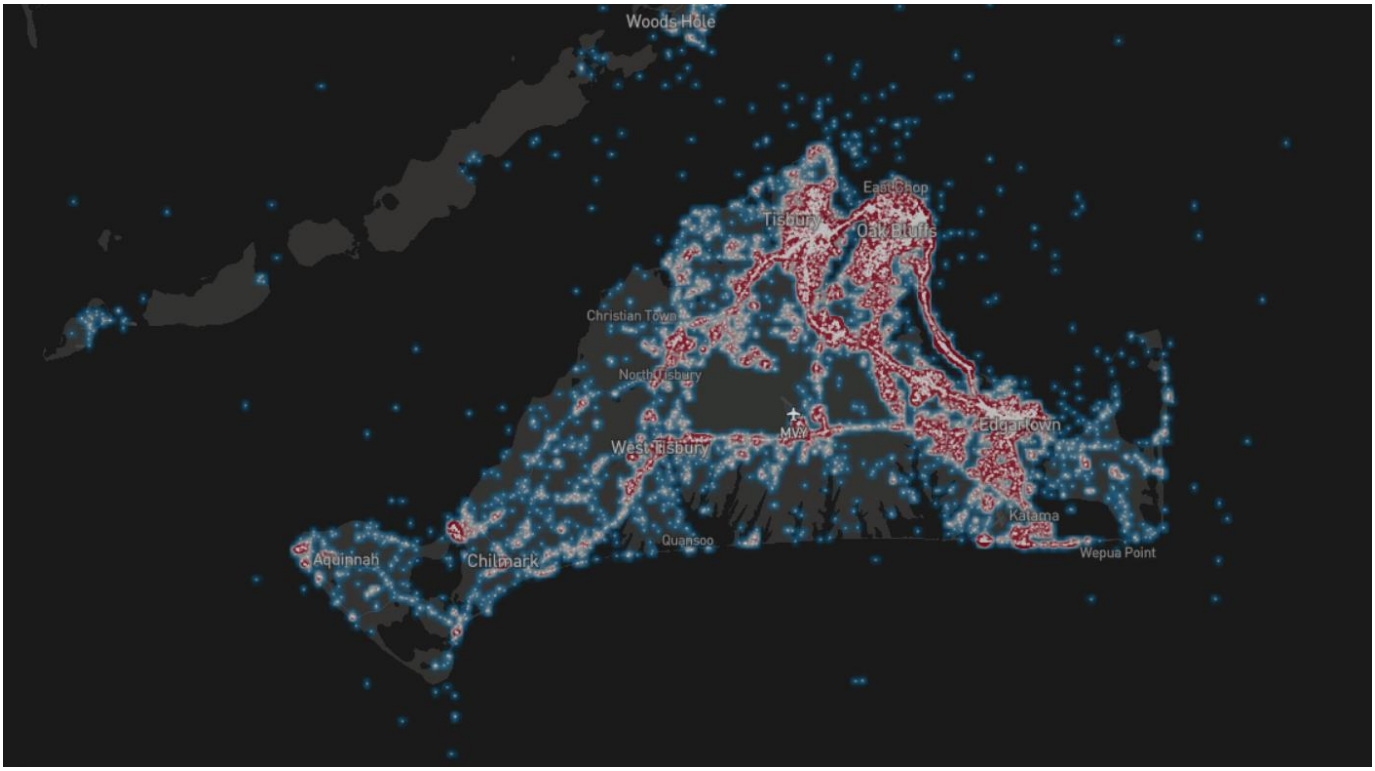


When examined against the drive test conducted by ACSI, this coverage appears to be validated in both signal strength (RSSI) and signal usability (bit error rate BER). These tests are limited to roadways and to not account for in-building coverage for specific buildings, but are a great test for identifying overt coverage flaws.





Although emergencies could happen at any location in the MVPSCS jurisdiction, the system appears to align with the coverage needs for the most common emergency locations. This was derived from geographically examining the 9-1-1 call volume compared with the coverage and drive test results. The results of the 9-1-1 geography study are viewable here:



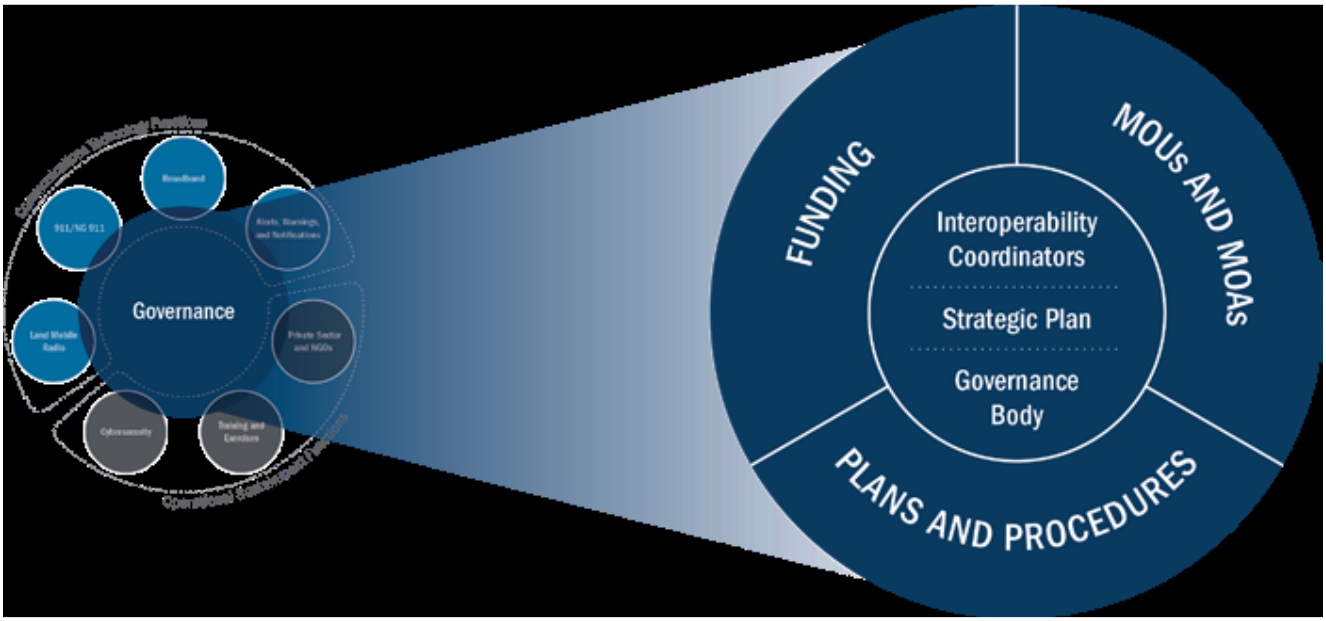
9-1-1 calls are geographically displayed based on the ANI/ALI location of landlines or GPS center point for wireless calls. Call data 2018-February 2022

