DRAFT

tusa

Harris County, Georgia

SUPPLEMENTAL REPORT TO 2017 REPORT

August 2022

1. Executive Summary

Tusa Consulting Services (TUSA), a radio consulting firm experienced in the field of public safety radio communications, was retained by Harris County, Georgia, to provide consulting services associated with the evaluation of the county-wide digital Terrestrial Trunked Radio (TETRA) communications solutions in 2017. TUSA's contracted scope of services included an assessment of user agency needs and recommendations for improving the overall performance and reliability of the TETRA radio communications configuration. A report was delivered to the County dated August 28, 2017.

This 2017 report included the following sections:

> Section A of this Report encompasses a detailed analysis of user interview processes, findings and identified expectations. Additionally, an overview of existing system equipment, site configurations and allied findings would be presented in a manner to facilitate interpretation of downstream conceptual solution paths.
>
> Section B includes conceptual system configurations that have potential for satisfying the goals and requirements identified in Section A. Each conceptual solution includes detailed coverage maps depicting portable radio on-street performance. A description of each configuration is provided as well as the pros and cons to help quantify the advantages and risks associated with the approach.
>
> Section C contains detailed budgetary cost information and probable timelines for the implementation of each Section B conceptual solution. Additionally, TUSA completed a life-cycle analysis for each configuration so that the County's executive and elected officials would have a meaningful feel for the costs associated not only for maintaining the system over a target period of not less than five years (or per County direction) but also for procuring a new radio network, if directed.
>
> Finally, in Section D, TUSA has provided guidance and recommendations on best practices that allow for the smooth integration of radio system improvements, enhancements and new technologies (and, of course, pre-requisite cost planning for such future enhancements).

TUSA was recently retained again to analyze the current system, and to refresh our recommendations that were made back in 2017. The County reported that the current system is still having the same issues that were reported back in 2017, except there are new issues, including audio quality, missing pages, and capacity concerns.

As part of our analysis, TUSA conducted site inspections with Dean Ginn of Dean's Commercial Two-Way. We visited all the sites to see if any of our recommendations were made from 2017. TUSA found all of those issues, that were identified in 2017, had not been addressed. We also discovered new issues, including but not limited to water intrusion at the Waverly Hall site and the monopole at Pine Mountain is leaning.

TUSA also revisited the propagation modeling from 2017 and updated it with the most recent land clutter data. The study showed that the current system still only provides marginal on street coverage but also poor in building coverage throughout the County. It should be noted that the existing TETRA system is designed for mobile radios and as such, was never meant to provide adequate in-building coverage as required by public safety professionals.

TUSA also conducted new user interviews with key stakeholders, including the Sheriff, Hamilton's Police Chief, 911, and EMS. Some of the more notable issues cited by radio users include:

Inadequate Radio Coverage – The primary area of concern communicated during the interviews was the lack of coverage being provided to support safe operations. The Sheriff's Office stated that coverage is spotty and getting worse. EMS related concerns about being able to call for back-up or law enforcement support if an unsafe environment is found on scene at a call. Fire services stated they are not consistently receiving pages which can delay services to the public.

Capacity – All users reported system busy alerts which are happening with increasing frequency. As the TETRA system grows and more radios are added, and as the County call volume increases, these delays in communications are a safety issue for both the public safety professionals and the citizens of Harris County.

Audio Quality Issues – Many users complained about audio quality issues. There are reports of voice traffic sounding robotic and others of garbled or missed audio. Users also indicted this is made worse during bad weather events.

Interoperability Issues – Users expressed concern about interoperability, particularly with neighboring Counties and GA State Patrol. Due to the more populated surrounding counties being on P25 800 MHz radio systems, Harris County's first responders do not have the ability to talk with radios that are UHF and not programmed for P25 operation. This affects everyone, particularly wide area users such as Sheriff's deputies and EMS which travels constantly outside of the County in performance of their duties. The Sheriff's Office stressed the importance for them to be able to talk to Georgia State Patrol which was lost when new consoles were installed.

Inadequate Radio Features – The user interviews revealed there were inadequate radio features. Many users expressed that their radios were lacking feature sets that can be found on modern radio systems. For example, users stated they wanted features like AES encryption, emergency button, stealth mode, display screens, and GPS location. Many radios were not rated to survive in driven rain or watery environments which is common in public safety.

These shortfalls cannot be fully resolved within the current radio infrastructure configuration. Additional tower sites are required to improve coverage reliability/audio quality – a fact supported by supplied coverage modeling that considers fully mobile radio and hand-carried portable unit on-street, residential and in-building operations.

TUSA stands by the original recommendations made in 2017. Harris County is going to have to invest in upgrading the current TETRA radio system owned by Diverse Power, or invest in a new standards based Project 25 radio system. Project 25 is the public safety standard that many counties throughout Georgia are migrating to. To this end, this report provides conceptual radio configuration solutions for Harris County's consideration. These configuration takes into consideration future growth, emerging technologies, and are structured to support coverage/capacity needs for a 15+ year life cycle. The Report also includes procurement / sustainment budgetary estimates, leveraging fresh information gleaned from recent P25 radio system procurements throughout the United States. The conceptual solutions presented:

- Expanding the current TETRA system
- Building a new standalone P25 system
- Joining a neighboring P25 system

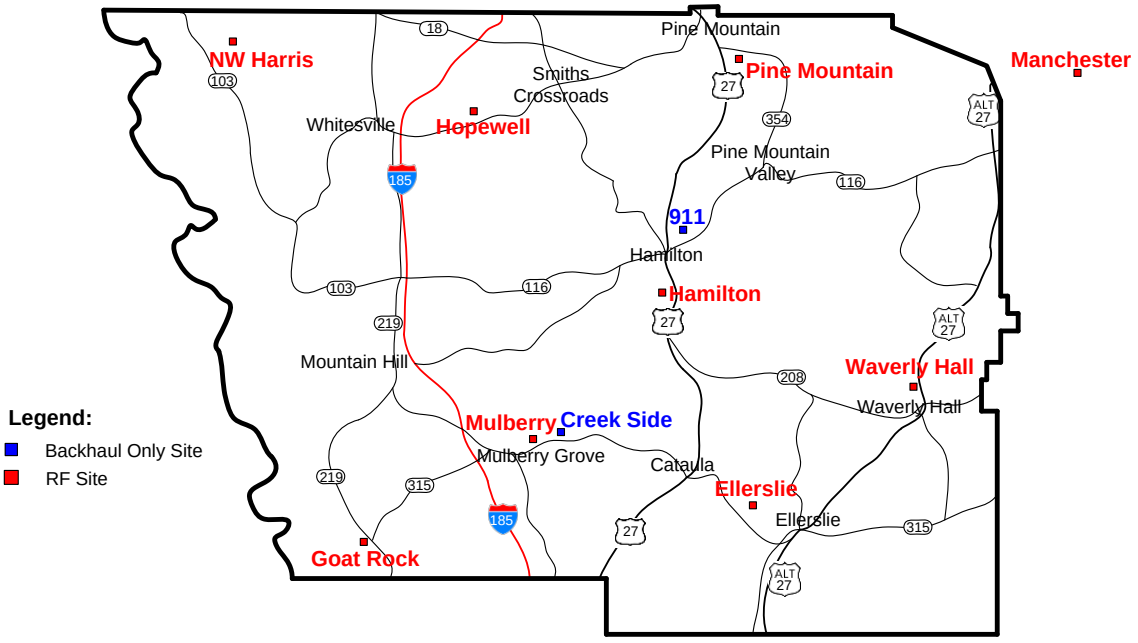
These conceptual solutions each directly address the audio quality, coverage, interoperability, and inadequate radio features identified in the report. These solutions also are designed to provide

additional redundancy required by counties that may experience complicating situations such as to protect from tornados, hurricanes and other extreme weather.

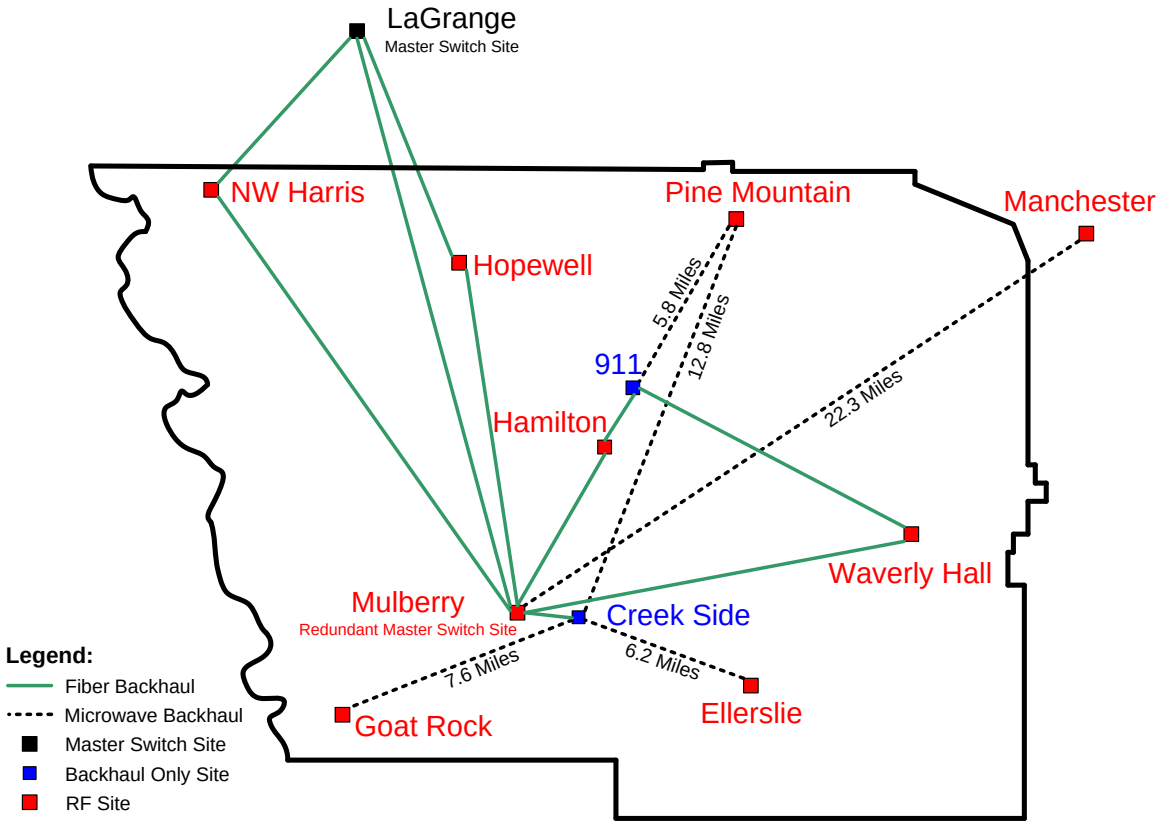
2. Existing System Configuration

The existing system configuration has not changed since the 2017 report and was described as follows:

The existing radio system used by Harris County public safety personnel is a non-simulcast UHF TETRA radio system owned by Diverse Power EMC. Coverage to the county is supported by nine base station tower sites and two backhaul sites. The configuration's master site is located outside the county in LaGrange GA. Six of the nine sites are using FCC Part 22 frequencies (former common carrier paging and radio-telephone channels), the other three sites are FCC Part 90 frequencies as used for public safety/local government and commercial business operations.



Backhaul configuration to the Master site in LaGrange is accomplished through microwave and above ground fiber links as shown:

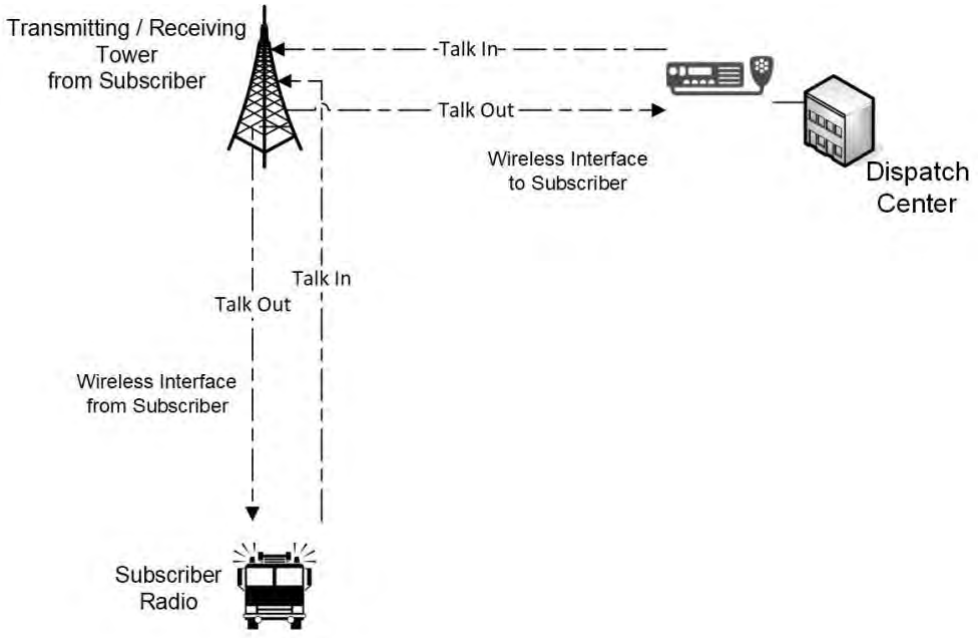


As part of the supplemental report, TUSA updated the existing coverage maps to include municipal boundaries with an additional one (1) mile boundary outside the county which is added to allow for anticipated growth in these areas. This allows the County to see not only how coverage is spread throughout the County but also the likelihood of inbuilding coverage in population centers where buildings are more likely to exist. In making this adjustment, the overall coverage of the bounded areas changes from the 2017 report as coverage outside the county but inside these areas is included.

TUSA also utilized the latest land and building data for coverage analysis. Updated coverage from prior systems that were built and tested has also been added to the coverage calculation making the coverage and propagation tool more accurate. These updated data sources result in more accurate coverage predictions for Harris County that was available in the 2017 report.

When reviewing the following coverage maps it is important to note, when a call is placed on the radio system, a transmitting channel is enabled, and the voted receive audio information is rebroadcast from the transmitter site. The resultant transmitted coverage is termed talk-out as the tower sites are then communicating out to distant mobile and portable subscribers.

Likewise, the receive path from field subscriber-unit to tower sites is termed talk-in coverage. Here in the talk-in path for the County's UHF radio system, each of the respective tower sites receives the incoming user portable radio's signal at differing levels and audio clarity/quality. Each subscriber operates on a designated voice communication channel that is a pre-configured frequency.



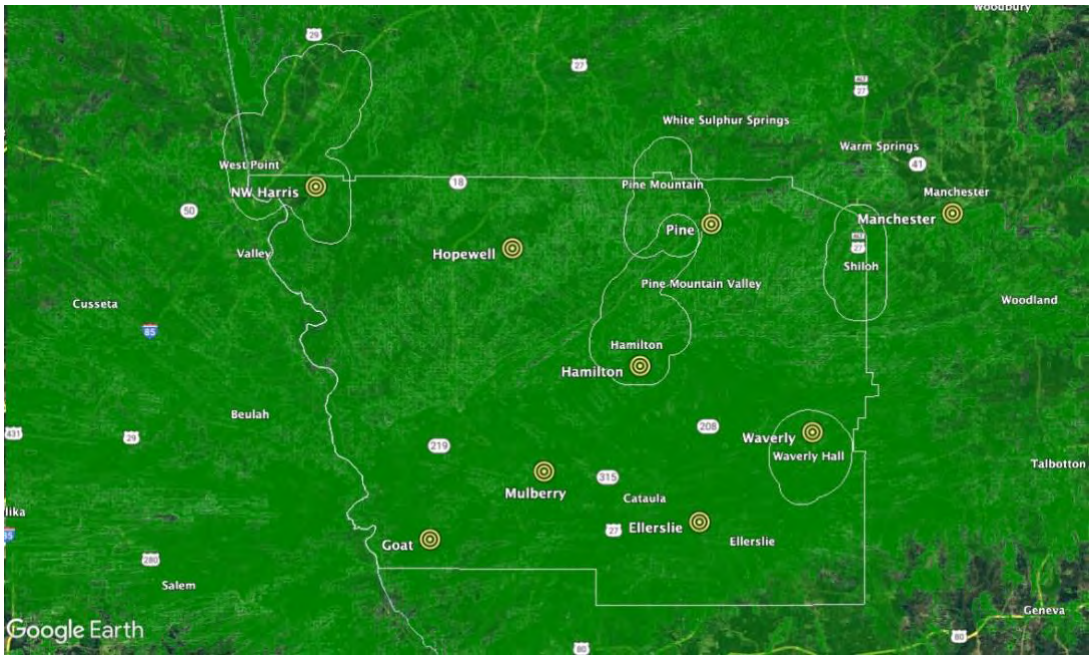
Since the power from the tower is much higher than the power from the mobile unit and both are higher power than a handheld unit, balanced talk-in, talk-out coverage is more difficult to achieve without tower top amplifiers, leaving users in areas where they can listen to dispatch but dispatch cannot receive the user's transmission.

The following coverage maps illustrate predicted portable radio talk-in and talk-out on-street performance, as well as within building structures whose losses are 12db (House, strip mall, or

small business) and 20db (Industrial building, large warehouse, or Walmart). Hospitals or other types of dense building layouts can typically exceed 20db.

As always, in evaluating the current TETRA system it is important to understand that the current state of the radio system is affecting the functional performance of the system even today. Numerous problems at these sites and poor radio maintenance are understood to be adversely affecting the ability of the radio system to provide a proper level of portable unit coverage to significant portions of the county. If the current radio system configuration was running at peak performance, the predicted coverage for mobile and portable operations would be as follows:

Mobile talk-out coverage (tower site to user mobile unit).

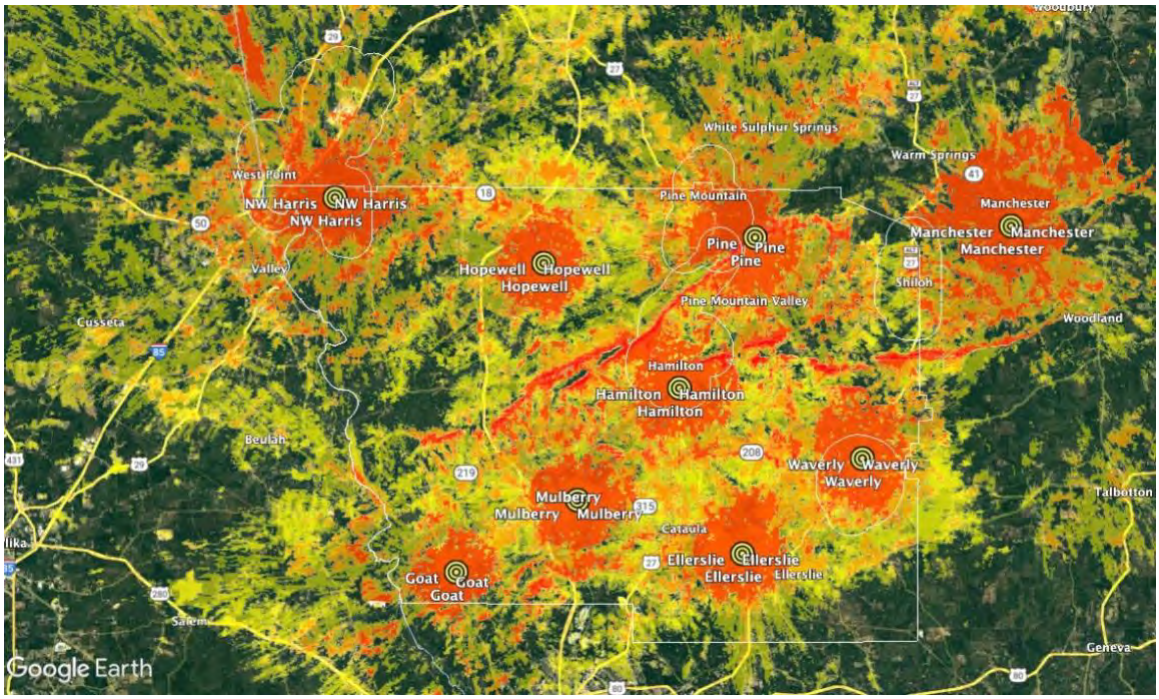


Mobile talk-in coverage (user mobile unit to tower site).

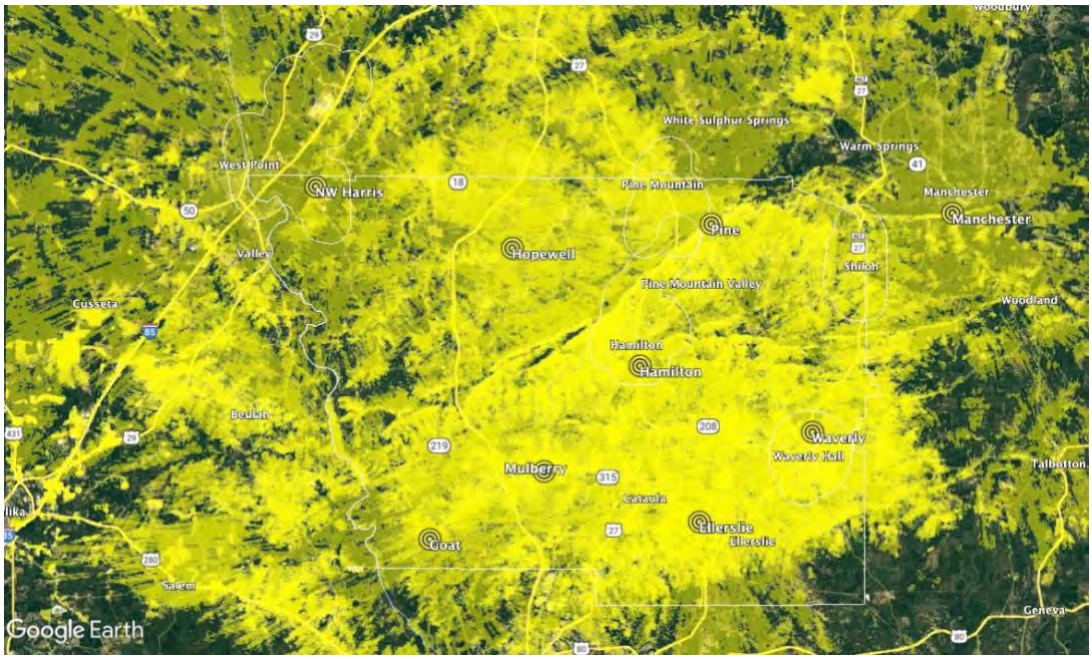
Coverage calculations for mobile radio users result in greater than 99% for both mobile talk in and mobile talk out coverage. For those users that operate exclusively out of a vehicle, this County-wide coverage would be more than sufficient assuming all equipment was in proper working order. Since most public safety professionals must leave their vehicles in operation of their duties, the following coverage maps are more indicative of the coverage these users experience.

Existing portable radio coverage is the most concerning due to the lack of inbuilding penetration. The following heat map shows an overlay of all portable talk-in colored based on the ability of the user to reach a tower given a level of density of a building.

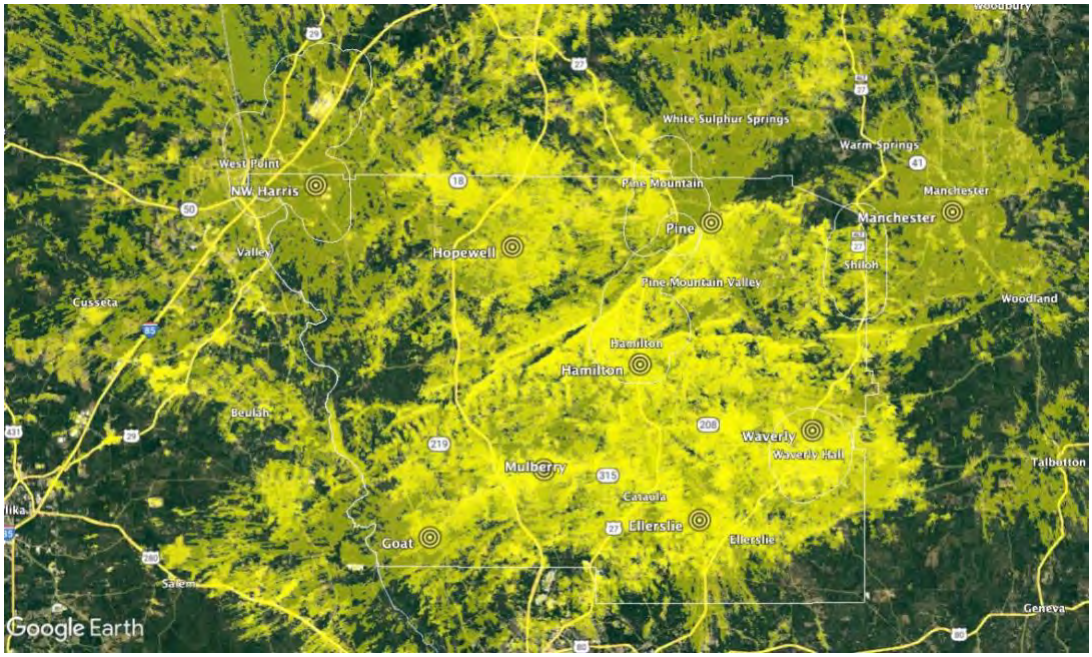
- Yellow represents a user on a portable radio on the street
- Orange a user on a portable radio in a light industrial or residential building, and
- Red a user in a heavy commercial building, school, jail, factory.



The next set of maps show each of these categories displayed independently. At the request of Harris County, zoomed in maps can be created of municipal areas or specific areas of the County.



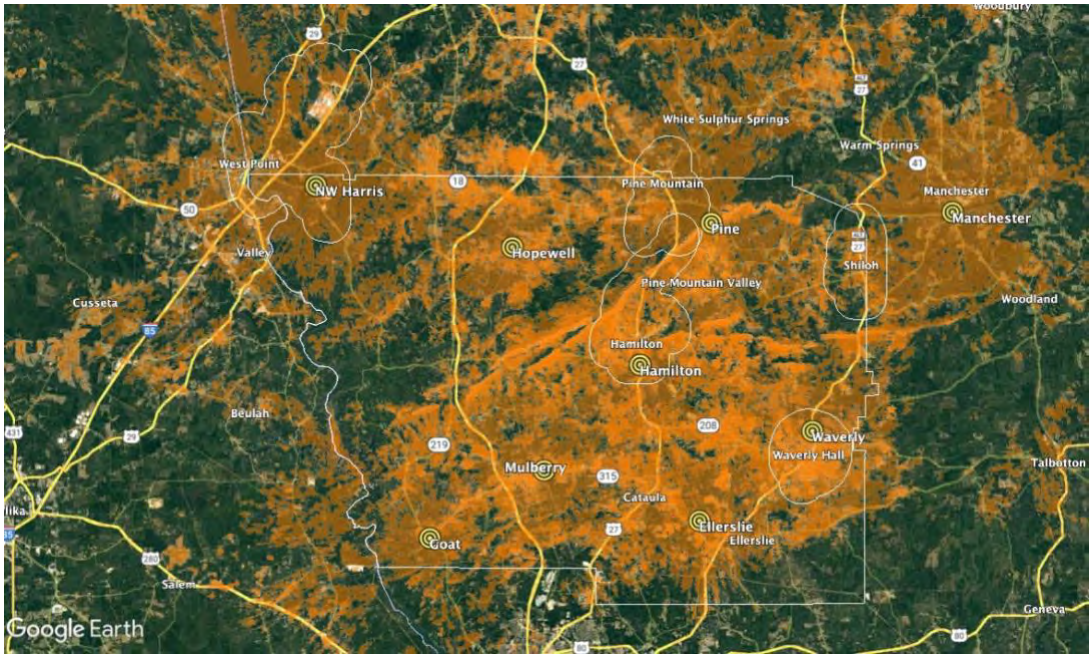
On-hip/On-street portable radio talk-out coverage (tower site to user portable unit).



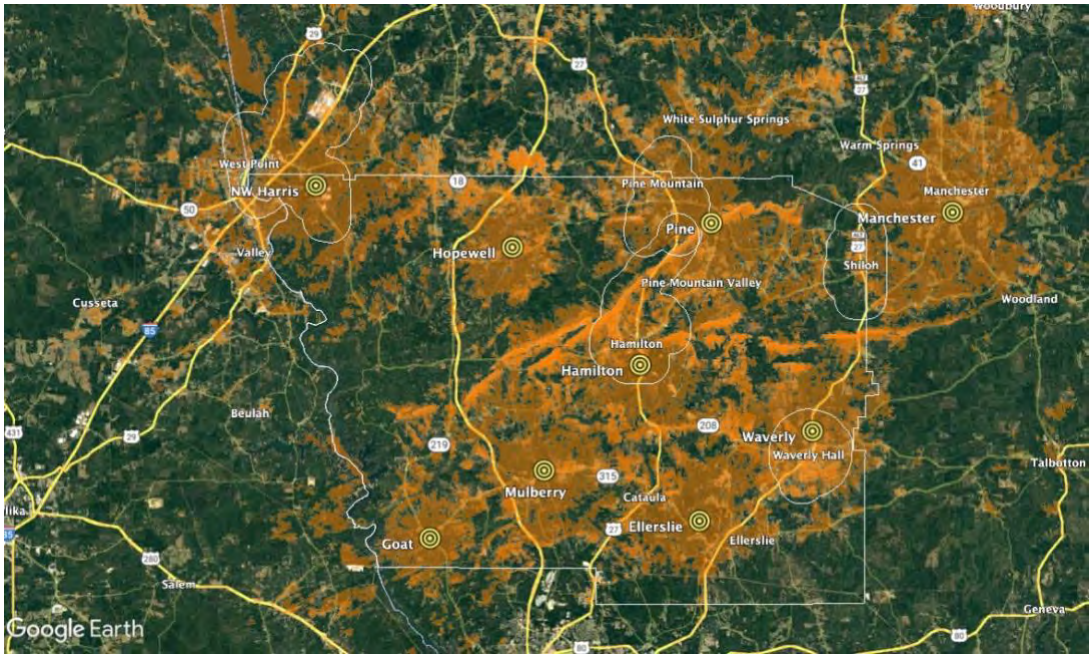
On-hip/On-street Portable radio talk-in coverage (user portable unit to tower site).

Comparing these two images, the imbalance in coverage is easily seen. Users in the field have far less coverage than is available to dispatch who is transmitting with the higher powered transceiver at the tower locations.

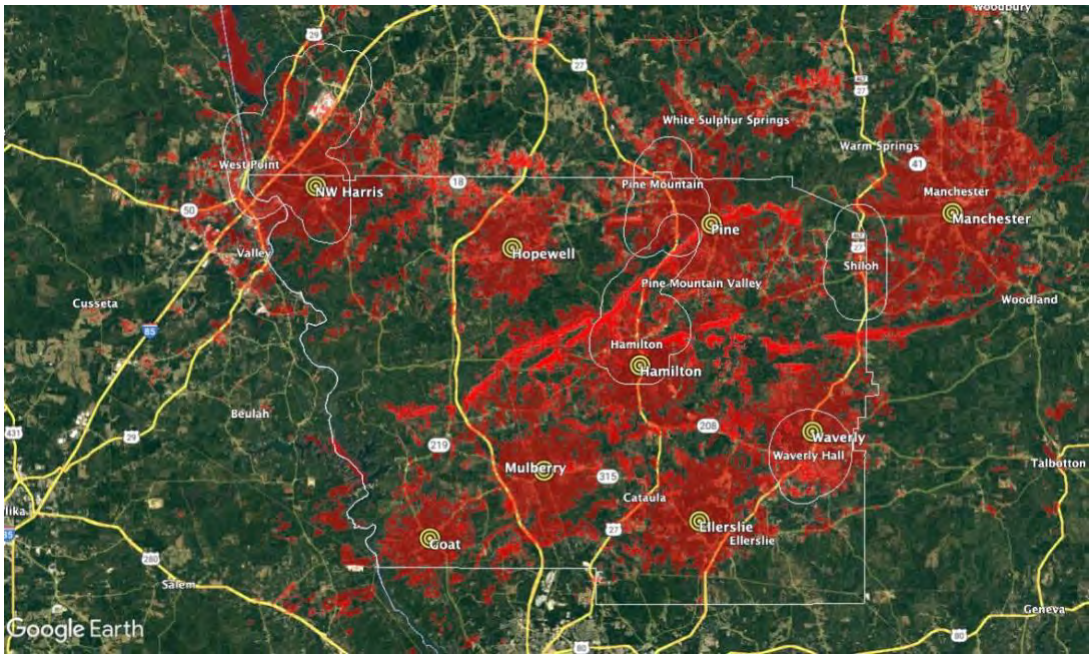
Portable radio coverage within building structures places even more demands upon the radio system's performance capability. As an example, portable radio talk-out coverage (tower site to user portable unit) into light industrial buildings, convenience stores, or residential homes.



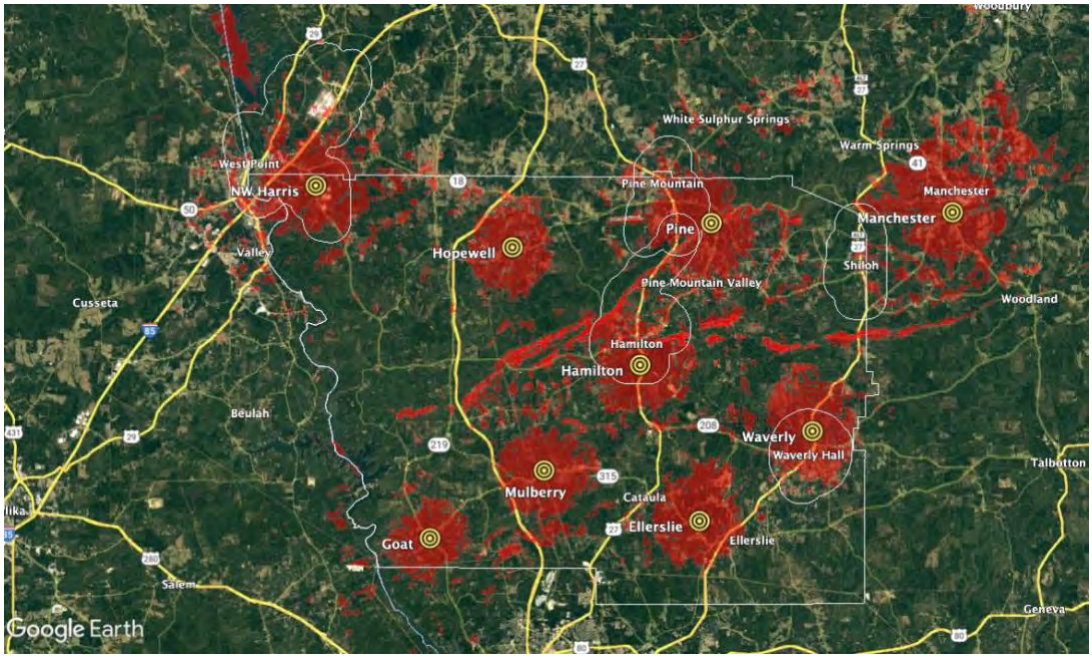
Portable on-hip talk-out coverage (user portable unit to tower site) from light industrial buildings, convenience stores, or residential homes.



Portable on-hip talk-in coverage (user portable unit to tower site) from light industrial buildings, convenience stores, or residential homes.



Portable on-hip radio coverage within dense building structures including schools, jails, county administration buildings, or large commercial buildings is essential to public safety. The figure above shows portable radio talk-out coverage (tower site to user portable unit) into dense buildings.



Portable on-hip radio coverage within dense building structures including schools, jails, county administration buildings, or large commercial buildings is essential to public safety. The figure above shows portable radio talk-in coverage (user portable unit to tower site) from dense buildings.

Coverage as a percent of the defined boundaries is calculated as follows:

	MTI	PTI	PTI 12db	PTI 20db
Harris County	99%	84.8%	-	-
Hamilton (+1 mile)	99%	97.8%	82.1%	64.5%
Waverly Hall (+1 mile)	99%	99.5%	91.4%	73.5%
Pine Mountain (+1 mile)	99%	97.0%	86.8%	60.0%
Shiloh (+1 mile)	99%	77.6%	39.4%	15.1%
West Point (+1 mile)	99%	84.6%	64.6%	43.2%

*Highlighted items indicate coverage below minimum acceptable limit.

For coverage to be considered acceptable for public safety use, county-wide portable outdoor coverage would be a minimum of 95% and indoor coverage inside the municipal bounded areas would also be 95% with 12db of loss expected for light industrial buildings, convenience stores, and residential homes.

As stated previously in this report, these coverage predictions assume all equipment both that the sites and in the field in use by public safety personnel is in proper working order. Since is it known that this is not the case, it is noted by users that actual coverage falls short of predicated coverage which would worsen these already subpar coverage numbers.

Given that no improvements have been made to the system since the last report and given the above coverage study and map presentations, it is clear that the current radio system's configuration is able to provide balanced coverage for only mobile unit operations. However, the system's configuration lacks necessary talk-in path balance for effective portable radio operations. Such a system is operationally dangerous for public safety portable-equipped users because while they may be able to hear communications from the various tower sites, the probability is high where they may not be able to respond (i.e., talk-in) to dispatcher calls or to request assistance. The system also fails to provide adequate inbuilding coverage especially in municipal areas where more dense buildings are to be expected.

3. User Interviews

The following are comments and concerns reported during user interviews conducted in 2022. Prior user interview results are available in the TUSA report dated 2017.

In both 2017 and 2022, prior to performing its coverage assessment, conceptual solution development and a radio modernization plan recommendation, TUSA first performed on-site user agency interviews to assess the suitability of the current radio systems, benchmark user expectations and to further identify areas whereby functional/operational improvements were needed. TUSA and these users/project stakeholders spent approximately 1 hour discussing key issues that the respective users had with the current system as well as discussing input each had on what they would like to see in the new system. New information from the 2022 interviews is as follows:

3.1. USER INTERVIEWS

TUSA conducted User Interviews with the following agency/departments:

- Harris County EMS
- Harris County Sheriff's Office
- Hamilton Police Department
- Harris County 911

To structure the user interview meetings to be as informative and efficient as possible, specific questions asked of the interviewees addressed the topics listed below:

- Operation Overview
- Forms of communications
- Cellular Coverage
- Radio Inventory
- Radio accessories such as portable speaker microphone
- Radio system(s) frequencies
- Encrypted Voice needs
- Radio Channel Congestion
- Radio Coverage Needs (critical buildings)

3.2. IDENTIFIED USER NEEDS

Different agencies and departments often have different perceptions of how a radio system performs. For example, the Sheriff's deputies or County EMS might have the best "big picture" view because they travel all over the county. These users are more aware of wide-area coverage challenges. A local fire department however might have problems with in-building portable radio performance due to poor coverage, or there are communications challenges when on mutual aid calls.

Dispatch center operations might be hampered by inefficient/obsolete equipment, or ergonomic issues, or be short staffed. All of these unique items, feed into what the user actually needs. This allows TUSA to develop a "picture" of how the radio system performs from the user's standpoint. The results of the online questionnaire and user interviews can be summed up into the following categories and priorities:

- Coverage

- Capacity
- Audio Quality
- Interoperability
- Inadequate Radio Features

COVERAGE

The common area of concern communicated during the interviews was the lack of coverage being provided to support safe operations. The Sheriff's Office stated that coverage is such that "5 people can be standing in the same room, and only one radio will receive the incoming voice traffic." They also stated

- inbuilding coverage is much worse than on street coverage and often is unreliable.
- There have always been dead spots, but they seem to be getting larger and more frequent.

EMS stated they cannot talk in the outer portions of the county including the river on the west side. With increased call volume the noticeable areas with poor coverage have become more problematic. They also expressed concerns that the radio system seems to perform worse during storms, a time when call volumes tend to increase. Concerns for personnel safety as "unstable persons" may require assistance, but EMS cannot reach dispatch to request back-up.

Hamilton Police reported that coverage inbuilding is poor and calling radio to radio is "a big waste of money." Coverage improvements are needed to properly carry out the public safety mission.

While there are no formally outlined minimum standards for either coverage or capacity for a Public Safety radio system, the objectives defined by TUSA for coverage and capacity follow those generally employed by best practices in the industry. Specifically, any potential solution should provide no less than 95% countywide portable, on the street coverage with a Delivered Audio Quality (DAQ) level of at least 3.4, and no less than 95% coverage county-wide on-street / on-hip, also at DAQ level of 3.4. Critical coverage areas are those other than wetlands, forests, and agricultural environments.

Today, portable radio coverage deficiencies are reported to exist in certain areas of the County and are clearly visible in the portable radio talk-in/talk-out coverage maps contained later in this Report. The majority of the performance shortfall is noted in multiple areas throughout the County. These shortfalls are likely amplified by the lack of preventative maintenance not being performed at all levels of the system; antenna systems, rf equipment, and radio equipment.

Of serious concern are reports that the Manchester site is connected to the network via a cellular modem rather than a hardened, licensed microwave hop or fiber line. This has reportedly been the case for some time. Cellular networks are not hardened against failure in the same way as a modern public safety radio system and it would be likely this connection will fail during peak call times or poor weather. These failures during a storm are reported by users as the radios enter a "fail soft" mode separating the users from dispatch and users on another tower until the connection is restored.

Lastly, Fire services report they are not getting pages with any consistency and are concerned that a missed page may mean losing valuable time when responding to a call.

As part of Phase 2 Request for Proposal (RFP) Procurement process, TUSA would be working with Harris County to further define the coverage parameters and critical areas that will be featured in the RFP specification. This will come after the County reviews our conceptual

solution presented in this report and determines what option best suits their desired level of coverage, feature performance, reliability, and interoperability. The goal is to find the best option that serves the public safety users of Harris County. This goal comes with a budget the County can support and still meet the needs of the user. We have presented our recommended coverage solution in the conceptual designs of this report that is based on the coverage needs expressed by the users and required by the critical building needs in the County.

CAPACITY

Minimum capacity requirements are defined as better than a Grade of Service (GOS) 1%, which is statistically defined as less than 10 in 1,000 calls could be delayed as a result of insufficient system capacity and the delay itself, should not exceed 0.5 seconds.

All users interviewed reported frequent and lengthy delays on the current system. With the number of user radios across the entire TETRA system growing, and with no administrative rights to ensure the best possible GOS for public safety users, there is no easy fix for this issue on the current system. Additional channels are required and the need to dedicate them to Harris County in order to improve the GOS.

Hamilton Police reported that with the increase in call volume, more capacity was required regardless of how the County proceeds with the next evolution of radio system.

Lastly, capacity of the service team is also a suspected issue. With Dean's Two Way performing more service in a much wider area, his team is spread thin. During a reported system outage or wide spread system issue, Dean Ginn's team, who has been a good partner to the County for many years, will have their attention divided across many counties and many agencies trying to restore service. This may result in extended outages or issues moving forward.

AUDIO QUALITY

Audio quality was another common issue identified by the user community. EMS reported difficultly understanding dispatch voice calls but were uncertain if it was due to the radio network or new consoles and training/turnover. The Sheriff's Office reported robotic sounding calls which made understanding voice calls more difficult even in areas where there was known coverage.

TUSA will address the audio quality concerns of the users when the RFP system procurement specifications are crafted, which require vendor-demonstrated reliable communications and performance. The eventual RFP Specification will also include a verifiable maintenance program to include yearly health checks and preventative maintenance of the system. Such maintenance would include transmission line sweeps, power level settings, and a host of other industry best practices that are necessary for the proper maintenance and sustainment of a radio system. This program would ensure software and hardware upgrades are identified in the overall lifecycle and maintenance program. The cost for this level of maintenance is captured in our Report's budget, as necessary to maintain the system for a typical 15-year period.

INTEROPERABILITY

Users expressed concern about interoperability given that few other surrounding counties and no state agencies operate on the UHF TETRA system. Right now, Harris County is extremely limited in their ability to communicate with the surrounding counties.

Harris County lost the ability to communicate with GSP when switching from DGNA consoles to Telex. They also lost the ability to send alpha numeric pages.

While TUSA addresses interoperability and operability later on in this report, we also want to discuss it here. P25 radios can be equipped/programmed to talk to surrounding P25 systems as well as state and national mutual aid channels. Use of other P25 systems does require mutual aid agreements and standard operating procedures (SOPs) to be developed between departments but often these agreements benefit both parties and are welcomed.

There are also other interoperability solution available as well, but those will ultimately be driven by cost. (i.e., multiband radios, Interoperability Overlays, control stations, cache of Radios, etc.). If Harris County remains on the UHF TETRA system, gateways and extra radios will be required to bridge the interoperability gap. Connecting directly or communicating directly to the P25 systems or other types of radio networks around you will assist with the audio quality issues.

INADEQUATE RADIO FEATURES

During the interview process, users expressed that their radios are lacking feature sets that can be found on modern radio systems. Modern P25 radio systems and subscribers have a majority of these features as standard, though these features may add complexity to the use of the radio.

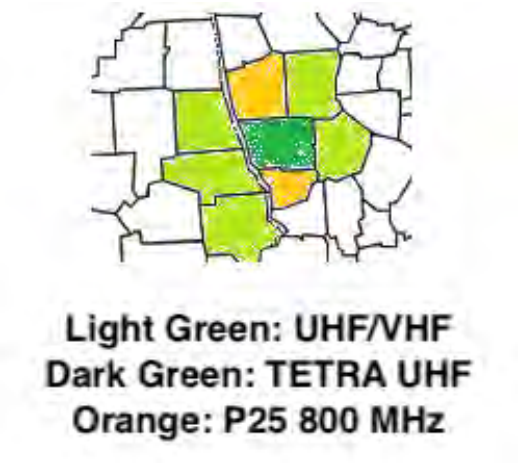
- Emergency Button with GPS
- Stealth Mode for undercover operations
- Extended Battery Capacity
- AES Encryption
- Man Down
- Voice Annunciation
- Weather Resistant/Immersion Capable Radios
- Speaker Mics
- Heavy Duty Clips
- Unit IDs

4. Identified Interoperability Requirements

Based on the user interviews conducted in 2017 with the different agencies the following list delineates the interoperability requirements for Harris County.

Chambers County, Alabama:

- Sheriff VHF
- County Fire UHF
- EMA VHF/UHF



Troup County, Georgia: P25 Phase 1 800 MHz

- Sheriff
- County Fire
- West Georgia Medical Center UHF
- West Point Fire
- West Point Police

Meriwether County, Georgia:

- Sheriff VHF
- County Fire VHF

Lee County, Alabama:

- Sheriff VHF
- County Fire VHF
- EMS VHF
- East Alabama Medical Center HEAR VHF
- Alabama First Responder Network P25 800MHz (single tower in Opelika)

Talbot County, Georgia:

- Sheriff VHF
- County Fire VHF
- EMS VHF

Muscogee County, Georgia: P25 Phase 2 800 MHz

- Sheriff P25 800MHz
- County Fire P25 800MHz
- EMS P25 800MHz
- Columbus Fire P25 800MHz
- Columbus Police P25 800MHz

Georgia Forestry and Georgia Department of Natural Resources

5. Site Survey Results

A detailed list of site comments and issues is located in the TUSA report dated 2017. The following is an excerpt and still valid as of this supplemental report:

> Serious problems in both construction and in the way the sites are maintained, which were:
>
> 1. Lack of an ice bridge at various sites, thereby exposing feedlines to environmental damage,
>
> 2. Cabling workmanship that does not meet industry standards,
>
> 3. Lightning protection systems improperly installed,
>
> 4. Lack of radio site fire suppression systems,
>
> 5 Absence of appropriate transmission line entry seals,
>
> 6. Structural issues with shelters,
>
> 7. Towers with structural issues,
>
> 8. Tower guy wires at risk due to potential falling debris,
>
> 9. Improper equipment rack grounding,
>
> 10. Lack of a Master Ground Buss Bar installation,
>
> 11. Improperly installed or missing external grounding ring,
>
> 12. Lack of appropriate cable runway systems.

The sites reviewed as part of both the 2017 report and the 2022 supplemental report include:

- Ellerslie Tower Site
- Goat Rock Tower Site
- Hamilton Tower Site
- Hopewell Tower Site
- Manchester Tower Site
- Mulberry Tower Site
- Northwest Harris Tower Site
- Pine Mountain Tower Site
- Waverly Hall Tower Site
- Creek Side Backhaul Site
- 911 Backhaul Site

None of the recommended improvements from the 2017 report were observed during the 2022 site surveys. As part of Conceptual Solution #1 – TETRA System UHF – Expansion, money is allocated to updating these sites and towers to bring them up to standards for a public safety system. Should it be determined this is not possible on a given tower after analysis by a structural engineer, then a new tower will need to be located/built at additional cost.

In addition to the issues reported in the 2017 TUSA report, the following new concerns were documented:

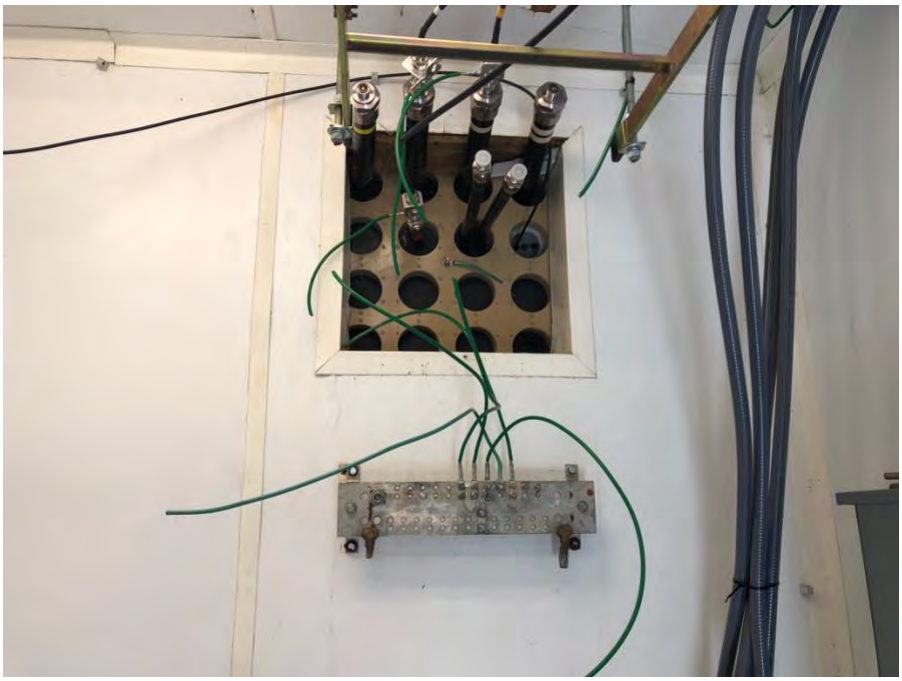
Many of the sites did not have sufficient back-up power to keep the system running in the event of a commercial power outage. The Hamilton site was without a UPS and the Pine Mountain site UPS was displaying a error. With no UPS or faulty UPS, should a generator fail to start at sites that even have a generator, the sites would not be available further decreasing coverage in the County.

The monopole at Pine Mountain was visibly leaning. This site should be inspected by a structural engineer to determine the best way to straighten the pole. Misalignment of the antennas, as a result of the pole leaning, can negatively impact coverage supplied by this site.