Governance and Maintenance

There was a considerable investment made by the State 911 Department's Development Grant program as an award to the Dukes County Sheriff's Office due to its status as a Regional Emergency Communications Center. This project does appear to have been publicly supported and publicly opposed by various members of the public safety community throughout the county. This project was indisputably overdue, and the legacy system was beyond its reasonable service life and outside the parameters of what represents a defensible or safe public safety system. The system was constructed as a result of the state funding and seemingly thousands of hours of planning and coordination is not sustainable without a durable plan for system administration, maintenance and funding.

In an increasingly complex and interconnected emergency communications ecosystem, public safety agencies must consider the various functions and people that exchange information prior to, during, and after incidents. Effective communications require a partnership among response entities across all levels of government and disciplines to ensure the right information gets to the right people at the right time. A strong governance framework to plan, collaborate and make decisions brings together all relevant participants with a stake in emergency communications.

Cohesive governance structures representing the whole community will provide greater perspectives on emergency communications systems' strengths, weaknesses, opportunities, and threats. The recommended governance model should embrace a whole system approach to public safety communications- beyond just the radio system. Other elements such as training, exercise, data, alert warning, and interoperability should be included.



To achieve these programs, several foundational pillars need to be established:

- Governance body and authority
- Strategic planning
- Funding
- Plans and procedures
- Intergovernmental and interagency agreements

Governance models

The MVPSCS program appears to have a well-structured governance model operated under the Massachusetts General Law authorizing joint public services operations.

The MVPSCS governance model[16] achieves the cornerstone requirements laid down by CISA.

Funding

A sustainable shared, and equitable funding model for the maintenance, upkeep, administration, and upgrade of the new MVPSCS is imperative and has been promulgated to support this effort. As articulated in the MVPSCS governance agreement, funding is derived from a shared assessment amongst the system's user groups- the towns. Funding is held separately in a standalone state account and is marked for the exclusive use of this program.

[16] **COOPERATIVE AGREEMENT FOR EMERGENCY COMMUNICATIONS AND DISPATCH SERVICES**

Conclusion

The MVPSCS is a well-structured and well-executed update and modernization to a long-known, failing, multi-agency public safety communications system. The Martha's Vineyard and Dukes County public safety communities represent the best in interagency collaboration and regional resource sharing. This project is one of the best examples of how interagency collaboration and resource sharing can develop and provide systems that would likely be unattainable and ineffective or grossly inefficient if deployed independently. The MVPSCS system has utilized the limited resources available and reconfigured them effectively and well-aligned with national best practices in interoperability, public safety operations, system design, and technology. No system can be expected to be perfect, and the MVPSCS project is no exception to this, but the effort and care invested into this system are evident. Sheriff Robert Ogden's staff has completed a successful overhaul of the infrastructure for the radio system and promulgated governance, best practices, and a sustainable management and maintenance program. Aggressively pursuing grant funding through the Massachusetts State 911 Department's Regional Emergency Communications Center Development Grant program, a competitive statewide grant, the DCSO was able to secure the funding needed to make the multi-million-dollar investment into the MVPSCS project. That project ushered in a new era of advanced communications, resilient subsystems, and a complete replacement of infrastructure and subscriber equipment.

Key improvement areas and recommendations.

- Continue training and exercise efforts;
- Establish a full-time department or division within the SO with a Director or Commanding Officer to oversee technology and interoperability;
- Ensure the use of appropriate resources for specialized missions (i.e. direct analog fireground channels);
- Establish wireline connectivity to the radio system from the communication center console;
- Reevaluate dispatch and 9-1-1 policies to ensure mission efficiency and appropriate workflow accounting for the dramatic improvements offered by the new system;
- Establish diverse path connectivity to all mission-critical radio sites;
- Develop and exercise a system continuity of operation and disaster recovery plan;
- Continue and enforce the preventative maintenance plan;
- Develop a strategic plan for the implementation of emerging technology and system replacement;
- Identify additional funding sources for system maintenance, operation and administration to further dilute community contributions;
- Ensure participation in state and regional interoperability committees and councils such as the Statewide Executive Interoperability Council, the Southeastern Massachusetts Homeland Security Council Interoperability Committee, and the FEMA Region 1 Interoperability Consortium.