The Mulberry site is directly adjacent to a power substation, which can cause a higher-than-normal noise floor and negatively impact coverage. Noise floor measurements should be taken at this location to determine if this site is problematic and if it can be reused in the next generation design.

The Waverly Hall site showed signs of water intrusion into the building. Should water reach the enclosed equipment, it would likely cause unrepairable damage and a loss of the site as a part of coverage.

Poor, damaged, or missing grounding at many of the sites can result in a loss of system coverage from a lightning strike or equipment damage from irregular commercial power due to the lack of UPS. All sites should be brought up to modern grounding standards, such as R56, to lessen the impact of coverage loss and equipment loss due to electric shock. Additionally, this grounding also protects personnel who work on this equipment and is seen as enabling life safety. Users report that towers have been taken down by lighting in the past.



6. RADIO TECHNOLOGY AVAILABLE TODAY

To fully understand the pros and cons of the various options available to Harris County and its user agencies, it is important to recognize the benefits and limitations presented by the technologies available today. The following is a brief overview of these technologies. This overview in no way attempts to touch on all the aspects of any of these technologies, but instead focuses on the features and limitations of each that directly relate to the County's situation.

The discussion also touches on the differences between analog and digital systems, as well as aspects of proprietary systems versus systems based on open standards. In addition, included is an overview of system configurations alternatives available to support wide-area coverage desired County, i.e., multisite, simulcast and hybrid systems.

6.1. ANALOG VS. DIGITAL SYSTEMS

Since the late 1930's, public safety radio communication has used analog Frequency Modulation (FM) near exclusively as its wireless communications technology. Analog FM is inexpensive, robust, and provides good voice quality given reasonable signal levels. In terms of disadvantages, while FM's strong signal voice quality is good, the quality begins to degrade rather quickly as communication distance increases. As users move farther and farther from the main transmitter site, and signal levels drop, static and other noise factors steadily increase until finally the received signal is rendered unintelligible.

In many cases users operating within the outer reaches of coverage can communicate only with difficulty. This usually requires message repeats and results in misunderstood message intention. Furthermore, analog systems provide little security from eavesdroppers. Anyone with an inexpensive scanner can easily intercept and monitor the traffic on an analog system. Analog voice scramblers are available however, they are expensive, offer poor voice quality and are cumbersome to implement.

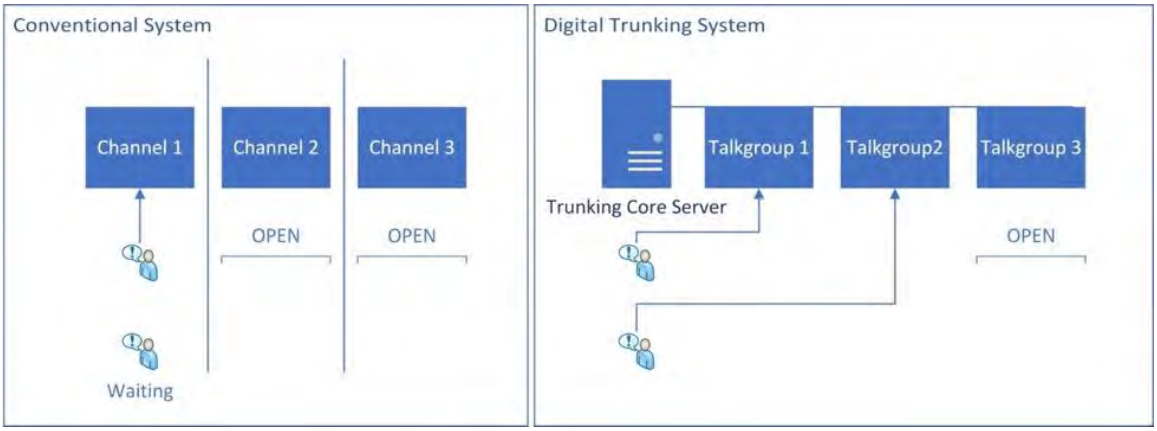
Digital communications systems first arrived on the public safety communications scene in the late 1980's. These initial systems were characterized by poor range and highly distorted voice audio; however, they were highly secure. In the past two and a half decades digital mobile radio technology has advanced to the point that voice clarity in digital systems rivals the best analog audio. Radio coverage of a digital system is equivalent to or exceeds that of a similar analog system. Furthermore, the static and noise that is typical in analog systems is dramatically reduced.

Today's UHF TETRA system provides inadequate call capacity for the County's agencies. Moving forward, additional channel capacity is required to allow all public safety professionals access to the network without the risk of extended queuing.

Digital communications systems provide increased efficiency in the use of system frequencies. In a conventional system, a user selects a channel based on how others will be able to communicate with them. A user selects the same channel that is associated with a given base station or repeater programmed to a single frequency pair. When a user makes a call, this ties up the base station, or repeater, associated with the given channel. When the user is done, the base station is left idle. Conversely, if two users both need to use the same channel at the same time, there is not enough bandwidth on the single channel to accommodate both users transmitting at the same time and one user must wait.

A digital trunking communications system uses these frequency pairs and assigns them to users on an as needed basis giving priority to selected users and emergency traffic. The figure below

depicts how two users would be routed by the trunking core server to utilize the available channel pairs, bringing all users who have selected, as before, to communicate with each other together on a talkgroup. In the case of Harris County, there are many departments, each using the digital TETRA system for public safety communications however, there is not enough capacity for all the users. When designing a trunking system, calculations are made to ensure that users can reliably expect to be able to communicate without waiting, or queuing, a method known as traffic loading analysis.



Conventional Versus Trunking Efficiency

Digital systems also provide significantly more voice security than analog systems. Voice encryption on a digital system is easy to implement, provides excellent voice quality, and is virtually impossible to crack. This allows public safety professionals to share information secure in the knowledge that the general public cannot intercept their transmissions and plan against or prepare for the coming actions. Often, those with nefarious intentions use scanners to avoid law enforcement giving them an unfair advantage.

Digital systems represent the future of public safety communications. As an example, the FCC has allocated a new section of spectrum in the 700 MHz band exclusively for public safety use, designed for digital systems only. Analog systems will not be permitted to utilize this new spectrum. The FCC has also mandated that newer radio systems moving forward into the future utilize less and less bandwidth making room for more and more users. The best way to accomplish meeting this mandate is with a digital system.

For some counties, the cost of a digital system is daunting considering for example the cost of conventional off the shelf radios they are used to buying. In the case of Harris County, many departments were buying models of radios that are not marketed to public safety, lacking many of the rugged exteriors and long-lasting components of a traditional public safety grade radio, built for public safety, with features and functions to match their needs. This decision was made primarily for budget reasons. On a TETRA radio system, these inexpensive radios can be purchase for as little as a few hundred dollars. When moving to a P25 radio system, these options for radios will no longer be available. TUSA is prepared to support the County should they choose to pursue a non-P25 radio solution so long as it includes equipment that can be software upgraded to P25 at a time in the future to grow Harris County should budget be the deciding factor. But TUSA does not recommended this approach as sustained funding for growing the

system in this manner is not always available when it is needed, and users are left where they are today, with a half operational system.

6.2. PROPRIETARY VS. OPEN STANDARD SYSTEMS

At the start of the digital transformation of public safety radio, older trunked systems utilized proprietary signaling protocols in their design. Some of these proprietary systems are still manufactured today but are less desirable. Examples of such systems are Motorola SmartNet/SmartZone, Motorola Solutions MotoTRBO DMR, L3Harris Technologies EDACS, and L3Harris Technologies OpenSky. While these proprietary protocols do significantly increase functional capabilities, they do so at the expense of intersystem interoperability and competition. In general, users with equipment from different vendors cannot directly communicate on the same digital system, and interoperability between them depends upon dispatcher relaying, console patches, or inter-system bridges. In terms of competition, if a system owner needs to expand or replace equipment in a proprietary system, the owner's procurement options are limited to one, or at most, two very limited number of vendors. Historically, this has resulted in a significant increase in the cost of a system over its lifetime.

All trunking systems initially developed and deployed for the public safety market, were proprietary. An agency that purchased a trunking system from one vendor would be stuck with that vendor for the life cycle of the system. That agency also was forced to buy user equipment (mobile and portable subscribers) from that same vendor as a cost that was not always very competitive. If a neighboring agency purchased a system from a different vendor, direct interoperability/roaming between the two was difficult at best. To address these and other issues, APCO, in concert with representatives of the Federal government and radio equipment manufacturers, have been working for more than two decades to develop a suite of open standards defining nearly all of the technical specifications needed to build systems that can meet the functional requirements of public safety communications yet not limit interoperability or competition. This suite of open standards is known collectively as Project 25 (P25).

TETRA is also a standards-based communications protocol that has been adopted in many foreign countries. While it operates in a digital configuration, there are many differences between TETRA and P25. The main difference is that P25 is designed with first responders in mind and the US Department of Homeland Security recognizes P25 as the standard for public safety in the United States. It should be noted that many of the Federal public safety communications grants available in the past few years, and expectedly in the future, either explicitly define P25 systems and equipment as a requirement, or heavily favor applications from agencies defining P25 in their requests. An agency applying for such a grant based on proprietary, non-P25 technology would be at a significant disadvantage in the competition for the available funds.

Many of the surrounding counties to Harris County have adopted this P25 standard. There is no easy way to directly operate a UHF TETRA radio on a 800 MHz P25 systema and vice versa, making interoperability more difficult with a TETRA radio.

While still evolving, sufficient progress has been made such that P25 compliant systems and user equipment are available today from multiple vendors. If adjacent jurisdictions or counties were to purchase P25 compliant systems from different vendors, user radios if properly programmed would be able to communicate directly with each other and on other P25 system infrastructure. In addition, each agency would be free to purchase radios from any vendor providing P25 compliant equipment, based on required features and budget.

Multiple vendors also now provide multiband radio user equipment. The multiband radio allows communication on multiple frequency bands (VHF, UHF, 7/800) and protocols (analog, digital, P25). This creates an environment of innovation at a cost competitive advantage to a customer from these multiple vendors.

Vendors that provide P25 equipment as of today are:

Infrastructure Equipment (in alphabetical order):

- JVC Kenwood (EF Johnson)
- L3Harris Technologies
- Motorola Solutions
- Tait

Subscriber Radios (in alphabetical order):

- BK Technologies (Relm)
- Icom
- JVC Kenwood (EF Johnson)
- L3Harris Technologies
- Motorola Solutions
- Tait

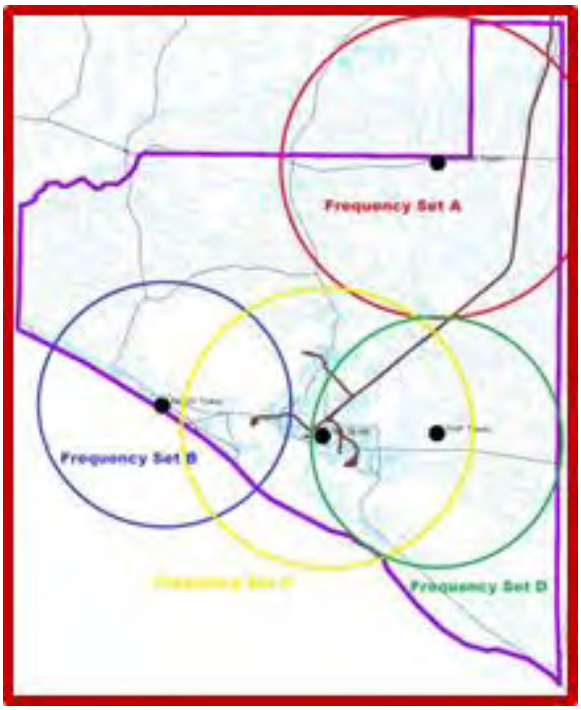
7. OPTIONS FOR COVERING LARGE GEOGRAPHIC AREAS

Wide area systems fill the need when an agency's radio coverage requirement exceeds that which is capable of being met by a limited number of tower sites. Simply adding tower sites will increase radio coverage but adding sites alone will not result in a cohesive public safety communications system. Coverage must be planned to allow balanced coverage.

Since coverage in dense building is non-existent in large portions of the municipalities, public safety agencies must rely on cellular for communications or must leave the building to communicate with dispatch. What is needed is the capability for users operating on one site or system to communicate with the users operating on the other sites/systems along with seamless switching between zones/channels/talkgroups when traveling in Harris County. That capability is provided by wide-area technology. The industry has developed several approaches to accomplishing this task, three of which have emerged as leading coverage enhancement options. Those three approaches are Multisite Networks, Simulcast, and Hybrid Simulcast/Multisite Networks. For those unfamiliar with wide area voice system technology, the following provides a general overview and describes the pros and cons of each approach. The following illustrations, while hypothetical cases in themselves, are representative of how such options are often configured.

7.1. MULTISITE NETWORKS

A multi-site network is comprised of radio sites spread throughout a geographic area, each having its own set of radio frequencies. The image shown is an example of such a configuration.



In order to allow communication between users operating in different tower site coverage areas, a means must be provided so that calls within the coverage area of one tower site are retransmitted on another tower site or combination of sites. Such wide area communication is accomplished through an intelligent central "switch" that monitors the site activity of every operational radio unit in the system and dynamically connects users together as needed. A call using a frequency on one site is connected to the appropriate, but different frequency on another. When a call is placed, the central switch determines which sites and frequencies are available to be assigned for that call and temporarily connects them all together via leased lines or microwave circuits.

The key characteristic of this type of network is that a completely separate set of radio frequencies (channels) is needed at each site. Because inter-site interference is not an issue, site placement is much less critical for a multisite network, compared to a simulcast system. In addition, a multisite network is extremely robust from the standpoint of reliability. In the event of a failure of one or more of the inter-site links, a simulcast site must operate with reduced capacity. A multisite network can continue to operate at

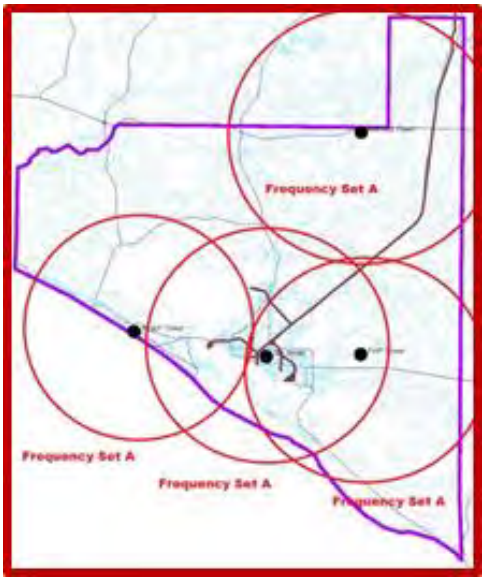
full capacity in the event of such a failure, although with reduced wide area coverage capability. The technical requirements for the communication links connecting the sites are also less critical than for simulcast systems, which can result in lower system implementation and operating cost.

While a primary strength in one regard, the requirement for separate frequency sets for each tower site is also a multisite network's primary weakness. The frequencies available for public safety use are extremely limited. The availability of frequencies can effectively block a multisite system's capability for future expansion, in terms of either coverage or capacity. If additional frequencies cannot be made available, additional sites cannot be added to an existing multisite network to increase its coverage.

Capacity expansion is further constrained by frequency availability as capacity expansion usually requires adding channels to multiple sites in the network. In order to prevent dropped or missed calls, the quantity of channels at each site must be high enough to handle all of the calls that the central switch may route to that site at any instant.

Another issue to consider is the effect of transitioning from one site to another when traveling throughout the service area. Site transitioning has an effect on the apparent coverage performance of a multisite network. In order to ensure that coverage within the required service area is contiguous, the coverage from adjacent sites must overlap each other. As users travel in these overlapping coverage areas, the radio must determine which site provides the strongest signal at that specific location and transition to the stronger site's operating frequencies. This transition is not instantaneous. To prevent missed calls due to excessive transitioning between sites, the transition to the stronger site is delayed until the signal difference between the current site and the new site exceeds a specific signal difference threshold. The net result is that a user may not always be operating on the optimum site. From the user's perspective, system coverage can be sporadically less than expected.

7.2. SIMULCAST TECHNOLOGY



Like multisite, simulcast is a technology that increases coverage beyond that available from a single site by implementing multiple sites throughout the desired coverage area. Simulcast differs from a multisite configuration in that the same frequency set is used throughout a given system. With a simulcast system, a channel's associated transmitter at each site broadcasts the same information simultaneously on the same RF channel as the other sites, hence the name.

The primary advantage of a simulcast system over a multisite network is that simulcast increases coverage without increasing the number of channels necessary to support the system. Also, given the same site configuration, inbound coverage from subscriber units to the base stations is improved over multisite because of the diversity effect of multiple receiver sites monitoring the same inbound frequency, and outbound coverage is improved because there is no site transitioning effect to contend with. From the user's point of view a simulcast system operates exactly like a single site system. There are no zones or site transitions for the user to contend with.

However, as a result of multiple sites transmitting on the same frequency, each site's transmitted frequency, phase and timing must be precisely controlled to prevent destructive interference as signals transmitted from multiple sites overlap. This requirement to precisely control the output signals from each site in order to prevent destructive time delay interference (TDI) makes the implementation and long-term support of a simulcast system more complex and costly than for a multisite network. This disadvantage also places constraints on a simulcast system's site placement. With the Industry's adoption of linear-simulcast base station technology (vs. non-linear simulcast), the design of a simulcast is much easier to accomplish with its more relaxed TDI constraints.

A simulcast radio system also requires highly stable and reliable inter-site connectivity. If inter-site connectivity is lost in a simulcast system, the affected sites will operate as stand-alone sites with severely limited capacity. This requirement for reliability and stability can usually only be met by a dedicated microwave or fiber optic sub-system. Currently leased circuits, even leased fiber, are not recommended for simulcast, and some vendors will not support simulcast systems utilizing them. From the standpoint of reliability, microwave has proved to be far more reliable and robust than leased circuits in the face of severe storms.

7.3. HYBRID SIMULCAST/MULTISITE CONFIGURATIONS

The final wide area system configuration one might consider is a hybrid design using a combination of multisite and simulcast technologies. This system configuration consists of several simulcast sub-systems, or "cells" connected together in a larger multisite network. From the standpoint of the multisite network, each simulcast cell looks like a single site, but each of these cells has significantly greater coverage than is possible from a single site. This design can provide a system solution when the geographic area is too large to be accommodated by a single simulcast system, and frequency constraints preclude a purely multisite network approach.

8. AVAILABLE WIRELESS DATA SYSTEM CONFIGURATIONS

The following section provides an overview of the various wireless data options currently available to Harris County's users.

8.1. COMMERCIAL WIRELESS DATA

Current public safety wireless data requirements are being met almost entirely by commercial wireless carriers. The initial deployments of commercial wireless data provided only moderate data rates and spotty coverage which is still true is Wakulla County in certain areas. Within the past several years, however, commercial system data rates have dramatically improved. Commercial wireless carriers are currently implementing improvements to their systems to provide significantly increased data speeds compared to services available only a few years ago.

As an example, AT&T, Verizon, Sprint, and T-Mobile have constructed high-speed downlink packet access (HSDPA) sometimes known as 4G, with initial deployments providing peak rates in excess of 1 Mb/s and theoretical peak rates of 14 Mb/s. While performance is good and getting better, it is important to remember that these systems are still commercial networks. They are not hardened to withstand severe storms and long periods without commercial power. In addition, public safety users do not receive priority over private subscribers. Experience proves that these systems quickly overload and are rendered essentially useless during and immediately after a natural disaster such as a hurricane.

The bottom line is that a commercial wireless data solution cannot be counted on to provide reliable public safety/mission critical service in an emergency situation. While commercial systems can provide economical high-capacity mobile data connectivity on a routine basis, public safety agencies should have plans in place to deal with inevitable service outages.

8.2. PRIVATE NARROWBAND WIRELESS DATA

A private narrowband data system provides data connectivity over narrow bandwidth RF channels that are primarily meant for voice service. These systems can provide good geographic coverage, but the narrow bandwidth limits data throughput. Such systems normally provide data throughput rates measured in thousands of bits per second instead of the hundreds of thousands of bits per second or more that a commercial data network can provide. The primary advantage of such a system is that it can be designed to public safety reliability standards. In addition, user access can be strictly controlled, reducing the possibility of system overload during emergency situations. In short, while the data throughput of a narrowband data system cannot match that of a commercial system, it is far more likely to be available when needed most.

8.3. PRIVATE BROADBAND WIRELESS DATA

Private broadband data systems operate on frequencies that have channel bandwidths measured in Megahertz. As such, they are capable of very high data throughput, but only over a very small area. Typically, these operate in the 900MHz, 2.4, 4.9, and 5GHz bands and utilize an access point model similar to Wi-Fi networks in their design. Because each access point only provides coverage over a small area, it would be extremely costly to cover an area the size of Harris County with broadband wireless.

Instead, a more practical approach would be to provide access points at strategic locations throughout the County to form high speed wireless "hotspots". This high-speed connectivity would then be available to users when they come within range of a hot spot, allowing them to

access the central network and perform functions that require very high speed, such as updating local databases or uploading reports. Outside of the range of hotspots, users would have to rely on other means of data connectivity, either commercial or private narrowband.

A limiting factor in the deployment of a network of hotspots is the cost and availability of high-speed data connections that are necessary to connect each hotspot to the primary network.

8.4. DATA ON THE TRUNKED VOICE NETWORK

Many trunked voice systems, including EDACS, OpenSky, and P25 have the capability of providing data communication using the voice network. This approach is called trunked data. It has the dual advantage of not requiring the implementation of a separate data infrastructure, and the data network inherits the same reliability as the voice network. The disadvantages are that a certain amount of voice capacity must be sacrificed in order to support trunked data, and that the maximum data rate that this technology can support is quite low (9.6kb/s).

Typically, trunked data rates are measured in hundreds of bits per second, instead of the kilobits or megabits per second offered by other options. This slow throughput of trunked data cannot support the requirements of modern public safety applications and most users that relied on this approach in the past have abandoned it for other options that provide the required higher data rates. The technology is still applicable in certain niche applications such as GPS location, over-the-air reprogramming/rekeying of radios, status reporting and short text message delivery.

8.5. HYBRID WIRELESS DATA

Each of the previous data options has advantages and disadvantages. Commercial data options have high throughput, good coverage, but poor reliability. Narrowband data has good coverage and reliability, but only moderate throughput. Trunked data has high reliability and low cost, but low throughput, whereas broadband data has excellent throughput, reasonable reliability, but poor coverage. A hybrid data solution is a mixture of the available options configured to provide an acceptable system solution when a single technology cannot. This hybrid approach does significantly increase cost and complexity.

Unlike with a voice multisite/simulcast hybrid approach where the subscriber equipment is essentially unaffected and the additional complexity is in the infrastructure, a data hybrid solution pushes the complexity out to the subscribers. In addition to multiple infrastructure subsystems, the mobile subscriber equipment must also be equipped with multiple radio platforms as well as additional software applications to permit selection of the appropriate data provider, depending upon the immediate circumstances.

8.6. FIRSTNET

Growing rapidly is FirstNet, a nationwide LTE broadband network to support First Responders. In 2012, Congress passed the Middle-Class Job Creations Act, which authorizes the creation of the First Responder Network Authority. This independent authority within NTIA is able to provide emergency responders with the first nationwide, high-speed, broadband network dedicated to public safety.

The construction of the new network requires each state to have a Radio Access Network (RAN), and each state can choose whether they will allow FirstNet to build the RAN, or each state can opt out and build their own RAN.

FirstNet released its initial state plans on June 19, and the state of Georgia has chosen to opt-in and will accept the FirstNet deployment plans. The new network will be built by AT&T. Part of the plan is to leverage AT&T's existing cellular network and give public safety priority on the network.

At the present time it is difficult to predict how rapidly FirstNet will grow into rural areas. AT&T is now challenging the definitions of what public safety grade is for networks. To complicate this more, on August 15, 2017, Verizon announced they will build their own dedicated public safety LTE core network as a viable option to FirstNet.

Currently, FirstNet is available for users to register their phones. However, state-by-state operational usage varies. There have been small test cases (flooding, hurricanes, etc…) that have allowed FirstNet to be utilized for data applications. In March of 2020, FirstNet announced their first PTT services for voice use. However, widespread voice use is still lacking due to infrastructure missing from sites such as generators and redundant network links.

TUSA offers coverage mapping services for all cellular networks including FirstNet should Harris County be interested in learning more about coverage from these types of networks.

9. METHODS FOR ENHANCING COVERAGE RELIABILITY

A radio system's portable radio coverage reliability can be extended through the use of devices designed to receive and retransmit signals, much like a repeater. These options are typically reserved for worst case environments, such as mountainous areas, or for very dense structures such as hospitals that commonly have radio penetration issues.

9.1. DIGITAL VEHICULAR REPEATER SYSTEM (DVRS)

A cost-effective solution to improve portable RF coverage reliability within a given radio system/network is accomplished using a Digital Vehicular Repeater System (DVRS). A DVRS provides repeater capability between portable radios (portable radios being the most susceptible to coverage problems) and the RF infrastructure system (tower sites). This dramatically improves coverage by leveraging the large mobile coverage of a radio system and extending it to portable radios which would otherwise have reduced coverage reliability in some buildings and remote areas.

A DVRS accomplishes this "repeating" function by using two radio devices integrated together with a hardware controlling device. One of the radios would be programmed onto the host trunked radio system with the appropriate talk groups. The second radio (usually supplied with the repeater device) operates outside of the frequency range of the trunked radio system. Because of this, a DVRS would require approval and licensing from the FCC via the state frequency coordinator.

On the flip side, there is a difficult engineering problem to overcome with these types of systems. Anytime there are two DVRS at the same physical location, a protocol must be established so a portable radio doesn't activate two or more DVRS simultaneously and potentially causes self-interference between multiple DVRS units. Technology has improved with these devices to help mitigate this issue.

9.2. BI-DIRECTIONAL AMPLIFIER (BDA)

The Bi-Directional Amplifier (BDA) amplifies and repeats the radio system frequencies from a donor antenna located in an area where host coverage is available. The amplified signal is then repeated in or toward an area experiencing degraded coverage. Likewise, the signal from a subscriber radio is repeated back to the donor antenna which directs it back to the host infrastructure site(s).

An important difference between BDA and Digital Vehicular Repeater System (DVRS) equipment is that BDAs do not change the frequency of the signal. This simplifies the operation of the BDA; however, results have a major drawback in this design. Because both uplink/downlink antennas operate on the same frequencies within a BDA configuration, they must be separated/isolated by some type of shielding mechanism. The more physical separation between the antennas, the better their performance will be. Water towers/water tanks offer the best type of structure for installing outdoor BDAs. Because of the metal used in these structures, these antennas can be separated in such a way as to offer the most advantageous isolation. Other types of structures appropriate for outdoor BDA configurations are buildings structures where antennas can be installed on opposite sides of the structure, thereby creating a shielding/decoupling effect.

In general, BDAs are more expensive in UHF than in 7/800 MHz, a factor that must be considered when designing and selecting a public safety radio system. However, BDAs are

almost always lower cost than building a new tower site should an isolated building or area need specific coverage.

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10. PROJECT 25 ISSI-KEY TO USER ROAMING

As cities and counties in Georgia move forward with their deployments of APCO Project 25 radio systems, the groundwork is being set for user radio roaming. First, of course, radios in a given region or area must be capable of operation on P25 equipped infrastructures.

Additionally, all new public safety trunked radio purchases should require radios that are operable on both the 800 MHz and the new 700 MHz voice channels if a network exists in the region or area of operation. These new radios should be fully compatible with Project 25's Phase-1 (12.5 KHz FDMA) and Phase-2 (12.5 KHz, two-slot TDMA) functional and operable requirements. By so doing, user radios newly purchased will be fully compatible with future Phase-1 and Phase-2 7/800MHz rollouts and will experience significantly longer service lives than those having only Phase-1 capabilities.

While equipping users with P25 compliant equipment will potentially allow a user to communicate while traveling outside of their home area, this step alone will not allow radio users to communicate directly with radio users located in another jurisdiction. Such interoperability and seamless roaming require the establishment of Memorandums of Understanding (MOUs), regional radio governance and technical committees, development of flexible Talkgroup profiles, and the instantaneous and continuous connectivity of radio system controllers (called switches) throughout the various regions.

Prior to P25, connectivity standards between compliant radio systems did not exist. These standards exist today at a base level where user IDs, talk group and transaction audio can be instantaneously routed between radio systems. These new switch interoperability standards are termed: Inter RF Subsystem Interface (ISSI).

Project 25 ISSI defines the types of functionality that can be supported between radio network/system switches. The ISSI P25 Standard is vendor neutral such that radio systems designed and deployed by competing radio vendors can support call interoperability and user roaming. This is an extremely important point as Project 25 would have otherwise failed its primary goal: open-architecture and elimination of proprietary solutions.

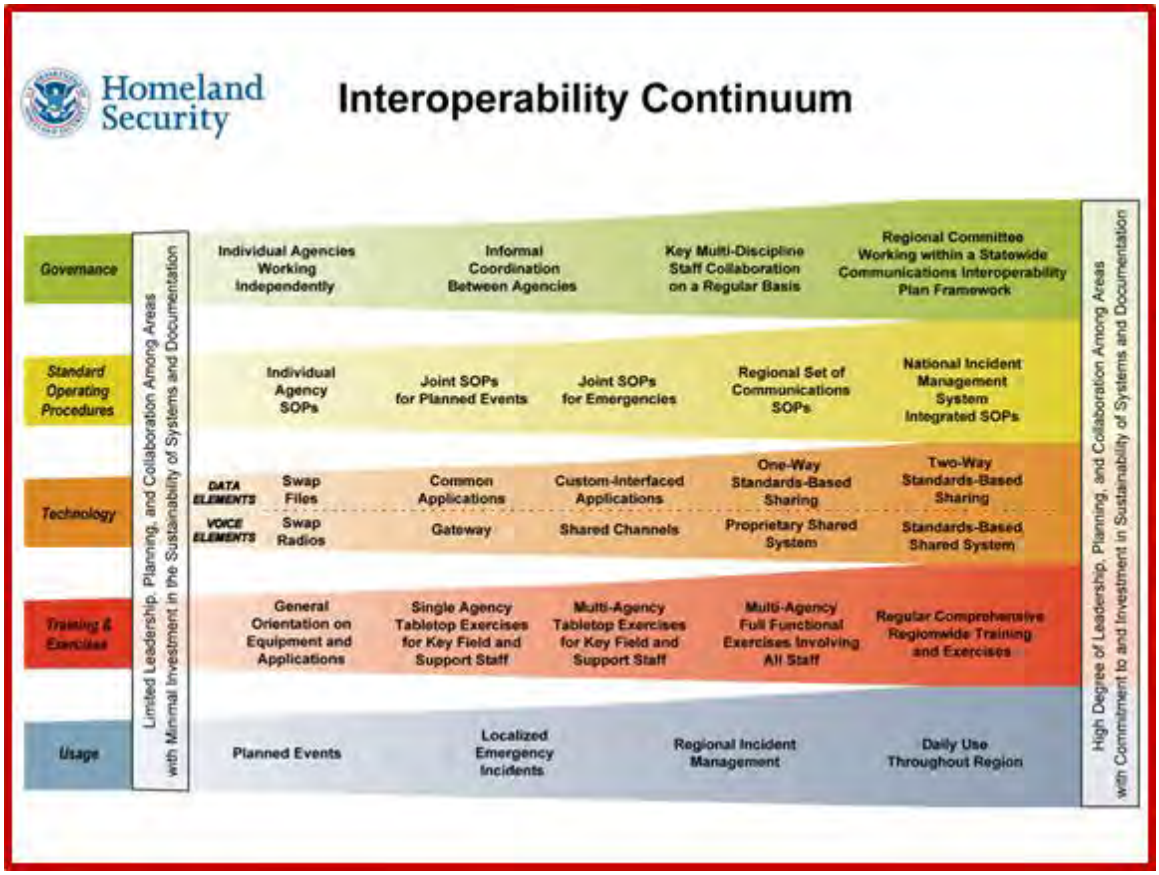
It is important to understand that ISSI is a functionality of the controllers/switches and gateways employed within the various deployed radio systems. All P25 cores/switches within a network that facilitates roaming must support ISSI or interoperability cannot occur via this method. Yet, nothing happens with respect to user roaming without a secure, reliable means for interconnecting the various radio system switches together and this is why an expanded microwave solution is so vitally important and bears consideration.

Should Harris County decide to continue to operate on the UHF TERA system, the county will not be able to take advantage of the surrounding coverage provided by neighboring P25 systems. Should Harris County elect to install a new P25 system, the P25 ISSI connection could be used to connect to other P25 systems such as Troup County and Muscogee County to allow users to roam onto these systems while still reaching back to Harris County dispatch and vice versa.

11. INTEROPERABILITY/ROAMING CONSIDERATIONS

Many states across the country, including Ohio, Michigan, Louisiana, Mississippi, and other states including Georgia have made great strides in improving public safety communications, interoperability, and user radio roaming.

Other interoperable solutions, of course, exist and those include swapping radios, gateways, shared channels, Nationwide mutual aid channels on VHF, UHF and 700/800MHz bands, and proprietary shared systems. The following illustrates the various recognized means for achieving interoperable communications:



Interoperability with the surrounding counties and agencies can be done either by direct connection through ISSI equipment, as explained in the Section: Project 25 ISSI-Key to User Roaming or by link radios for each channel that these groups operate on.

11.1. NIFOG AND NPSPAC MUTUAL AID SYSTEM

All public safety agencies in the State of Georgia have access to nationwide frequencies set aside for mutual aid. In every band public safety can operate, these channels are pre-defined and allotted by purpose to be used during emergency response. This plan is known as the National Interoperability Field Operations Guide (NIFOG). Unfortunately, it is often the case that responders do not all have radios that operate in the same frequency band, and to communicate

across bands with other users, a gateway must be in place to connect users in disparate frequency bands.

Those who operate 800 MHz systems, or own subscriber units that operate on a participating Public Safety system, have access to the nationwide mutual aid channels generally referred to as the TAC (Tactical Communications) channels. These are 5 distinct 800MHz channel assignments that are designated for conventional analog communications in support of mutual aid operations and interoperable communications. These channels are generally set aside for 3 main categories:

- Day to Day Interoperability – Generally used during routine Public Safety operations such as accident scene response or other first response activity. Several area jurisdictions may respond to these types of calls. TAC channels are generally used so that Public Safety agencies may all use a designated common channel for communications during these routine events.

- Mutual Aid Disaster Response – Planned use of specified channels during joint response to major disasters that may exceed the resources of one specific agency. These events include possible terrorist activity, airplane crashes, bombings, large forest fires and other major events and acts of nature when the situation overwhelms local responses and outside support is requested.

- Task Force Interoperability involving state, local and/or federal agencies coming together for a period of time in response to major events such as sporting events, political rallies, or for investigations related to prolonged criminal activity.

The Association of Public-Safety Communication Officials (APCO) and the National Public Safety Telecommunication Council (NPSTC) have jointly developed a new ANSI (American National Standards Institute) Standard for Channel Naming for Public Safety Interoperability Channels. The standardization of mutual aid channelization across the United States is important as it reduces confusion during mutual aid events and ensures uniformity.

11.2. STATEWIDE RADIO COMMUNICATIONS

Currently, Georgia does not have a unified statewide communications system that would benefit Harris County. For this reason, many counties are forming their own smaller regional networks to share the cost of communications and improve reliability and functionality.

11.3. DIVERSE POWER TETRA SYSTEM

This option has been utilized by Harris County since before the initial report in 2017. Since Diverse power owns and operates several of the sites as well as the core in LaGrange, this solution provides the County with communications with benefits and drawbacks.

The benefits include:

- Lower total cost of maintenance
- Lower responsibility of equipment

The drawbacks include:

- Less control of options and functionality
- Less visibility of future changes that may require unplanned investment
- Fewer options for interoperability
- Fewer opportunities to recover costs through revenue sharing on a County owned tower

12. ENHANCED MICROWAVE SUBSYSTEM

Immediate attention has been given by the federal government in driving the convergence of new public safety and federally operated radio systems toward Project 25 digital voice standards. It is important that newly deployed digital radio networks depart from prior Project 16 trunked radio configurations. Where each manufacturer had developed highly efficient, and proprietary radio systems, but they were incompatible technology solutions. As radio networks expand in step with coverage needs, the role of remote antenna site connectivity takes center stage. Connectivity is essential as this allows independent antenna sites, each singularly exhibiting natural coverage and performance limitations, to be combined into a cohesive wide-area network. The critical importance of reliable connectivity between sites can overshadow other radio network design considerations as the loss of even a single linkage could lead to devastating consequences.

The fragility of some wide-area trunked radio and commercial cellular networks was vividly laid bare through the devastating effects of Hurricane Katrina. Here, low-cost fiber and copper T-1 connections were either directly damaged by storm winds and flood waters or power-starved by the depletion of run-time limited battery backup systems and the lack of reliable on-site power generation equipment. By far, the biggest contributor to the collapse of radio communications throughout areas damaged by Hurricanes Rita and Katrina was the combined result of failed site interconnectivity and loss of electrical power support. Those few radio systems that remained operational (Harrison County, MS as an example was one of those few) did so due to their use of private point-to-point microwave facilities and well planned standby electrical power systems sized for days, not hours, of operational capacity.

Using the lessons learned from those types of events, a modernized P25 Radio Network would require development of an expanded IP-packet switched, protected public safety digital microwave network supportive of the County's range of needs. In this envisioned configuration, broadband microwave technology would provide resilient, seamless interconnectivity with the principal radio dispatch E9-1-1 center as well as linkages to the County's trunked radio system sites, backup dispatch locations and ISSI connections to other regional or future P25 networks. This microwave system could be easily scaled to include linkages to other P25 radio systems as those materialize.

One of the more exciting features of an enhanced digital microwave solution is its inherently private broadband capacity. The microwave network's excess capacity could be used to support the County's data needs by providing multiple points of entry for outside federal and state criminal history databases. Thus, loss of connectivity to such databases within one municipal area would not preclude backhaul of such data from other points in the microwave network.

By comparison, the use of commercial broadband services, while having economic benefits, is inherently susceptible to service interruption. The hundreds of miles of copper and fiber cabling necessary to interconnect these various radio communication systems and dispatch facilities would pass through unprotected spaces and right of ways. As such, they would be vulnerable to unintentional damage caused by the forces of nature or construction crews. Worse, the expansive design of wired facilities opens the possibility of unauthorized activity that could compromise the security of critical communications resources.

By direct contrast, a County-managed microwave backhaul subsystem is fully private. Access points are limited to the antenna sites, themselves, and the interception of microwave communications would require the ability to intersect the actual elevated and narrowly focused radiated signal. Furthermore, the information contained within the microwave network,

particularly voice and mobile data communications, would be encrypted using nationally recognized (standards-based AES) security systems having codes that would take impossibly long periods of time (hundreds of thousands of years on average) to decipher.

Finally, there is the issue of telephony and video conferencing connectivity. The excess bandwidth provided in a microwave network approach can be efficiently and securely used to support emergency telephone or video conference communications between dispatch centers and/or Emergency Operation Centers (EOC's) in support of response coordination. If configured with steerable antenna arrays and made operable on public safety 4.9GHz allocations, full transportable/mobile PSAP-Radio Dispatch facilities could be deployed. And since P25 radio consoles and NG-9-1-1 telephony/CAD is now IP-based, their deployment and utilization would no longer be limited to fixed-core infrastructures.

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13. SUBSCRIBER RADIOS

Public Safety users have stringent expectations for system reliability, radio coverage and audio quality. Interruptions in radio service availability and access are, in most cases, unacceptable. High-quality portable unit coverage is desired and necessary throughout the user-agency's geographic service area, both on-street and within buildings and automobiles. Delivered audio must be of the highest order of clarity with little background noise or radio static.

Current TETRA radios do not offer all in one radio the features that public safety requires to maintain safe operations. The features include but are not limited to:

- Emergency Button Activation/Acknowledgment
- Hazardous Location Operation (Intrinsically Safe)
- 256-bit AES encryption for secure communications
- AVL (Automatic Vehicle Location – GPS services)
- Man-down emergency activation without user intervention
- IP-68 submersible for use in environments where rain and water are common

These requirements greatly exceed the needs of, for example, a commercial, radio-dispatched delivery service, but are essential to the mission of Public Safety departments. Unfortunately, increased performance leads to more complex and costly radio communication infrastructures.

Coverage reliability is enhanced through proper consideration of environmental losses, building losses and other user configuration factors. For example, at 800 MHz, it has been found that in-vehicle propagation losses may be 6 to 10 times higher than those encountered on-street. Portable radios operated at hip-level (by speaker/ microphones) are subjected to additional body losses which may be 8 to 10 times higher when compared to utilizing the same radio at head level. Building propagation losses vary widely due to location (densely packed structures are affected by shading losses) and construction materials, further aggravating portable radio operations.

The following illustrates the propagation losses at 800MHz that must be overcome by virtue of tower site placement and antenna configurations for typical geographic settings:

Environment	Category	Environment Loss dB
Water	Lakes	0
Snow & Ice	Snow Pack	0
Wetland	Non-forested	3
Open Land	Bare Land	5
Range Land	Herbaceous	3-7
Transportation	Roadways	5
Agricultural	Grassland	7
Residential	Suburban	10
Forest	Pine greater than 30 ft	15-21
Mixed Urban/Buildings	Apartments less than 4 stories	15
Commercial/Industrial	Commercial Services	19
High Density Urban	Skyscrapers	28

How users intend to operate radio communications systems and equipment likewise has a profound impact on infrastructure design configurations. Generally speaking, Public Safety systems are optimized for the user group having the most stringent operational requirements, which automatically provides an enhanced performance margin to those groups having lesser needs.

To illustrate this point, consider that firemen utilize insulated "turn-out" gear due to the high heat and water encountered during fire-fighting incidents. Radios are usually placed within these coats and so the antenna is shielded or in contact with water-soaked fabric material. This naturally adds to signal loss. Sheriff's deputies usually carry their radio in a belt holster. Thus, when inside an automotive vehicle, the radio is often jammed into the seat, with the antenna in contact with a fabric surface of some type…and the radio is enveloped within the vehicle's steel framework. So, in that instance, the additional propagation losses due to the vehicle's local environment can be in the order of 8-12db.

In order for a radio system to meet an agency's coverage expectations, these types of configurations and losses must be properly considered during the project's design stage. A principal advantage of P25 technology is that radios are designed to an open standard, but what means is there to ensure where radios bought from multiple sources will, in fact, work on a host radio system?

Fortunately, this aspect as considered by EIA/TIA when developing the P25 standards and a means for compliance testing has been established. Multiple independent testing facilities have been certified by TIA/EIA as having the appropriate test equipment and expertise to accurately assess how closely vendor radios comply with P25 standards. Vendors routinely publish compliance testing statistics for manufactured radios whereby knowledgeable parties can determine if proposed products appropriately conform to P25 Industry standards.

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14. FREQUENCY ANALYSIS

Harris County primarily operates in the 450-470 MHz (UHF) frequency band.

The benefits include:

- Generally better outdoor coverage;
- Less attenuation of signal by pine needles than 700/800 MHz,

The drawbacks include:

- In building coverage isn't as strong when compared with 700/800 MHz;
- Mutual Aid partners such as Troup County and Muscogee County already operate in 700/800 MHz;
- Interference in UHF can be intermittent, come from a variety of different sources, and hard to pinpoint or eliminate.

To grow the system, and allow additional users onto the network, new frequencies may have to be obtained regardless of if the County decides to move over to a new 700/800 MHz P25 system. By utilizing a simulcast system, the number of required new frequencies can be reduced. If Harris County chooses to create a regional system or join an existing system, then the requirement for sites and frequencies may change depending on the configuration utilized. In an RFP specification, TUSA also allows vendors the additional flexibility to find frequencies from other systems to use as a transition phase, should Harris County choose to join an existing system, rather than build a separate stand-alone countywide system. Creating a regional system or joining an existing system can result in a cost savings for the County with shared sites, maintenance, and responsibility.

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15. Conceptual Coverage Improvement Configurations

This section focuses on providing conceptual design information geared to addressing interoperability and coverage shortfalls and expectations derived from interviews with County radio user agencies. TUSA considered the following when evaluating potential tower site placement solutions for next-generation conventional and trunked radio system configurations:

- The primary design goal is to achieve reliable balanced portable radio coverage especially within the populated areas of the county including
  - Portable on-hip, countywide on-street radio coverage (95% outdoor)
  - Portable on-hip, in-building 12 db withing the city limits plus one (1) mile of Hamilton, Waverly Hall, Pine Mountain, Shiloh, and West Point
  - Balanced talk-out/talk-in coverage required, with a bias toward talk-in performance;
- Location of tower sites would focus on County-provided critical building/area locations;
- 20db coverage within high-density commercial/educational building structures (higher margins available within 3-mile radius of tower sites);
- A baseline user radio configuration for the study consists of a hip-mounted portable radio device; quarter-wave antennas mounted on the radio package; use of remote speaker-microphones such that the user's radio is on-hip for both talk-in and talk-out coverage pathways;
- Project 25 (P25) Conventional, P25 Phase 1 trunking & P25 Phase 2 trunking coverage (i.e., 9.6kbs control channel/12kbs voice; 2-slot TDMA if phase 2 trunking);
- The minimally allowed delivered audio quality is TSB-88's defined DAQ 3.4 for a portable on the hip & DAQ 4.0 for mobile;
- New greenfield sites to minimize the potential for interference as might exist with co-location onto shared rental site facilities;
- New sites to maximize coverage of unpopulated areas of the county while balancing cost
- Construction of licensed microwave backhaul network;
- Reuse of existing County tower sites to support a seamless parallel implementation.

TUSA developed coverage map overlays utilizing Google EarthTM. By so doing, County personnel can more readily evaluate and consider predicted coverage based on critical building locations and look through the county to identify any areas of concern.

For all the following conceptual solutions, TUSA attempts to give special consideration to the reuse of existing equipment or sites where possible. In the case of Harris County, there is very little that can be considered for reuse from the existing site RF equipment for the conceptual solutions if the County migrates to a P25 system.

It is important to recognize that the TETRA radio system in Harris County is owned by Diverse Power EMC, and as such, was designed to provide coverage to the mobile radios used by vehicles the power company deploys throughout the county and elsewhere. As such, the TETRA radio system was not designed to provide radio coverage for the portable radios that Public Safety personnel routinely use.

Additionally, Public Safety personnel require a more durable a radio system that is available 24/7/365 and can endure harsh environmental conditions.. Public Safety personnel are more vulnerable to radio system outages and as such so is the general public in times of natural disaster. Whereas public safety officers must routinely function within building structures, power company personnel have radio coverage needs that are principally outdoors and are to "the vehicle" rather

than to "the person". The two services have coverage, capacity and audio quality needs and expectations that are vastly different.

The current TETRA radio system in Harris County presents a significant coverage problem for portable radio equipped Public Safety personnel. The effective on-street portable coverage is currently below the desired 95% county-wide even if the system was operating at peak performance. Interviews with Public Safety personnel indicate that its actual operations fall below the predicted coverage.

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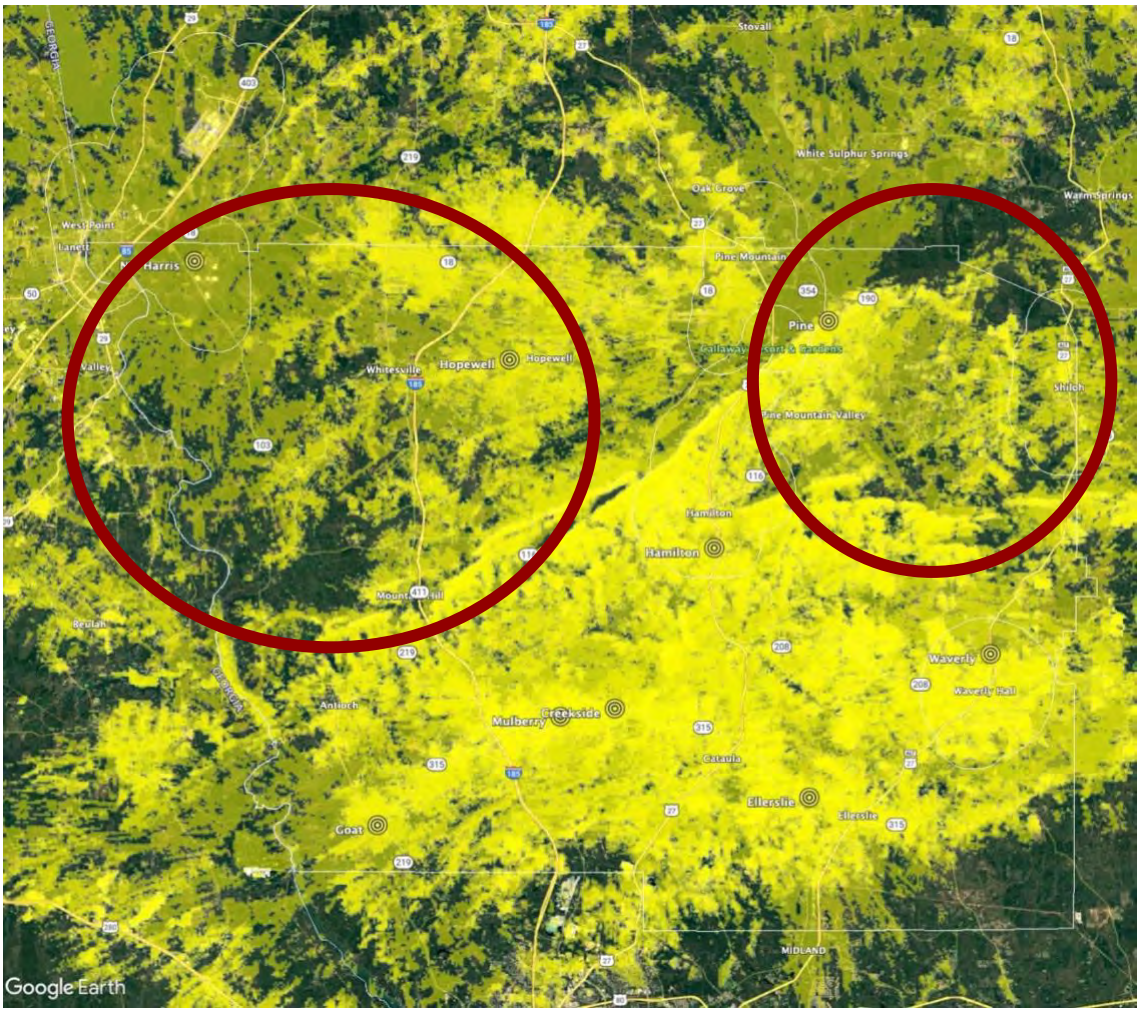
The biggest coverage deficit as depicted by the portable coverage map below occurs in the western part of the County with pockets of poor coverage along the I-185 corridor.



Portable on-hip talk-in coverage currently below 95%.

With today's Public Safety personnel, the portable radio has become a critical lifeline when working in the field, away from Police stations and Fire stations. Many of the operations and functions that must be done in the line of duty, are often done away from a vehicle where a more powerful mobile radio is located, using a less powerful portable radio. As the importance of portable radios has grown in the Public Safety world so has the radio systems that support these portable radios. This is accomplished by placing tower sites in such a way as to give optimal radio coverage to the less powerful portable radios.

In our observation and in talking to PowerTrunk officials, the TETRA radio system in Harris County was not designed for portable radios, but as a mobile radio system for Diverse Power personnel operating from their trucks. In such a design, tower sites are placed further apart because the mobile radios that access it have more transmit power (typically ten times more than portable radios) and larger antennas than portable radios. Portable radios have a difficult time performing well on a radio system designed for mobile coverage.

Another factor that is contributing to the coverage performance problems of the portable radios on this system is that the coverage footprint for a TETRA UHF system is smaller than other types of more common systems such as 700/800MHz systems that can utilize receiver preamplifiers. A couple factors contribute to this type of portable coverage problem. First, technical limitations often preclude the use of UHF tower-top receive preamplifiers compared to 700/800MHz systems. Because of the much higher frequencies used by 700/800MHz systems, they are less prone to interference and provide better portable coverage performance over a wider area. Further, the FCC-designed frequency separation plan for 700/800MHz allows for the efficient use of tower-top preamplifiers, thereby enhancing portable radio operations.

Second, the TETRA UHF portables used by the county only provide an output power of 1.8 watts compared to typical P25 UHF portable that provide an output power of 5 watts. The smaller power output of the TETRA portable causes the TETRA UHF system to provide smaller coverage footprints per tower site for portable radios. In short, adding tower sites to the current Harris County TETRA system will be less cost effective than adding tower sites onto a traditional radio system optimized for Public Safety personnel.

While increasing the number of TETRA tower sites to fill in the coverage gaps for portable radios could be done, because of the coverage footprint limitations on a TETRA UHF system, the improved portable coverage is minimal verses the cost for additional sites. Because of this, the costs required to improve the portable on-the-street coverage of the Harris County TETRA radio system to the industry standard 95% would likely be more expensive than purchasing a new radio system. On average each additional tower site (as confirmed by coverage analysis) is only improving the configuration's portable coverage by 2 to 3 percent. At that rate it would require as many as five additional tower sites to increase the portable coverage from the current 79.9% to the industry recommended 95%, if appropriate tower sites could be located.

Reliability is another issue that needs to be addressed on the Harris County TETRA system. Public Safety personnel are often called into life threatening situations. Many times these situations take place when conditions are less than perfect. Tornados, floods, ice storms, wildfires are a few examples of where first responders require a highly reliable radio system. When conditions are at their worst is when a public safety radio system must perform effectively for first responders. Having an unreliable radio system for public safety not only endangers the lives of first responders, it also endangers the lives of the general public.

It is our conclusion that since this system was designed as a mobile radio solution its conversion to one supporting reliable countywide portable radio coverage is likely to be costly and cumbersome to maintain. providing. However, as we have pointed out earlier, the current portable coverage could be modestly improved and deliver portable coverage in the order of 85.6%. In addition, a new site on the west side could further improve portable coverage. Should the County elect to remain and expand this radio system, those additional tower sites be placed within populated areas or near to specific, high-traffic roadways.

TUSA recommend sufficient time and design consideration be allowed to qualify location that delivers the most amount of coverage to the highest population on the west side, while limiting incidental coverage within neighboring Alabama. Further, a frequency plan for the new site(s) must be developed to ensure no self-interference conditions are presented to existing tower sites. The supplied map configurations attempt to exclude the use of third-party leased sites, when possible, for good reason. Leased sites that must accommodate microwave backhaul and transmit/receive antennas are at a typical lease cost of $3,000-$5,000 a month and with annual escalation factors. A County owned new tower site will cost more money up front, but it will save the County

significantly over time. In fact, the break-even point for owned versus leased towers in today's market is approximately between Years 6 - 8. A new site (Tower, Shelter, and other equipment) is an investment in the County's long-term infrastructure and will last well over 50 years or at least two (likely three) generations of radio technology if properly maintained.

For all the conceptual solutions the County will be required to add their own microwave network to connect the new network together in case Diverse Power will not allow use of the existing system. The preferred design for any microwave network being used to connect radio towers in a public safety radio system is a ring configuration. With this design, any loss of signal between any two sites is rerouted back through the opposite side of the ring back to the control point(s) to maintain the site's connection to the system. Depending on the selection of solution, the microwave network will be connected to all sites, including sites that may be built or be preexisting outside the County connected to other County systems.

The conceptual solutions developed by TUSA for consideration by Harris County include:

1. Conceptual Solution #1 - TETRA System UHF – Expansion System
2. Conceptual Solution #2 - P25 System 800 MHz – Standalone System
3. Conceptual Solution #3 - P25 System 800 MHz – Join Existing System

For each solution the city limits plus (1) mile is used to determine coverage. Since several of the cities exist in both Harris County and the neighboring County, this required sites to be placed in the adjacent counties for coverage. Should Harris County determine they only wish to cover these cities to include what is within the boundary of Harris County, this would reduce cost to the overall system implementation.

REGIONAL CONFIGURATION CONCEPTS

All three conceptual solutions are inclusive of toward operable coverage. Many of those interviewed expressed needs to communicate with other agencies, with each having varying types of radio systems in different frequency bands, and configuration types, interoperability can be accomplished in several conceptual ways:

CONTROL STATION LINKAGES

Regardless of the choice made to build a standalone system, to create a new regional system, or join another existing system, talkgroup-specific control station with either UHF or 800 MHz links could be established and controlled via a digital radio system core (whether owned by Harris County or shared with another agency). This is an expedient, relatively low-cost solution that would allow Harris County users to have specific interoperability talkgroups programmed into their radios such that whenever those groups are switch-enabled in the field, the radio system would activate the control station link. These links between a Harris County talkgroup, and control station links could also be controlled by dispatch. Thus, a radio user positioned within the Harris County radio system's footprint, could then communicate with neighboring jurisdictions. This option would require, on the TETRA system, Diverse Power's cooperation to set up these talkgroups at the Core.

In the reverse case, where an outside agency wanted to communicate with a Harris County public safety agency, that user would request access via the control station, whose receive audio pathway is always present at the County's dispatch center consoles. The dispatcher would then alert the parties and direct communications to the appropriate linked Talkgroup.

The advantage to this configuration is that control of who accesses Harris County radio resources is fully controlled by the County on a new P25 system, or shared control with Diverse Power on the TETRA system. Further, software updates made by outside counties to their radio systems would have no direct impact or cost to County radio operations. Finally, this linkage concept is relevant to P25, legacy P16, conventional radio systems, and other neighboring systems.

PROJECT-25 CORE SHARING

Should a given number of jurisdictions utilize the same vendor for their respective Project-25 radio infrastructure solution, it is possible to share P25 core equipment. By so doing, a regional communication system is formed and controlled under the umbrella of a shared core/management structure.

In practice, such a configuration involving two jurisdictions may consider constructing geographically separated and mirrored P25 cores (i.e., one located in each jurisdiction). By doing so, enhanced network reliability is gained and users within the constellation of co-joined tower sites could freely roam and communicate throughout the combined geographic region.

A significant cost and maintenance limitation exists with shared-core configurations. If the owner of one core requires software features that the other may not need, both parties must still fund complete the sought hardware/software change. So, each participant is locked in with respect to maintenance and upgrade costs that either of the former two methods circumvents. Of course, the core itself is not inexpensive…in the order of $1M or more, depending upon the configuration and features needed and the required annual software/hardware support can be in the order of 10% of the initial buy-in cost.

A shared core configuration requires the development of MOU/governance processes which must survive the life of the radio communications network. It is possible to decouple cores at a later date, however, doing so risks service and coverage disruption and is not a process that one can easily undertake.

The concept of core sharing can only take place once the vendor for the subject jurisdictions is known. P25 standards do not now support the integration of core-to-core connectivity across vendor platforms, thus such an endeavor essentially leads to a sole-source/single-vendor radio infrastructure configuration (however, this does not preclude sole-source/single vendor for subscribers). This model is used above in Conceptual solutions #3, where Harris County either joins an existing system such as Troup County or Muscogee County and shares their core, or where Harris County creates a new regional system and places one half of the geographically separated core in another county, a partner who then shares in the costs of maintenance and can use that half of the core to build out their own modern radio network.

PROJECT-25 INTER RF SUBSYSTEM INTERFACE (ISSI)

Specific to a new P25 system, the radio system core controllers utilized by adjacent counties can support ISSI gateways. These gateways allow for the interconnection of disparate P25 radio systems in a manner that supports many P25 common features (I.e., Unit ID, Emergency Call, Group Calls, etc.) and roaming across radio systems. To support this level of interoperability, each P25 system must be equipped with ISSI equipment, one gateway per desired system connection.

Additional gateways could be purchased for planned growth connectivity to other future P25 systems Of course, concurrence in the form of a Memorandum of Understanding (MOU) or inter-government agreement (IGA) would be required for each such interconnection. The purpose of MOUs or IGAs here is to establish user roaming protocols, what talkgroups could be shared

across radio systems and cost/response responsibilities for maintaining this equipment and the various Ethernet linkages needed for the actual voice/data transport between gateways.

The use of ISSI gateways has been encouraged, due to their inherent Talkgroup management flexibility and the ability for radio users to roam outside their home systems and yet retain the ability to communicate with home groups and dispatch personnel. ISSI also falls within the P25 standards for different vendor infrastructure to communicate. A further advantage is, as was the case for control station linkages, software upgrades made to participant radio systems do not in themselves force others to undertake the cost of in-step software changes. Yet, the cost of ISSI gateways varies considerably by vendor. Costs have been seen to range anywhere between $250,000 and $2M, depending on the locations involved and willingness of vendors to support ISSI connectivity due to strategic market concerns.

Conceptual Solution #1 - TETRA System UHF – Expansion System

Harris County has access to a few UHF frequencies used in the current UHF TETRA System. This conceptual solution reuses those frequencies but requires licenses for more as more capacity is needed at the existing sites in addition to the new sites. For interoperability with Troup County and Muscogee County, this conceptual solution would require the County to purchase dual band radios (UHF and 700/800 MHz). This additional cost is included in the budgets later in this report.

This conceptual systems would provide an expansion of the current TETRA system to a 16-site TETRA System. In addition to filling in gaps throughout the County, this design adds tower sites around the I-185 corridor in addition to improved coverage in the city limits plus one (1) mile boundaries.

There are other Pros and Cons to expanding a UHF TETRA system.

Pros

- Reuse of existing UHF frequencies
- UHF has better wide area coverage than 800 MHz requiring fewer overall towers
- Some county radios may be able to be reused
- Diverse Power handles Core operations
- Diverse Power shares maintenance costs

Cons

- Limits Mutual-Aid with other agencies that remain on VHF or 700/800 MHz technologies without multiple radios.
- Radio roaming mutual aid abilities with Troup County and Muscogee County require a separate radio than the TETRA radio.
- UHF has worse in building coverage that 800 MHz requiring towers to be located near population centers
- UHF is more difficult to balance talk-in / talk-out
- UHF BDAs are more expensive than 700/800 MHz BDAs to cover dense critical buildings
- Diverse Power owns the system and does not require the County's permission to make any modifications up to and including termination of the system.
- TETRA equipment is not eligible for federal grant funds
- County investment would not be owned by Harris County

The following are the coverage expectations based on the UHF conceptual design as listed in a table of coverage expected in the towns plus one (1) mile:

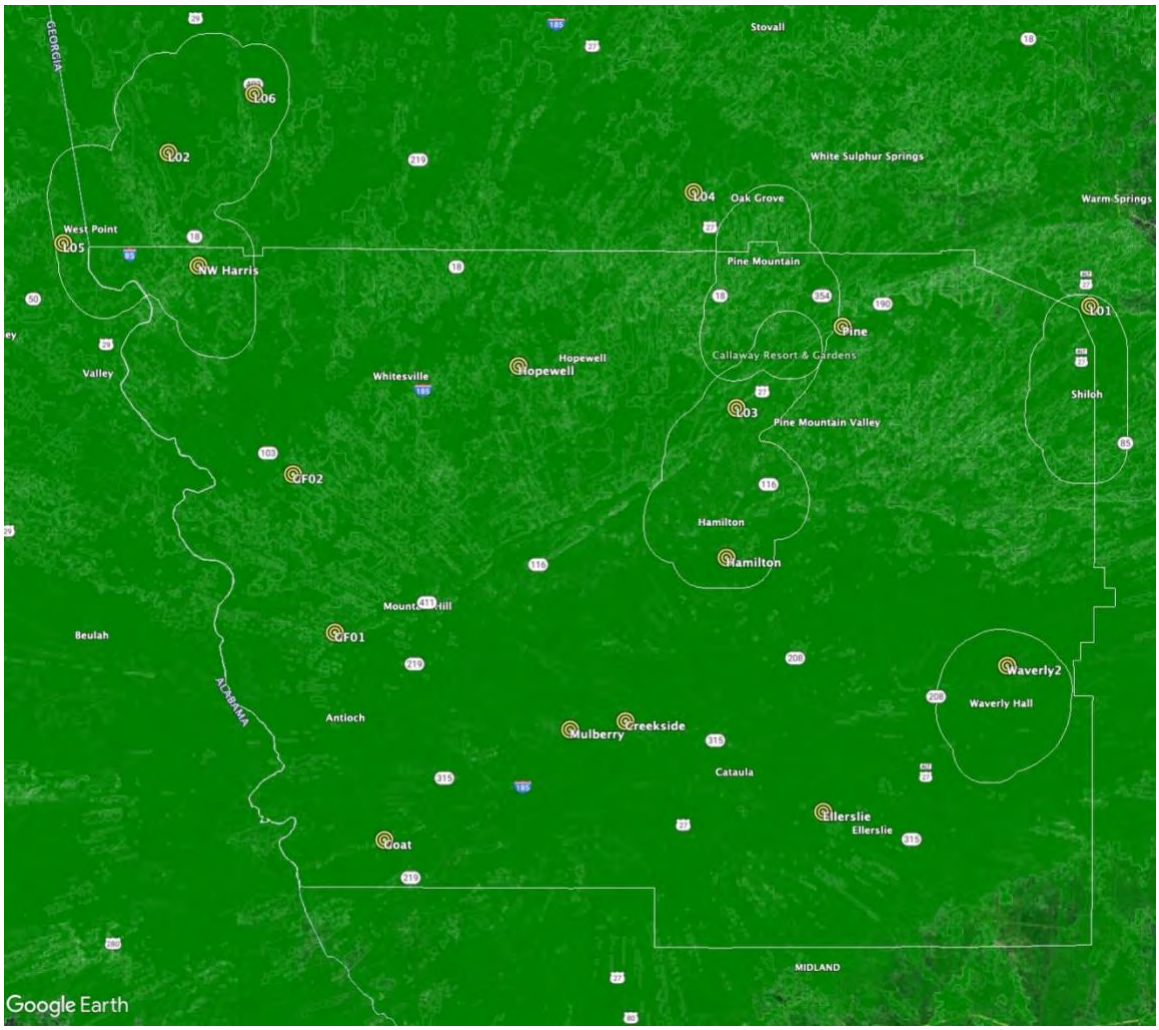
	MTI	PTI	PTI 12db	PTI 20db
Harris County	99.9%	95.3%	-	-
Hamilton	99.9%	99.8%	96.5%	88.4%
Waverly Hall	99.9%	99.8%	95.1%	77.5%
Pine Mountain	99.9%	99.7%	96.5%	82.5%
Shiloh	99.9%	97.9%	95.3%	77.8%
West Point	99.9%	99.6%	95.9%	87.6%

*Highlighted are below minimum goals for coverage set at start of coverage modeling section

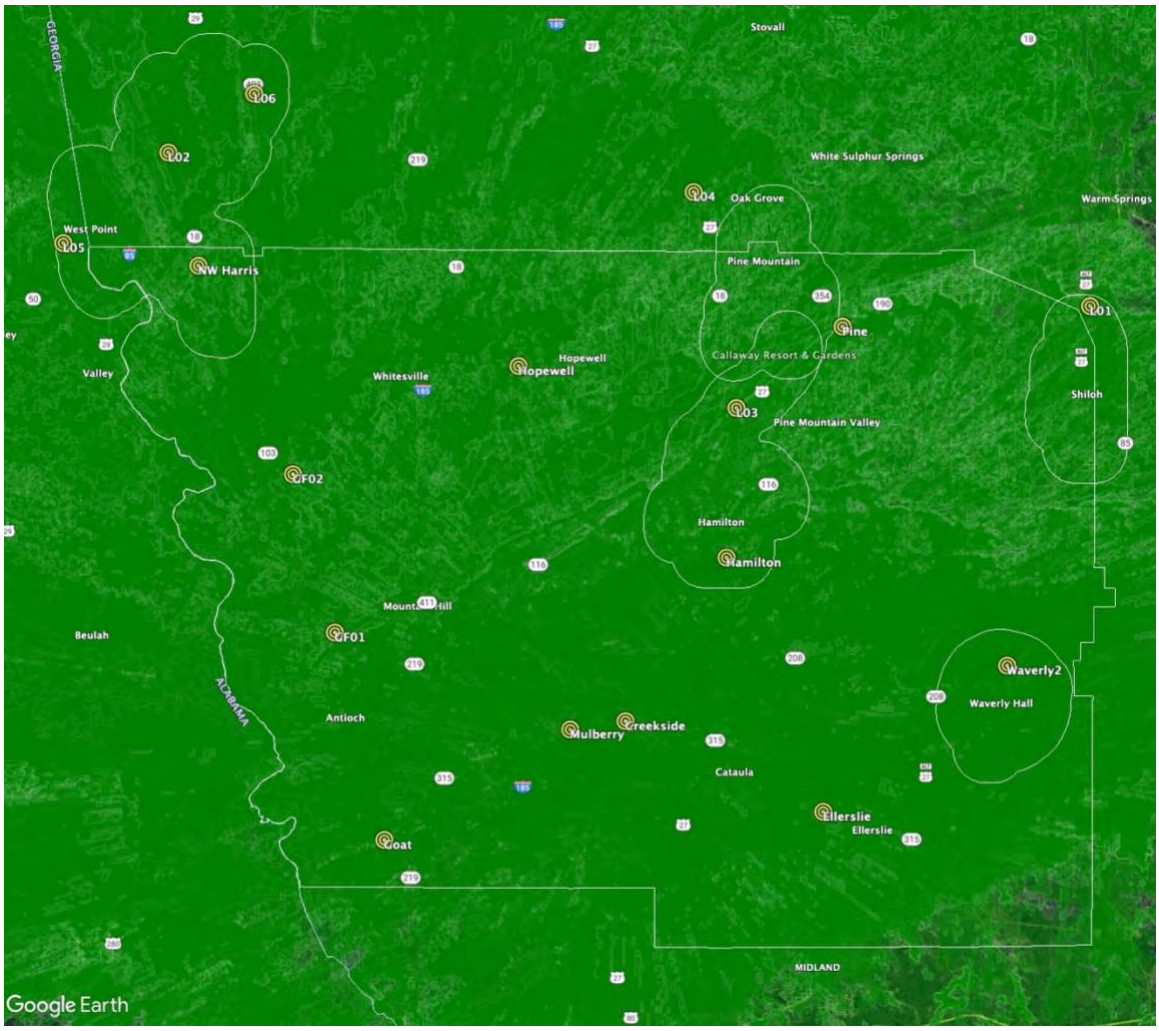
This solution would reuse four of the existing sites with modifications to add talkpaths (Ellerslie, Goat Rock, Hamilton, NW Harris, Mulberry, Pine Mountain and Hopewell). It would reuse the Waverly site with a directional antenna adjustment and additional talkpaths. It would also require the addition of two (2) new greenfield sites (GF01 and GF02) as well as six (6) lease sites (L01 through L06).

All lease sites except L03 are outside the boundary of Harris County and may be removed or modified as a cost savings option if coverage throughout the expanded city boundaries is not required.

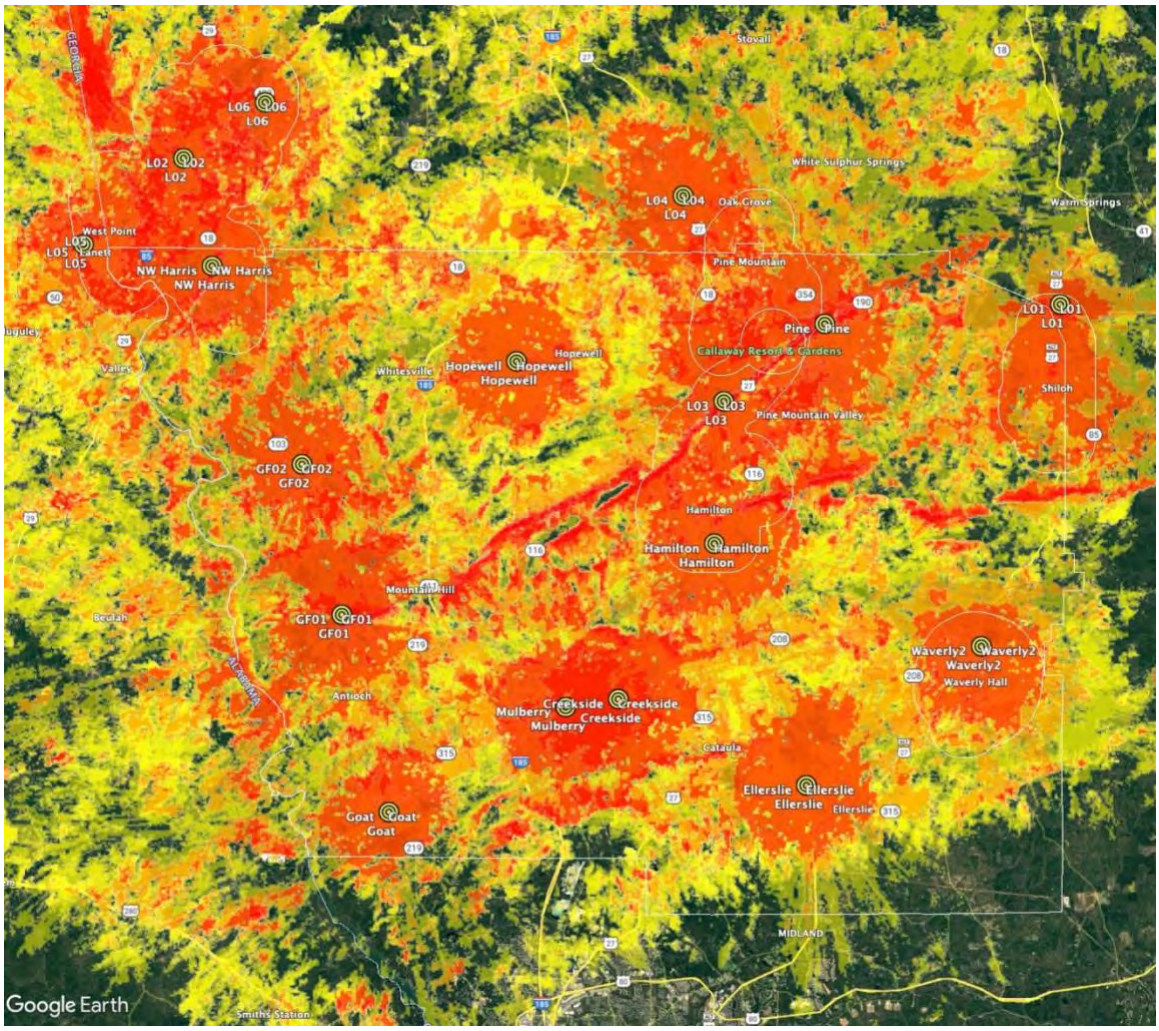
The coverage maps for Conceptual Solution 1 are as follows on the next pages:



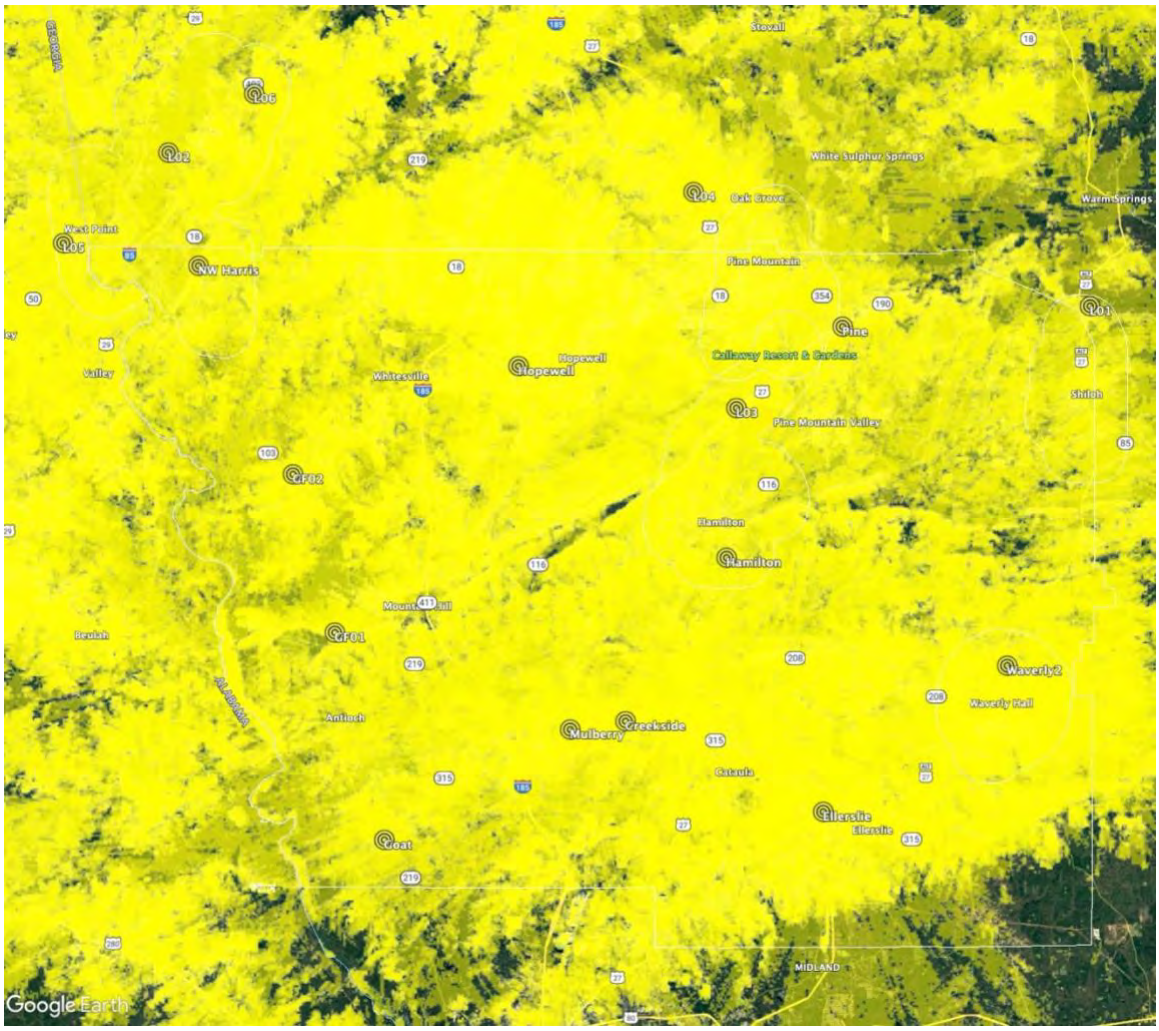
Mobile talk-out (a tower to a user in the field)



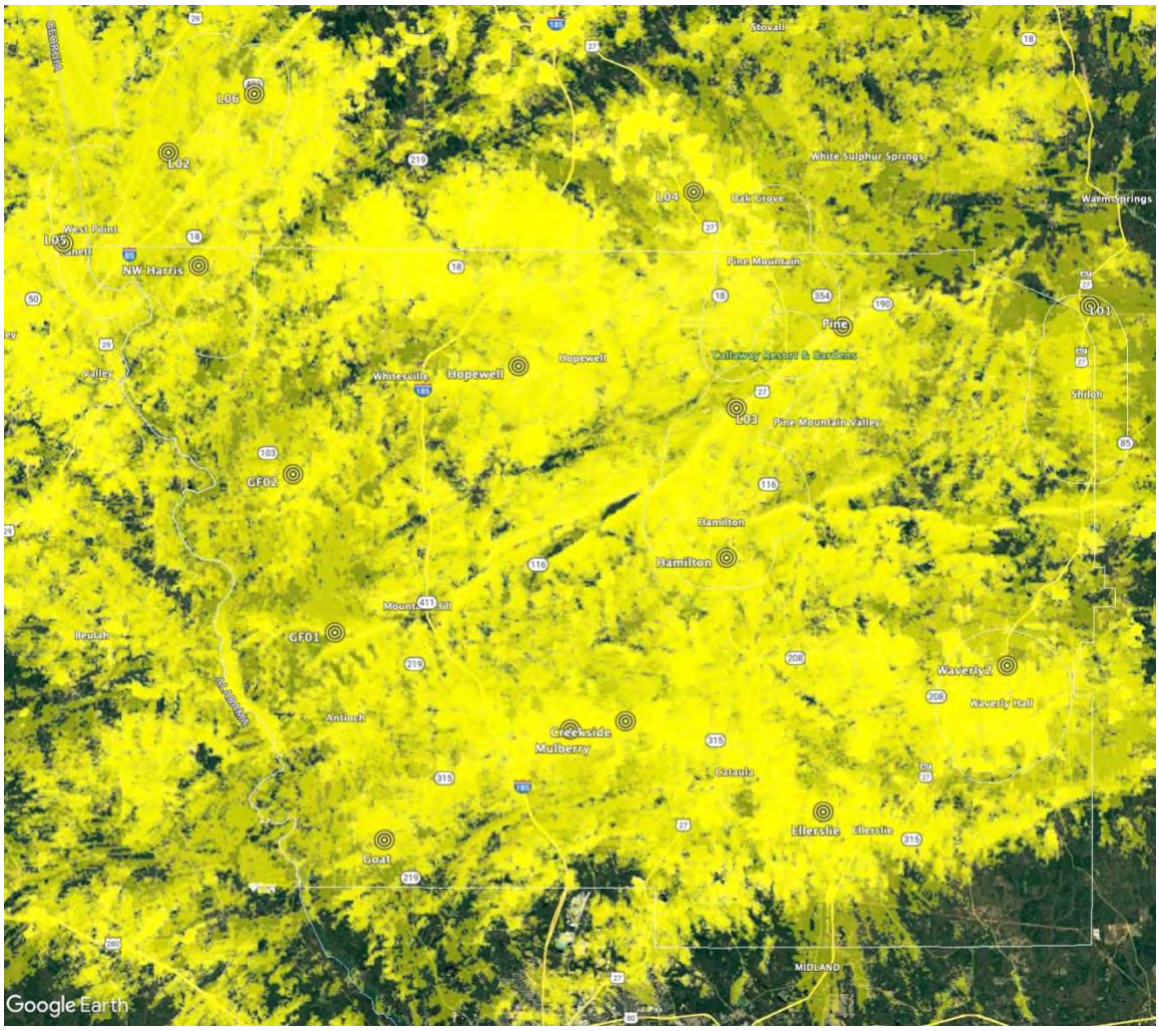
Mobile talk-in (a user in the field to a tower)



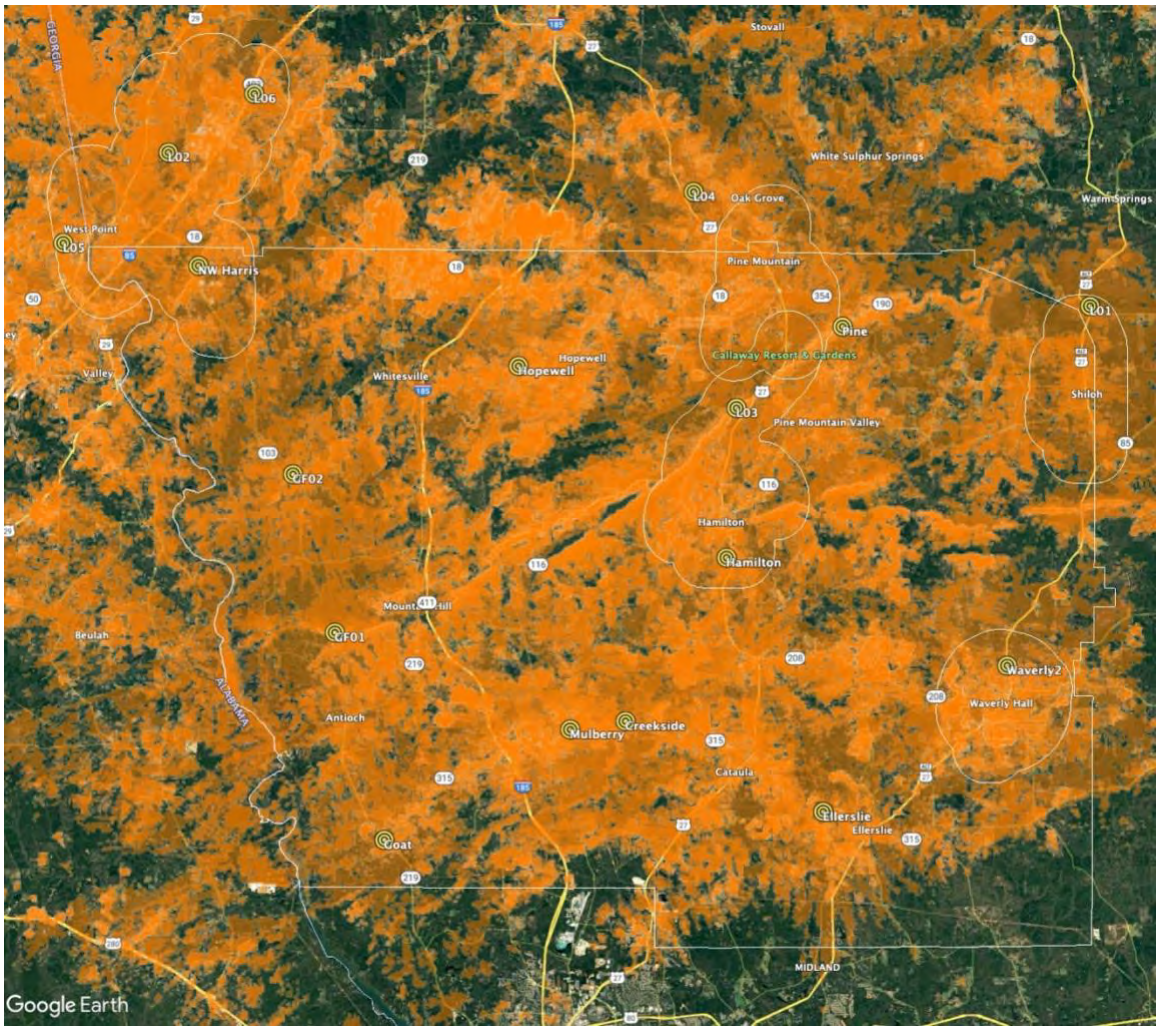
This heat maps illustrates the improved coverage resulting from the expansion of the current TETRA system which would provide 95.3% portable on-hip/on-street coverage to Harris County.



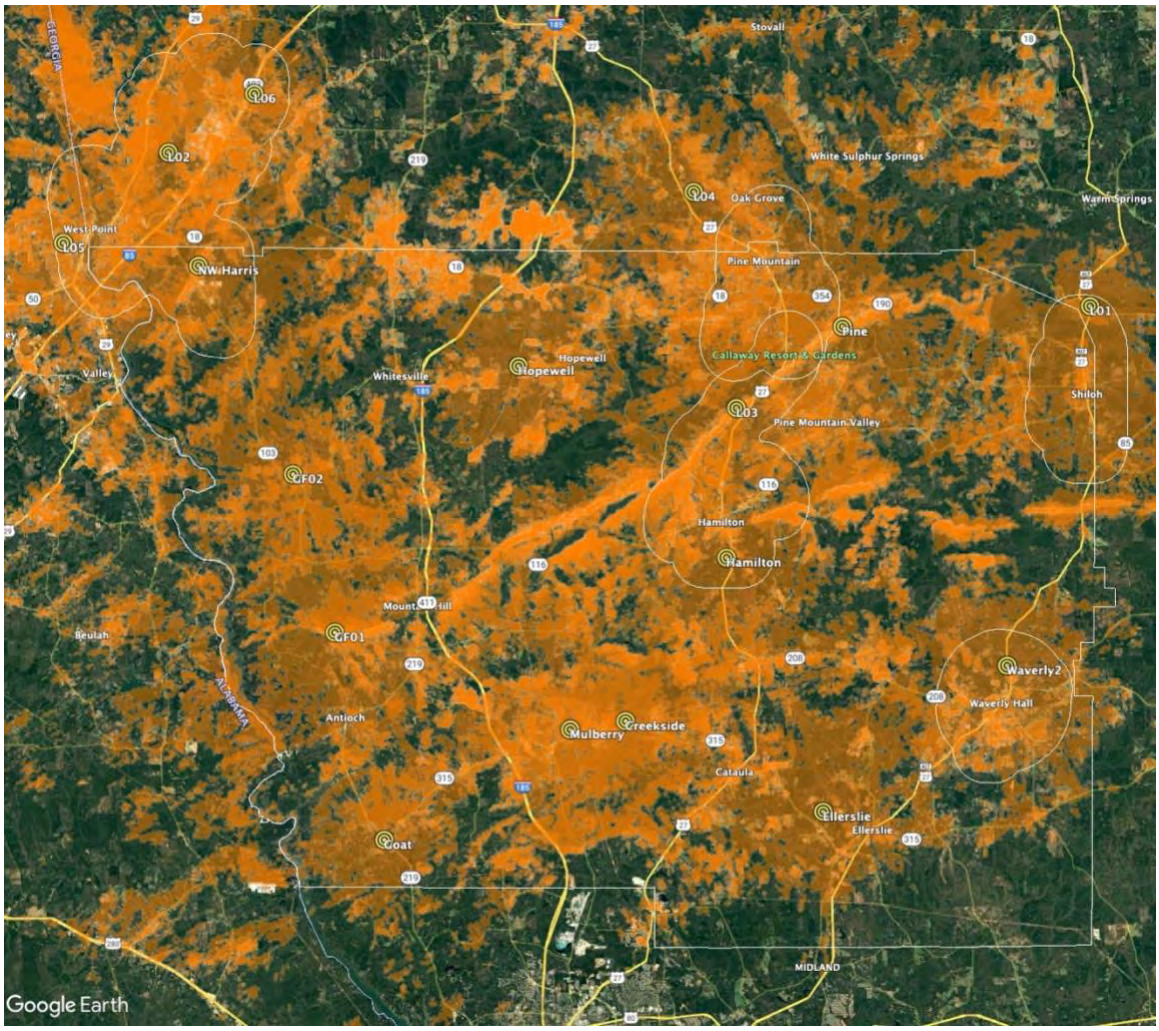
Portable on-hip talk-out on the street



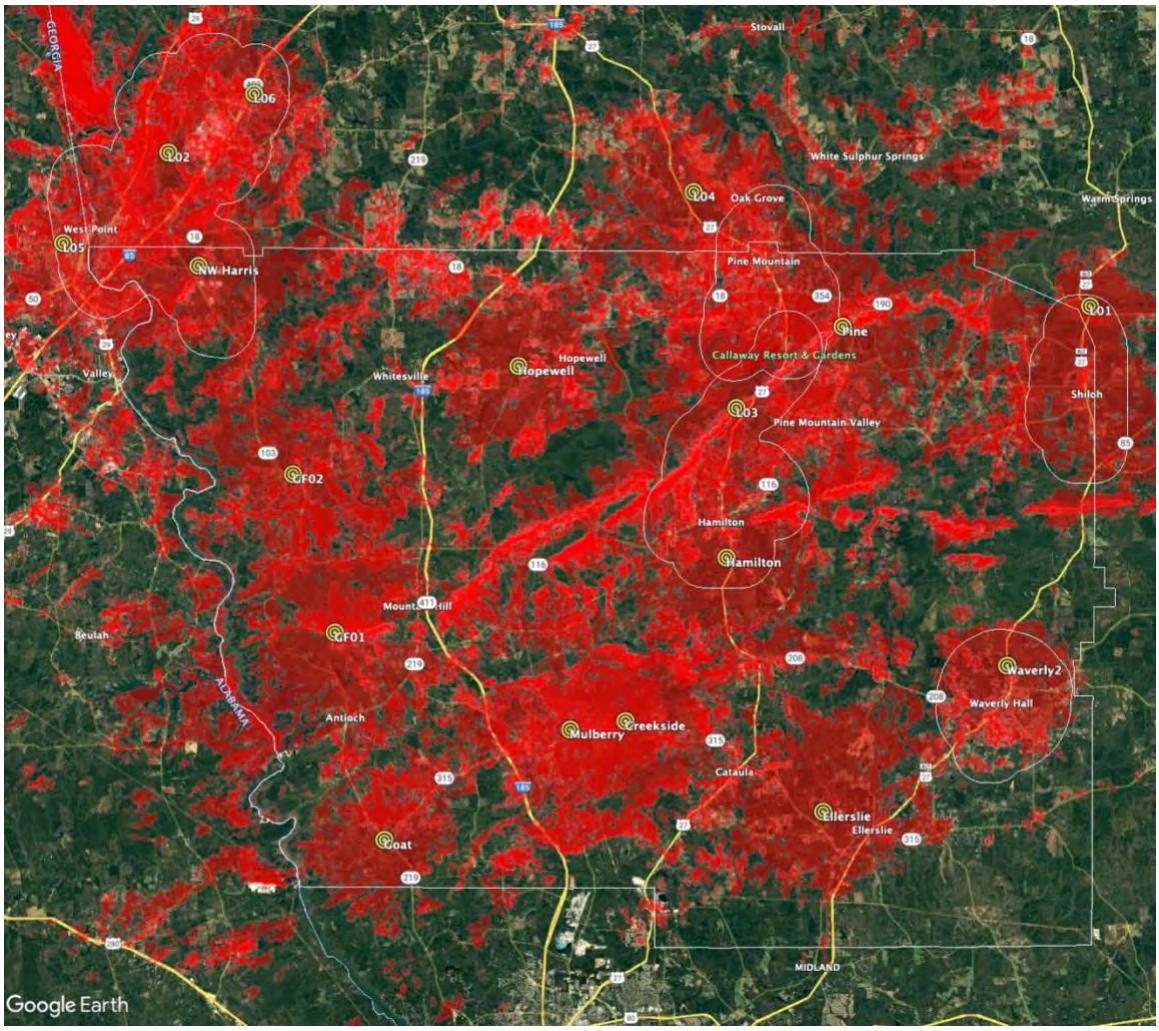
Portable on-hip talk-in on the street



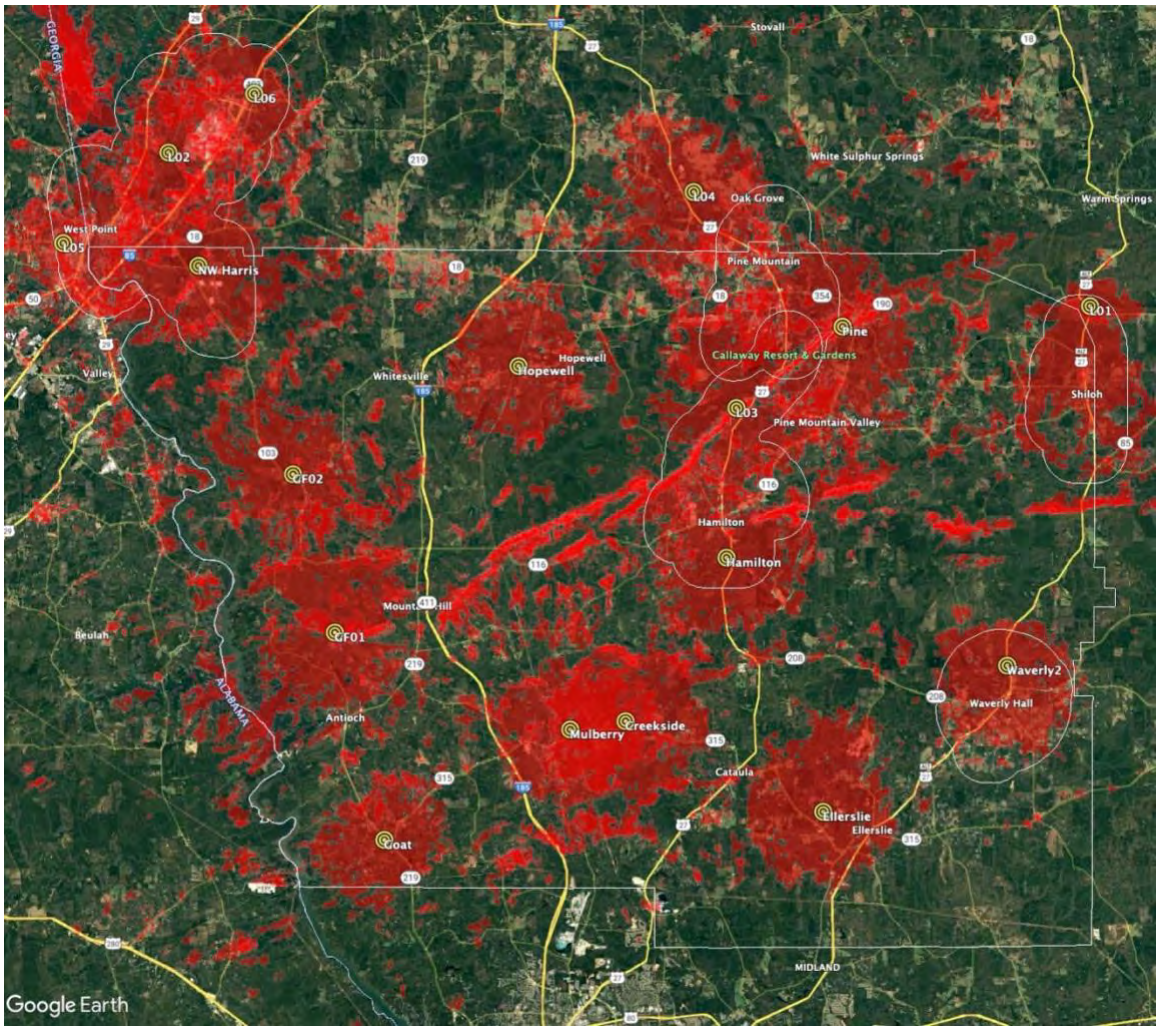
Portable on-hip talk-out inside 12db buildings



Portable on-hip talk-in inside 12 db buildings



Portable on-hip talk-out in 20db buildings



Portable on-hip talk-in inside 20 db buildings

Conceptual Solution #2 - P25 System 800 MHz – Standalone System

The remaining conceptual solutions migrate Harris County to an 800 MHz P25 trunking system. While transitioning to 800 MHz has the tendency to require more sites than VHF or UHF for coverage, with the use of TTA devices on towers in 700/800 MHz to provide balanced Talk-out/Talk-in coverage, in the case of Harris County, only 15 total towers are required to meet the same minimum coverage requirements. Also, the strong FCC frequency planning in 700/800 MHz which reduces interferences issues and the ability to provide lower cost BDA devices for In-Building coverage, may offer a savings in the long term by providing much higher likelihood of delivering coverage into critical buildings throughout the county. In a VHF/UHF system, the only way to reasonably add coverage into an existing dense building is to construct a site near that building. A new site can, at times, cost upwards of $1,000,000. Whereas, depending on the size of a building, a BDA can cost between $20,000 for a smaller building, to $400,000 for a very large complex, such as a college or a jail. Fortunately, 800 MHz also provides much better in-building penetration than VHF/UHF. However, when a system is properly designed, with sites built near higher population areas, fewer BDAs are needed.

The standalone 700/800 MHz conceptual systems would provide a 15-site simulcast P25 trunking operation. By utilizing simulcast technology, all sites will be both transmit / talk-out and receive / talk-in sites compared to the single transmit site in the county today. This option increases overall talk-out coverage and creates a much more balanced talk-out / talk-in design. In addition to filling in gaps throughout the County, this design adds four (4) lease tower sites and three (3) greenfield sires around the County including to provide better inbuilding coverage than is possible with a greater number of UHF sites.

TUSA included new towers physically located in neighboring counties as part of this report. Just like in conceptual solution #1, the option of removing lease sites in the neighboring counties is a cost saving option. The difference when removing sties in this option is, the shared P25 coverage is still available and would benefit the county with a mutual aid agreement with Troup County and Muscogee County.

There are other Pros and Cons to an 800 MHz P25 Trunking System:

Pros

- Better Coordinated Frequency Planning by FCC
- BDA are less expensive and easier to use.
- Large group of interoperability channels
- Radio roaming mutual aid abilities with Troup County and Muscogee County without a separate radio
- Ownership of the system with administrative rights and privileges
- Ability to use federal grant funding on new equipment

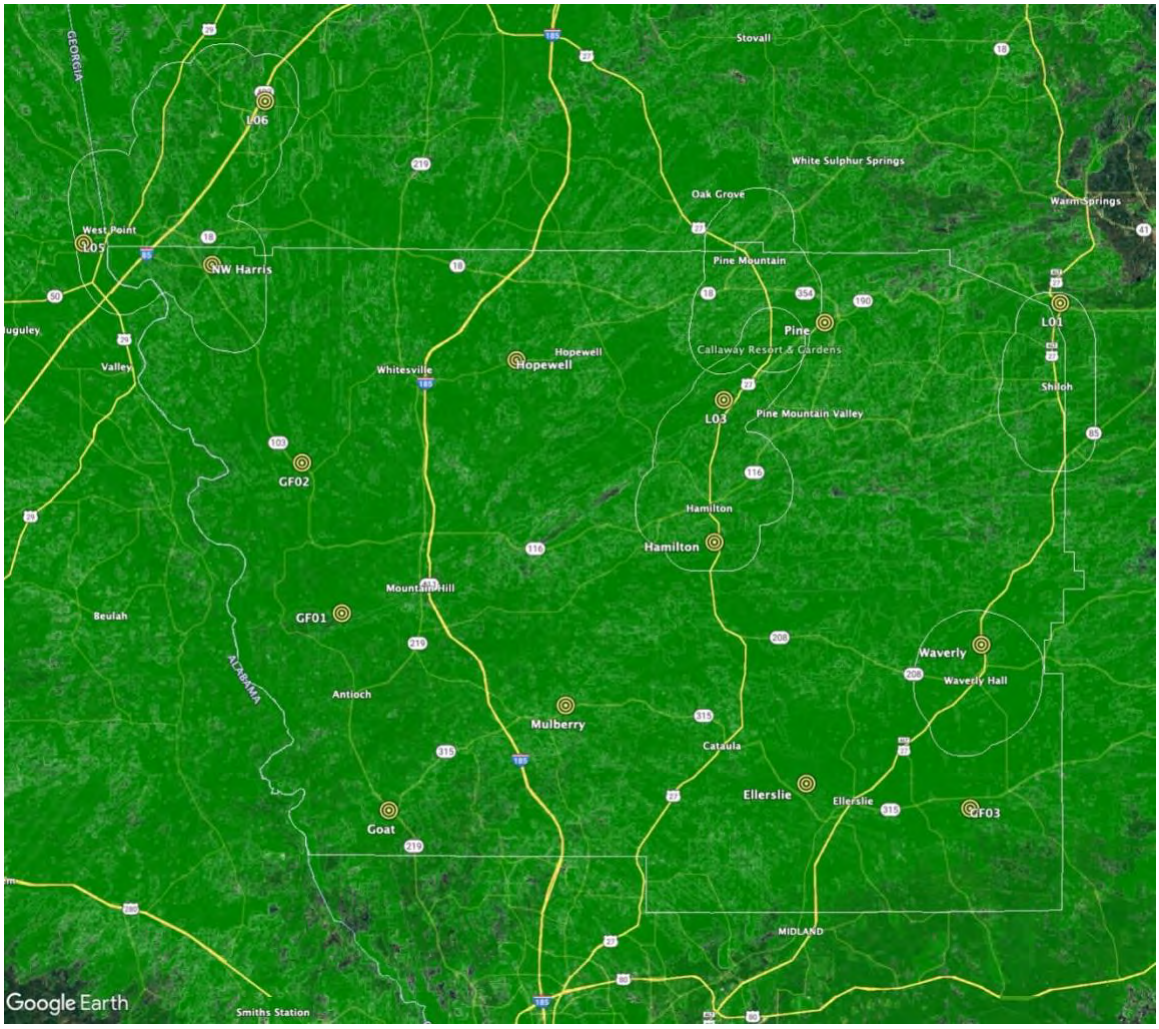
Cons

- Requires hardware replacement for all radios in the County.
- Requires a larger CAPEX expenditure to initially implement the new system than the TETRA expansion option

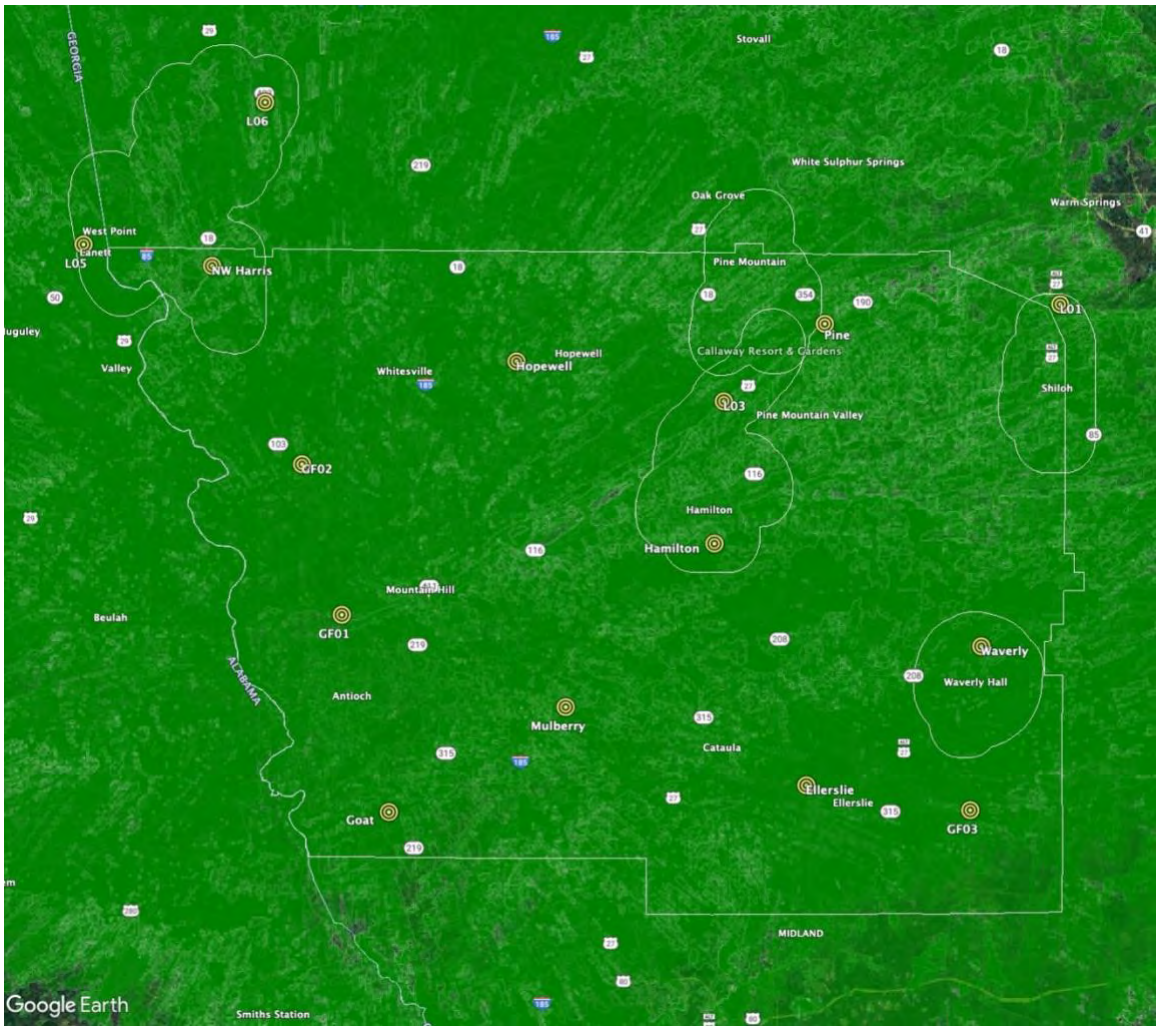
The following are the coverage expectations based on the 800 MHz conceptual standalone design listed as table of coverage expected in the towns Harris County:

	MTI	PTI	PTI 12db	PTI 20db
Harris County	99.9%	96.3%	-	-
Hamilton	99.9%	99.8%	97.8%	94.3%
Waverly Hall	99.9%	99.9%	99.6%	97.4%
Pine Mountain	99.9%	99.1%	96.5%	88.7%
Shiloh	99.9%	98.5%	95.2%	89.8%
West Point	99.9%	99.1%	95.2%	88.4%

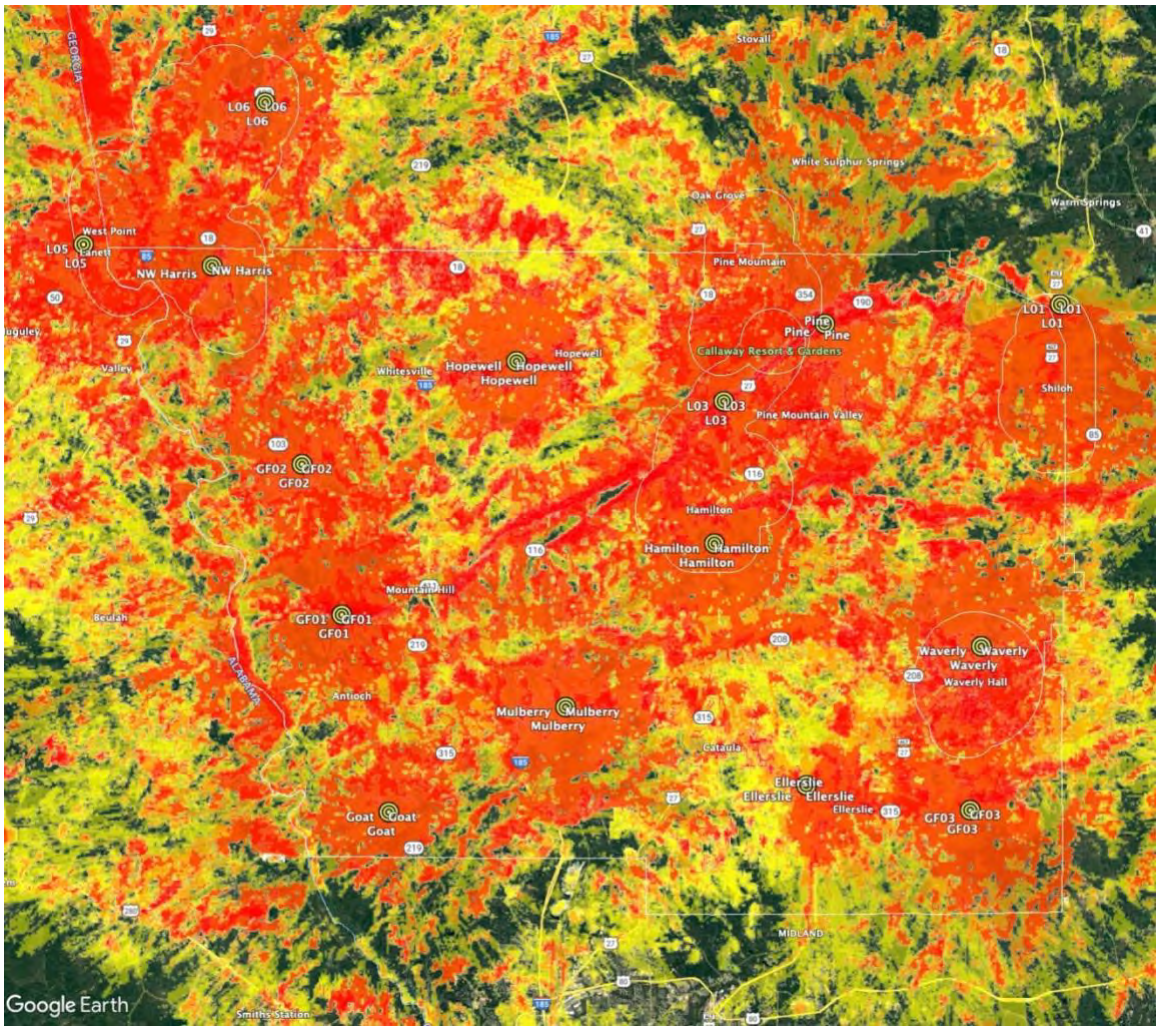
*Highlighted are below minimum goals for coverage set at start of coverage modeling section



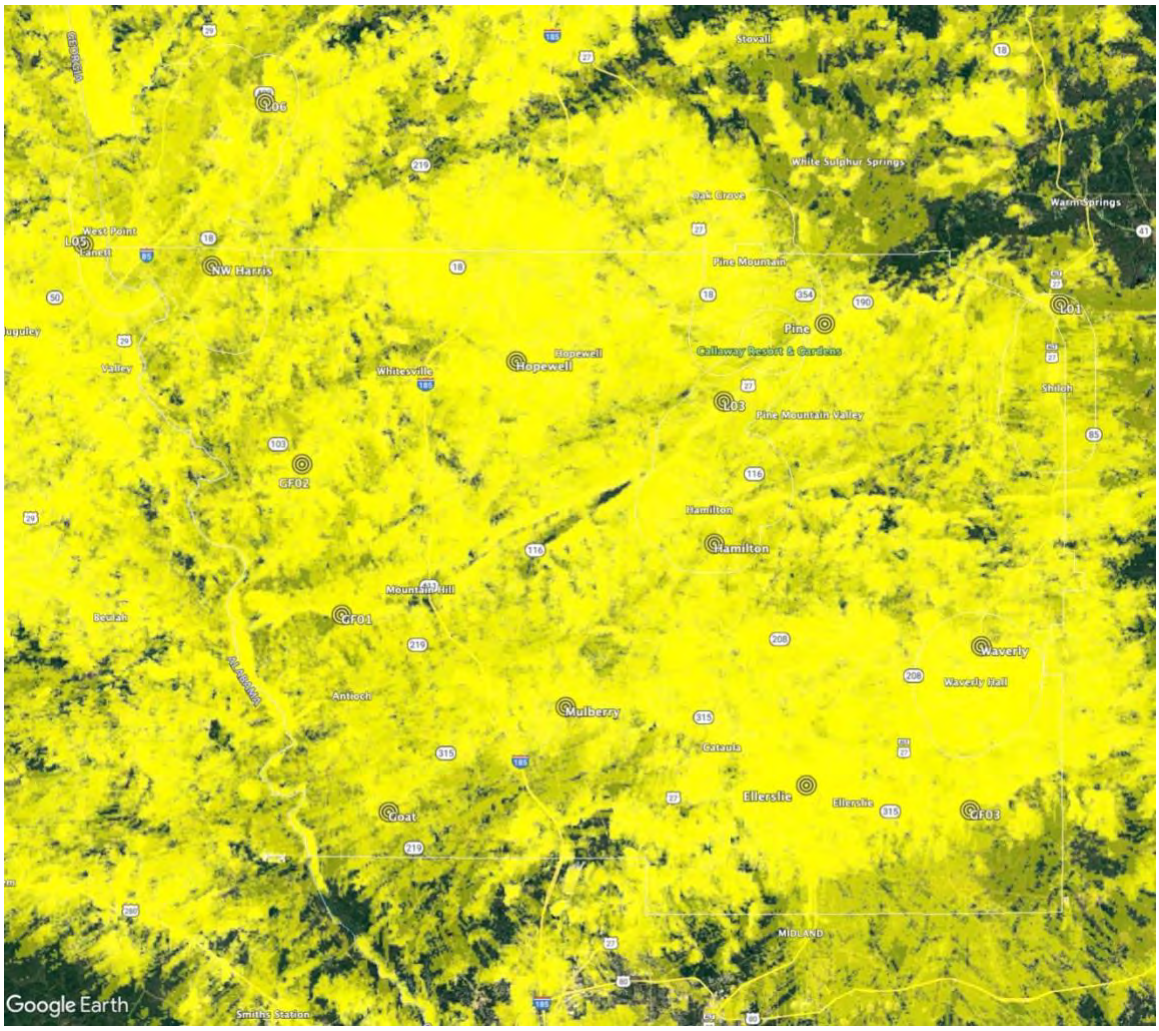
Mobile talk-out (a tower to a user in the field)



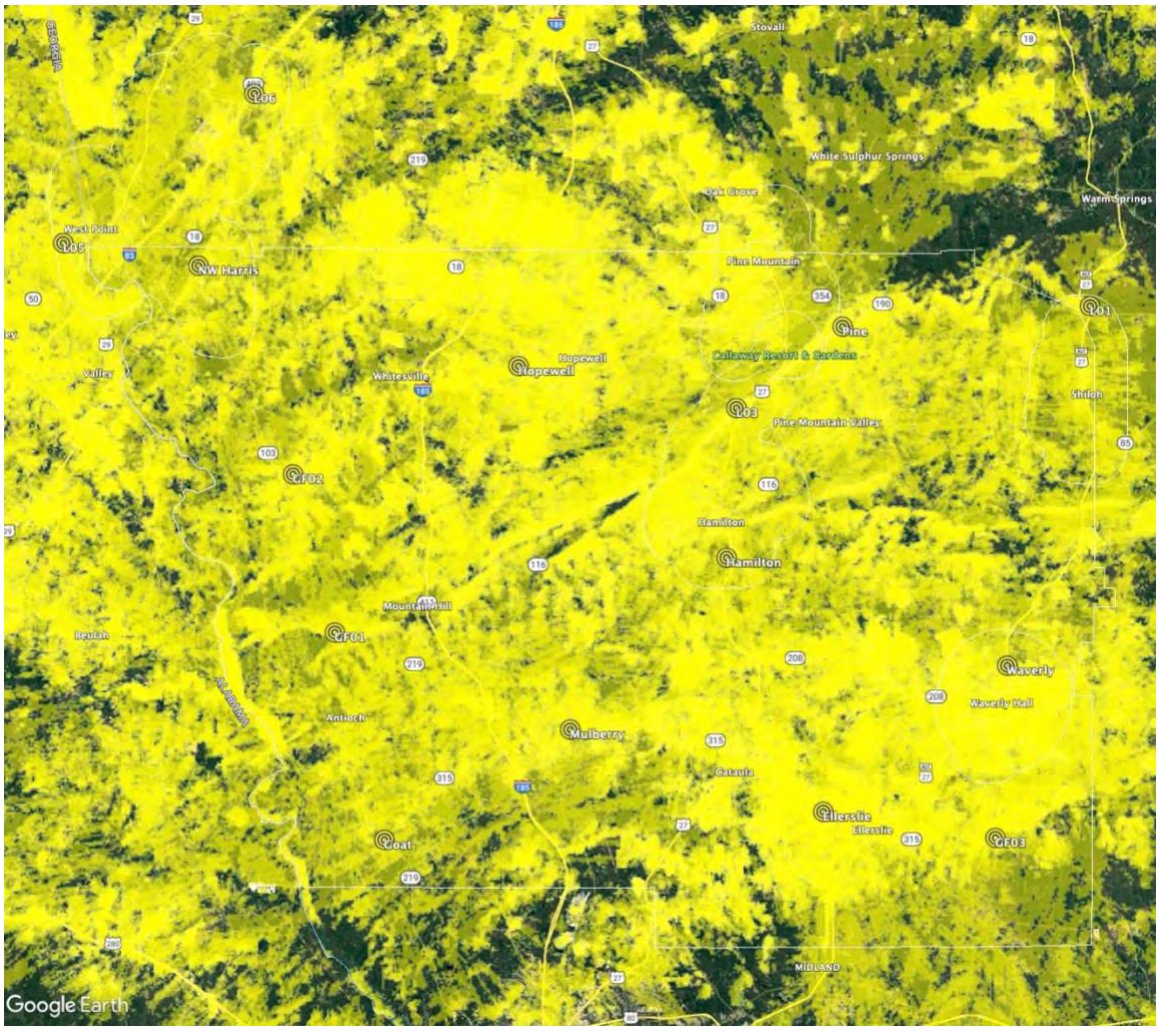
Mobile talk-in (a user in the field to a tower)



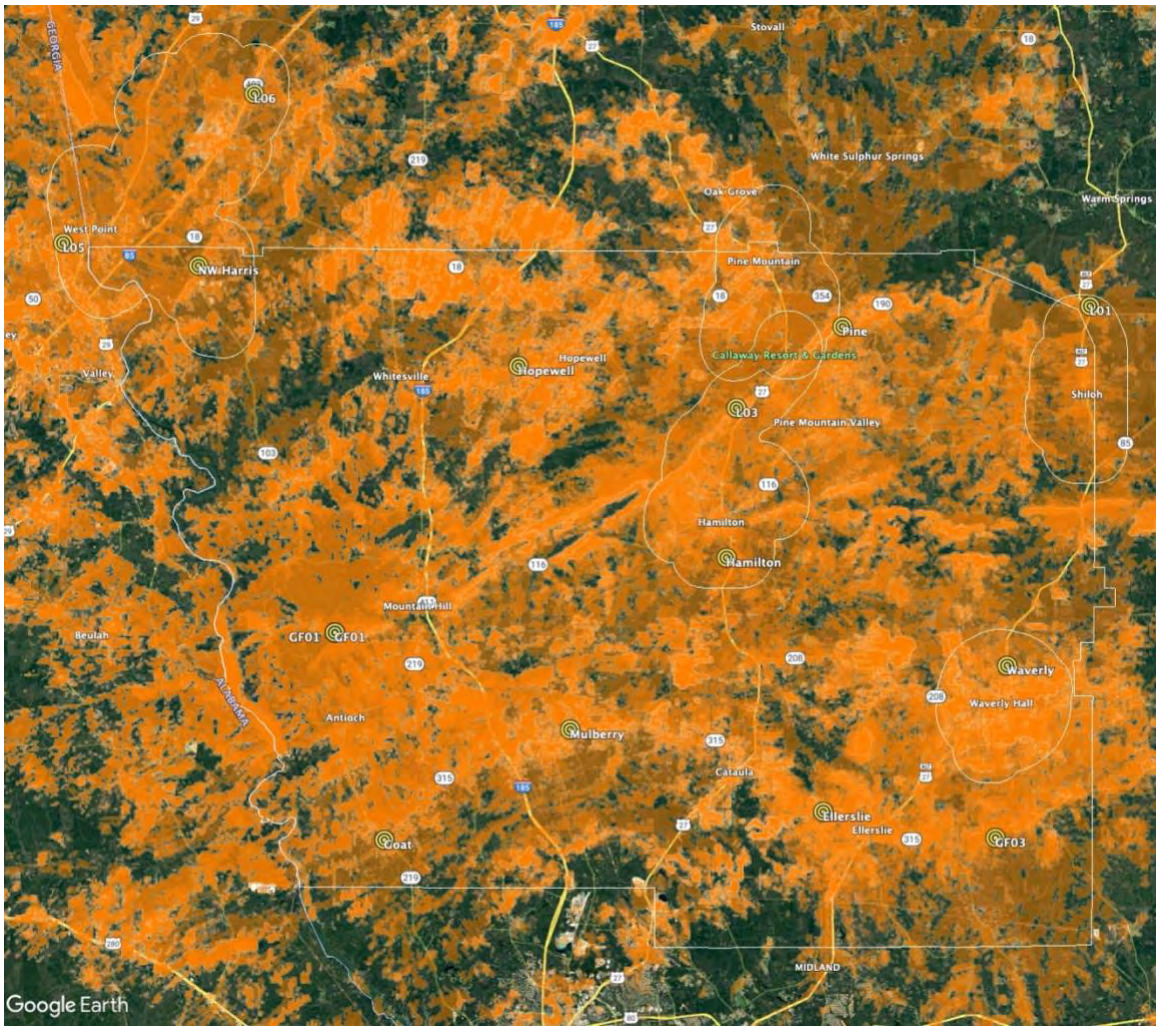
This heat maps illustrates the improved coverage resulting from the expansion of the current TETRA system which would provide 96.3% portable on-hip/on-street coverage to Harris County.



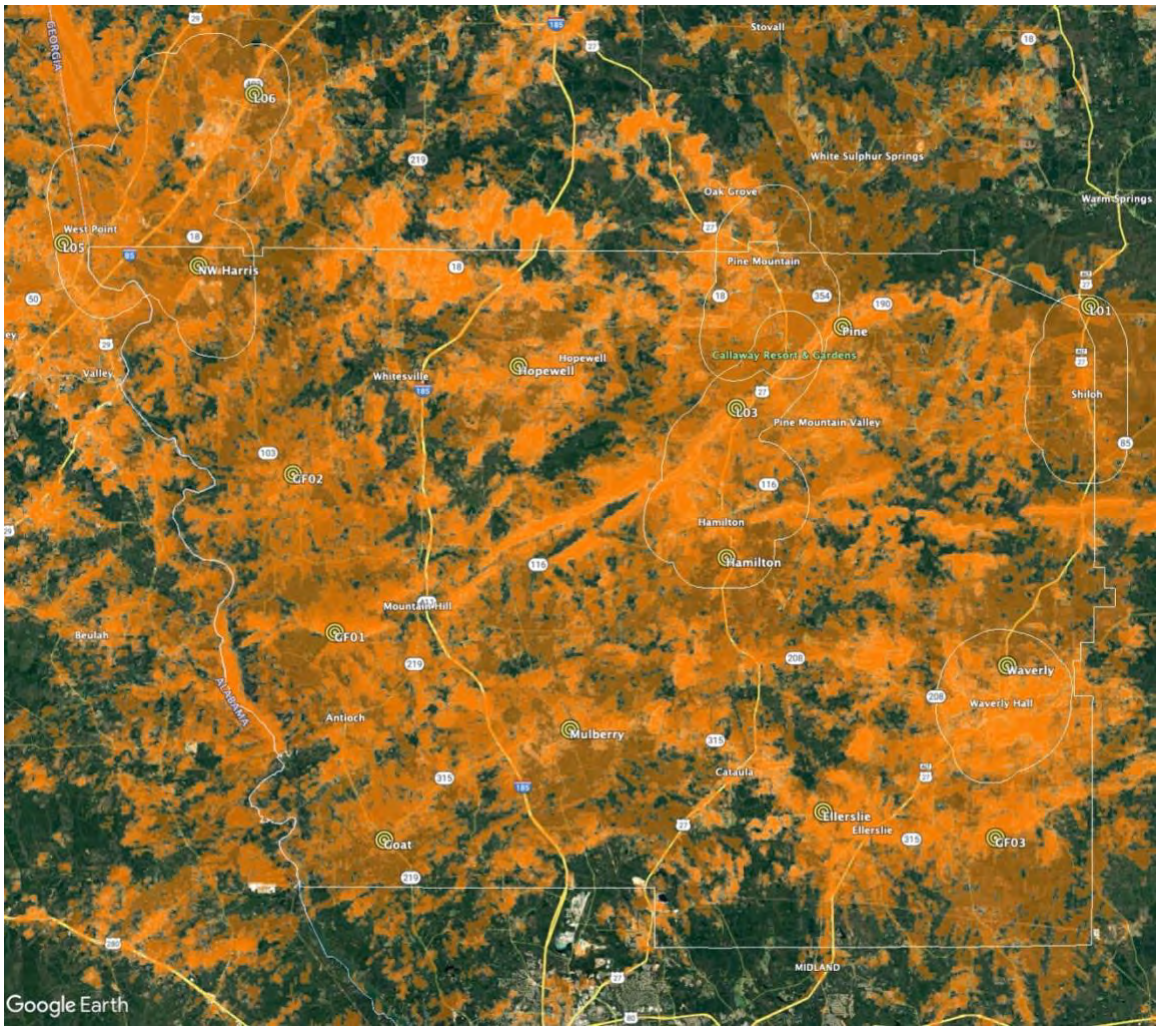
Portable on-hip talk-out on the street



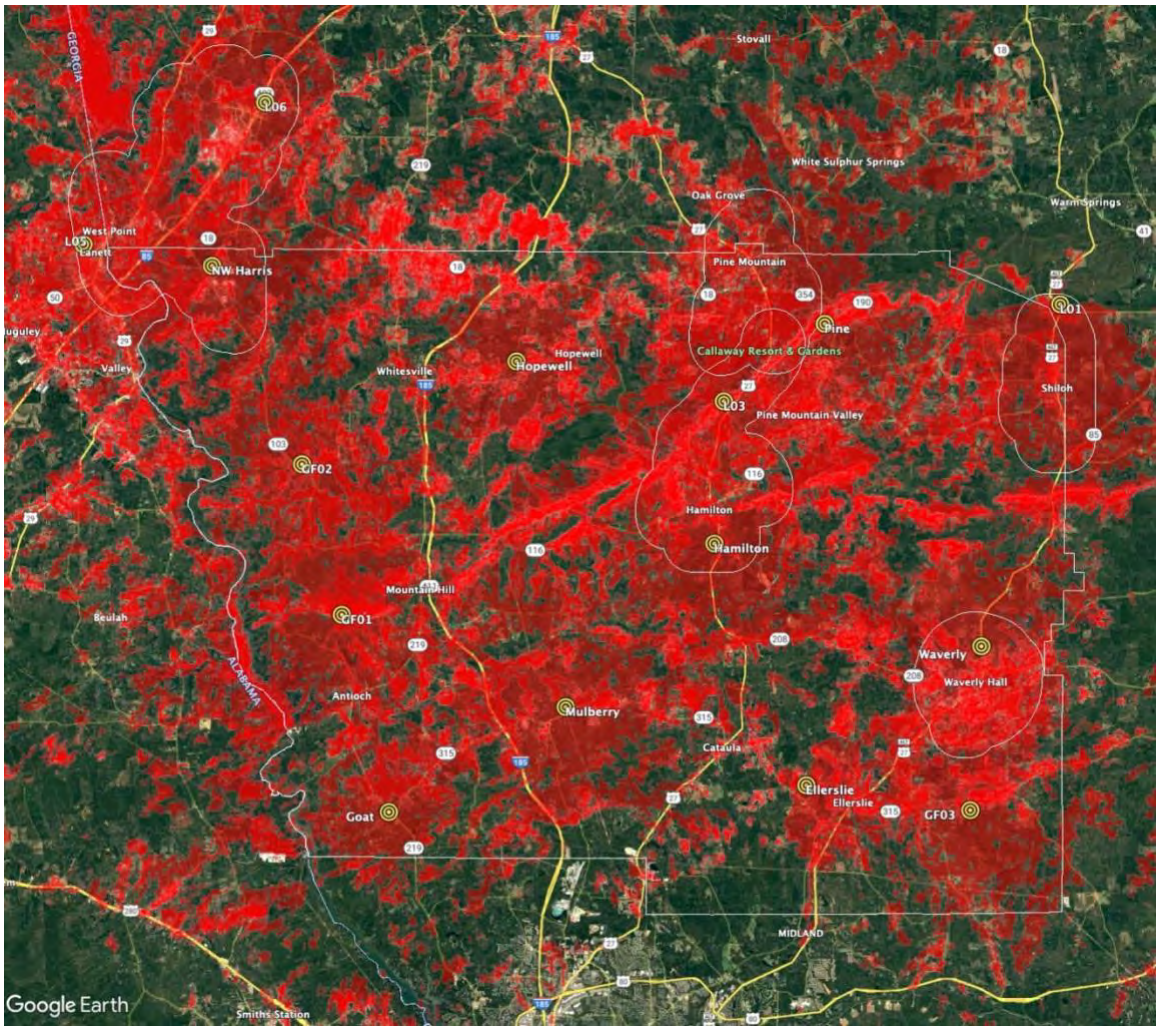
Portable on-hip talk-in on the street



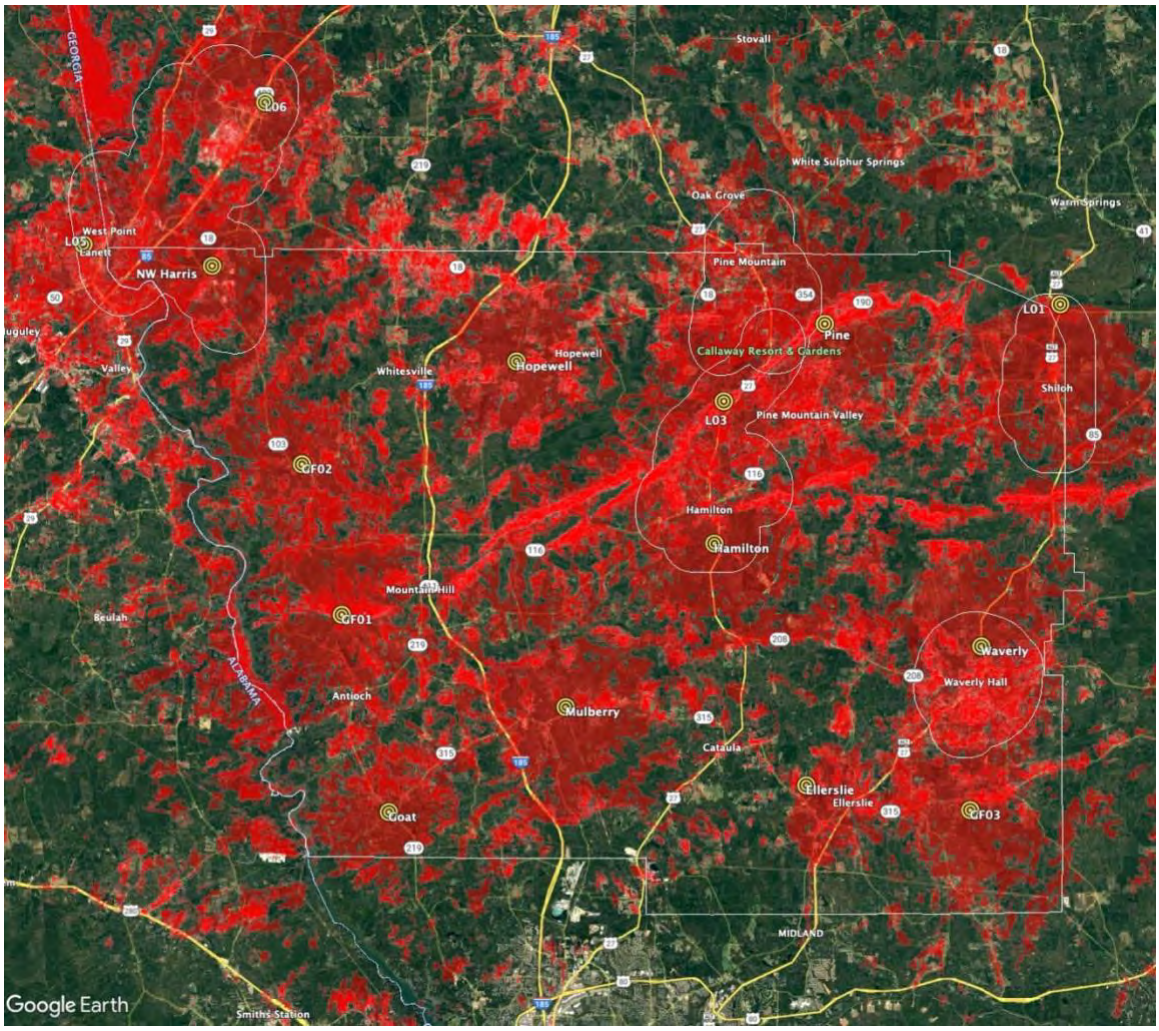
Portable on-hip talk-out inside 12db buildings



Portable on-hip talk-in inside 12db buildings



Portable on-hip talk-out in 20db buildings



Portable on-hip talk-in in 20db buildings

Conceptual Solution #3 - P25 System 800 MHz – Join Existing System

Of the two 800 MHz conceptual solutions, one is a standalone system option where Harris County would own and operate their own core and network without cooperation with any other county. While a stand-alone system offers the most overall self-control for the county, TUSA is also respectful of the significant prices involved with these systems. Because of this, TUSA is also including conceptual solutions that include sharing costs with neighboring counties by joining an existing system such as Troup County or Muscogee County.

If Harris County elects to use an existing core, with the permission of the owner, they can select to install single core with the existing core as the backup rather than paying for two geographically diverse cores within Harris County. Some vendors also allow for a simpler version of the core that is cloud based further reducing CAPEX costs. Furthermore, since Harris County would then share in the maintenance of the core(s) rather than be solely responsible, this reduces OPEX as well.

For this conceptual solution, the tower locations and count remain the same as the previous conceptual solution. Existing sites in Troup County and Muscogee County do not provide the required indoor coverage to the municipal areas (plus 1 mile) for West Point and Shiloh. However, if it is determined that inbuilding coverage outside of the county within these two municipalities is not required, as before, several tower sites can be removed for a cost reduction.

For coverage maps and percentages, see Conceptual Solution #2. The budget for this and all conceptual solutions is located in the next section of this report.

16. Conceptual Design Budgets

The following budgetary estimates for P25 systems are based off actual prices that TUSA has seen in recent RFPs with other clients. It takes into consideration cost results seen by other recent procurements throughout the country.

The budgetary estimate for expanding the TETRA system is based off estimates from Diverse Power EMC, Dean's Two-way, and industry averages.

The budgetary estimates also look at the total cost of ownership over a 15-year anticipated lifecycle period. Often, a proposing vendor will discount the system on the front end, only to make up for it on the back end. TUSA looks at the entire life cycle of the system as proposed by responsive vendors, including maintenance and upkeep as part of the RFP specification process.

There are multiple options in today's procurement environment that the County can consider. These options typically are:

- Capital Outlay (CAPX) – County pays for the system and then budgets yearly for maintenance throughout the system life cycle.
- Leased Option (OPX) – County pays for the system over a defined period to include maintenance throughout the system lifecycle.
- Service Option – Vendor builds the network, and the County pays a monthly service fee over the lifecycle.

16.1. Conceptual Solution #1 - TETRA System UHF – Expansion System

The following budget shows the anticipated procurement costs for Conceptual Solution #1 - TETRA System UHF – Expansion System. TUSA budgets for full replacement of radios throughout the county even through in the conceptual solution, some UHF radios may be able to be reused as back-up or cache radios. Included in this budget is

- New Transmit and Receive RF equipment to all new sites
- Additional Transmit and Receive RF equipment to existing sites for capacity increase
- New antennas and lines at each new site
- New additional sites, including towers, to reach minimum of 95% coverage countywide portable on-hip, with the other stipulations in coverage requirements
- New shelters at all new sites and Hamilton existing site
- New user TETRA radios
- New IP technology at new sites (Microwave and correlated network devices)
- DC Power plants and generators at all sites to allow for 8 hours back up for RF equipment and 18 hours back-up for microwave and network equipment
- 15 years of support and maintenance

CONCEPTUAL SOLUTION #1 - TOTAL COST OF OWNERSHIP

There are pros and cons associated with this conceptual solution that can be defined as follows:

Pros

- Less CAPEX to expand system
- Some UHF radios may be able to be reused as back-up or cache radios
- Reuse of existing frequencies
- Continued use of existing RF equipment
- Continued use of existing microwave equipment
- Shared maintenance

Cons

- Additional radios capable of 800 MHz P25 required for interoperability
- UHF band is an unusual band for public safety, most operate in VHF or 700/800 MHz
- In-building BDAs are more expensive than in the 700/800 MHz band
- More difficult to achieve talk-in / talk-out balance than 700/800 MHz
- Less autonomy operating on Diverse Power's Core
- Equipment not eligible for federal grant funds
- Testing to determine coverage baseline prior to final expansion design
- Noted intermodulation issues from 2017 report still a concern
- Little control over system/Core maintenance, features, functionality
- TETRA radios not containing all required public safety features and functions

Harris County Conceptual Sol. #1 - TETRA UHF - Expansion System	
Pricing Summary	
Description	**Total**
Voice Infrastructure	$4,016,000
Systems Integration	$1,244,960
Training and Interop	$300,000
Voice Infrastructure Total	**$5,560,960**
Site Construction	$6,752,000
Site Construction Contingency	$1,012,800
Site Construction Total	**$7,764,800**
Microwave	$2,222,816
Microwave System Integration	$689,073
Microwave Contingency	$222,282
Microwave Total	**$3,134,171**
Customer Dispatch Centers	$184,412
Dispatch Center Total	**$184,412**
Customer Subscribers	**$626,759**
Customer Grand Total	**$17,271,102**
Competitive Procurement Process	
Infrastructure	$12,344,948
Dispatch	$138,309
Subscribers	$501,407
Competitive Process Grand Total	**$12,984,664**

Harris County Conceptual Sol. #1 - TETRA UHF - Expansion System	
Maintenance Budget	
Description	**Total**
Competitive Process Grand Total	**$12,984,664**
Maintenance Services (2-5 yr plan)/Estimated	
Corrective Maintenance and Software/Hardware Maintenance	$770,787
Preventative Maintenance	$88,000
Subscriber Depot & Return	$124,704
Microwave Maintenance	incl
HVAC	$36,000
Generators	$76,800
Battery Plants & UPS	$64,000
Logging Recorder	$25,000
Year 2-5 Maintenance Services Plan Total	**$1,185,291**
Average Yearly Total	**$296,323**
Maintenance Services (6-10 yr plan)/Estimated	
Corrective Maintenance and Software/Hardware Maintenance	$1,025,147
Preventative Maintenance	$117,040
Subscriber Depot & Return	$207,840
Microwave Maintenance	incl
HVAC	$41,400
Generators	$88,320
Battery Plants & UPS	$73,600
Logging Recorder	$25,000
Year 6-10 Maintenance Services Plan Total	**$1,578,347**
Average Yearly Total	**$315,669**
Maintenance Services (11-15 yr plan)/Estimated	
Corrective Maintenance and Software/Hardware Maintenance	$1,178,919
Preventative Maintenance	$134,596
Subscriber Depot & Return	$259,800
Microwave Maintenance	incl
HVAC	$62,100
Generators	$132,480
Battery Plants & UPS	$84,640
Logging Recorder	$25,000
Year 11-15 Maintenance Services Plan Total	**$1,877,535**
Average Yearly Total	**$375,507**
Lease Cost Estimate Years 1-15 (6 lease sites)	**$2,160,000**
Total Cost of Ownership 15 years	**$19,785,837**

Harris County Conceptual Sol. #1 - TETRA UHF - Expansion System																	
Infastructure Site Budget																	
	Ellerslie	Goat Rock	Hamilton	Hopewell	Waverly2	NW Harris	Pine Mountain	Mulberry	GF01	GF02	L01	L02	L03	L04	L05	L06	Total
Additional Base Station Count	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
Repeater Eq.	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$120,000	$1,600,000
Primary & Secondary Core																	$0
Simulcast Control Point Eq.																	$0
Rx Antenna System(antenna, multicoupler, TTA)	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$480,000
Tx Antenna System (antenna, combiner)	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$336,000
Installation Services	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$1,600,000
Voice Infrastructure Total	**$206,000**	**$206,000**	**$206,000**	**$206,000**	**$206,000**	**$206,000**	**$206,000**	**$206,000**	**$296,000**	**$296,000**	**$296,000**	**$296,000**	**$296,000**	**$296,000**	**$296,000**	**$296,000**	**$4,016,000**
Systems Integration																	**$1,244,960**
Voice Infrastructure Grand Total																	**$5,260,960**
Site Construction																	
Shelter - Foundation	$0	$0	$350,000	$0	$0	$0	$0	$0	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$3,150,000
Tower-Foundation	$0	$0	$0	$0	$0	$0	$0	$0	$400,000	$400,000	$0	$0	$0	$0	$0	$0	$800,000
Generator Subsystem	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$752,000
UPS or Battery Subsystem	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$560,000
Site Development	$0	$0	$0	$0	$0	$0	$0	$0	$70,000	$70,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$290,000
Site Upgrades / Overloaded Tower Work	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000		$0	$0	$0	$0	$0	$0	$0	$1,200,000
Site Construction Total	**$232,000**	**$232,000**	**$582,000**	**$232,000**	**$232,000**	**$232,000**	**$232,000**	**$232,000**	**$902,000**	**$902,000**	**$457,000**	**$457,000**	**$457,000**	**$457,000**	**$457,000**	**$457,000**	**$6,752,000**
Site Construction Contingency																	**$1,012,800**
Site Construction Grand Total																	**$7,764,800**

Microwave Radio Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$765,056
LAN/WAN Equipment	$0	$0	$0	$0	$0	$0	$0	$0	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$200,000
DC Power System	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$560,000
Antenna Systems	$0	$0	$0	$0	$0	$0	$0	$0	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$360,000
Path Surveys	$0	$0	$0	$0	$0	$0	$0	$0	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$40,000
Installation Services	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$297,760
Microwave Total	**$45,000**	**$45,000**	**$45,000**	**$45,000**	**$45,000**	**$45,000**	**$45,000**	**$45,000**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$2,222,816**
Microwave Systems Integration																	**$689,073**
Microwave Contingency																	**$222,282**
Microwave Grand Total																	**$3,134,171**
Administrator Training	$0																$0
Licensing	$50,000																
Coverage Testing Baselining	$50,000																
ISSI (one gateway)	$0																$0
Critical Building BDA Solution Contingency (x6)	$300,000																$300,000
Broadband Gateway (100 user license)	$0																$0
Training and Interop Grand Total																	**$300,000**
Site Infrastructure Grand Total																	**$16,459,931**

Harris County Conceptual Sol. #1 - TETRA UHF - Expansion System		
Dispatch (0 Primary, 0 Backup)		
	Pickens County PSAP	**Dispatch**
Dispatch Positions	0	0
Desktop	$0	$0
Microphone	$0	$0
Headset	$0	$0
Auxiliary Speaker (Qty. 2)	$0	$0
Backup Control Stations	$0	$0
Interoperability Control Stations (Multiband Qty. 4)*	$29,412	$29,412
LAN/WAN	$0	$0
Radio Network Manager	$0	$0
Logging Recorder*	$30,000	$30,000
Alarm Monitoring	$100,000	$100,000
Installation Services	$0	$0
Training	$25,000	$25,000
	$184,412	
Dispatch Equipment Total		**$184,412**

Harris County, Georgia Radio
Consulting Services Supplemental Report

tusa | Consulting Services
Raising the Bar in Critical Communications

Harris County Conceptual Sol. #1 - TETRA UHF - Expansion System												
Subscriber Budget												
		Total	**List Price**	**HCSO**	**Antioch VFD**	**Hamilton VFD**	**Ellerslie VFD**	**Pine Mn VFD**	**HC EMS**	**911**	**Hamilton PD**	**Waverly Hall PD**
Mobile												
	Qty.	98		60	12	2	5	4	8	0	3	4
All Agencies - Dash Mount - w/ TETRA - Single Band	Total	**$98,000**	$ 1,000	$ 60,000	$ 12,000	$ 2,000	$ 5,000	$ 4,000	$ 8,000	$ -	$ 3,000	$ 4,000
	Qty.											
Public Works/Schools - Dash Mount - w/ P25 - Single Band	Total	**$0**	$ 2,500									
	Qty.											
Public Works/Schools - Remote Mount - w/ P25 - Single Band	Total	**$0**	$ 3,100									
	Qty.											
Law/Fire/EMS - Remote Mount - w/ P25 - Single Band	Total	**$0**	$ 4,660									
	Qty.											
Law/Fire/EMS - Dual-Head Mount - w/ P25 - Single Band	Total	**$0**	$ 5,660									
	Qty.											
Law/Fire/EMS - Remote Mount - w/ P25 - Multi-band	Total	**$0**	$ 7,650									
	Qty.											
Law/Fire/EMS - Dual-Head Mount - w/ P25 - Multi-band	Total	**$0**	$ 8,650									
Installation & Programming	Total	**$22,750**	$250	$15,000	$3,000	$500	$1,250	$1,000	$2,000	$0	$750	$1,000
Removal Old Equipment	Total	**$6,825**	$75	$4,500	$900	$150	$375	$300	$600	$0	$225	$300
		$ 127,575	$ 32,545	$ 79,500	$ 15,900	$ 2,650	$ 6,625	$ 5,300	$ 10,600	$ -	$ 3,975	$ 5,300
Options / Accessories												
Lights and Siren Control	Total	**$0**	$350									
Status / Messaging Control Box	Total	**$0**	$0									
Undercover / Low Profile Handheld Controller	Total	**$0**	$675									
In- Cab Headset	Total	**$0**	$1,300									
Other: AES Single Key	Total	**$5,265**	$195	20	0	0	0	0	0	0	3	4
Other: AES Multi-key	Total	**$0**	$495									
Other: GPS Location Service	Total	**$0**	$395									
Other: OTAR	Total	**$0**	$195									
Other: OTAP	Total	**$0**	$195									
		$5,265										
Portable												
All Agencies - w/ TETRA - Single Band	Qty.	191		60	37	20	30	16	9	10	4	5
	Total	**$229,200**	$1,200	$ 72,000	$ 44,400	$ 24,000	$ 36,000	$ 19,200	$ 10,800	$ 12,000	$ 4,800	$ 6,000
Public Works/Schools - Limited/No Keypad - w/ P25 - Single Band	Qty.											

	Total	**$0**	$2,560									
Law - Limited/No Keypad - w/ P25 - Single Band	Qty.											
	Total	**$0**	$4,875									
Law - Full Keypad - w/ P25 - Single Band	Qty.											
	Total	**$0**	$5,075									
Fire/EMS - Limited/No Keypad - w/ P25 - Single Band - C1D2	Qty.											
	Total	**$0**	$5,175									
Fire/EMS - Full Keypad - w/ P25 - Single Band - C1D2	Qty.											
	Total	**$0**	$5,375									
Law - Limited/No Keypad - w/ P25 - Multi-Band	Qty.											
	Total	**$0**	$5,875									
Law - Full Keypad - w/ P25 - Multi-Band	Qty.											
	Total	**$0**	$6,075									
Fire/EMS - Limited/No Keypad - w/ P25 - Multi-Band - C1D2	Qty.											
	Total	**$0**	$6,175									
Fire/EMS - Full Keypad - w/ P25 - Multi-Band - C1D2	Qty.											
	Total	**$0**	$6,375									
Programming (1 each)	Qty.			60	37	20	30	16	9	10	4	5
	Total	**$9,600**	$50	$3,000	$1,850	$1,000	$1,500	$800	$450	$500	$200	$250
		$ 238,800		$ 3,000	$ 1,850	$ 1,000	$ 1,500	$ 800	$ 450	$ 500	$ 200	$ 250
Options/Accessories												
Carry Case - Hard Shell - with Belt Loop - D-swivel	Total	**$0**	$ 215									
Carry Case - Nylon Shell - with Belt Loop - D-swivel	Total	**$0**	$ 195									
Carry Case - Leather Shell - with Belt Loop - D-swivel	Total	**$0**	$ 275									
Carry Case - Hard Shell - with Shoulder Strap	Total	**$0**	$ 265									
Carry Case - Nylon Shell - with Shoulder Strap	Total	**$0**	$ 245									
Carry Case - Leather Shell - with Shoulder Strap	Total	**$0**	$ 325									
Belt Clip	Total	**$5,730**	$ 30	60	37	20	30	16	9	10	4	5
Single Bank Desktop Changer (1 each)	Total	**$0**	$ 110									
Single Bank Vehicular Charger	Total	**$0**	$ 250									
Multi-Unit Charger (6 bay) (1% rounded to whole number)	Total	**$0**	$ 660									
Multi-Unit Charger Wall Mounting Bracket	Total	**$0**	$ 50									
Speaker Mic - Basic - w/ Emergency Button	Total	**$0**	$ 200									
Speaker Mic - Rugged - w/ Emergency Button (Law)	Total	**$0**	$ 350									
Speaker Mic - Rugged - High Temp - w/ Emergency Button (Fire)	Total	**$0**	$ 700									
Spare Battery (1 each)	Total	**$0**	$ 140									

Spare Antenna (5% rounded to whole number)	Total	**$0**	$ 90									
Other: Ear Piece	Total	**$0**	$ 50									
Other: AES Single Key	Total	**$15,405**	$ 195	60	0	0	0	0	0	10	4	5
Other: AES Multi-key	Total	**$0**	$ 495									
Other: GPS Location Service	Total	**$0**	$ 395									
Other: OTAR	Total	**$0**	$ 195									
Other: OTAP	Total	**$0**	$ 195									
		$ 21,135										
Control Station (non-dispatch)												
	Qty.	12		1	1	1	1	1	4	1	1	1
Control Station /Desktop Radio	Total	$ 73,488	$6,124	$6,124	$6,124	$6,124	$6,124	$6,124	$24,496	$6,124	$6,124	$6,124
	Qty.	12		1	1	1	1	1	4	1	1	1
Antenna System (1 each)	Total	$ 9,900	$825	$825	$825	$825	$825	$825	$3,300	$825	$825	$825
Installation & Programming	Total	$ 13,476	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$4,492	$1,123	$1,123	$1,123
		$ 96,864	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$32,288**	**$8,072**	**$8,072**	**$8,072**
		$0										
	Qty.	132		0	33	33	33	33	0	0	0	0
Unication Pager	Total	$ 87,120	$660	$0	$21,780	$21,780	$21,780	$21,780	$0	$0	$0	$0
Training		**$50,000**										
Subscriber Total		**$626,759**										

16.3. Conceptual Solution #2 - P25 System 800 MHz – Standalone System

The following budget shows the anticipated procurement costs for Conceptual Solution #2 – P25 System 800 MHz – Standalone System. Included in this budget is

- New Transmit and Receive RF equipment to all sites
- New antennas and lines at each new site
- New additional sites, including towers, to reach minimum of 95% coverage countywide portable on-hip, with the other stipulations in coverage requirements
- New shelters at all new sites and at Hamilton existing site
- New Primary and Secondary Core
- New user P25 800 MHz radios
- New IP technology at new sites (Microwave and correlated network devices)
- DC Power plants and generators at all sites to allow for 8 hours back up for RF equipment and 18 hours back-up for microwave and network equipment
- 15 years of support and maintenance

CONCEPTUAL SOLUTION #2 - TOTAL COST OF OWNERSHIP

There are pros and cons associated with this conceptual solution that can be defined as follows:

Pros

- Ability to use federal grant funding
- Easier interoperability with neighboring counties and state agencies
- Autonomy and control of the system
- Designed to avoid intermodulation and interreference issues
- Tower-top amplifiers available to balance talk-in and talk-out coverage requiring fewer sites than UHF
- Lower cost of In-building BDAs than UHF
- Radios available with public safety features and functions

Cons

- Higher maintenance costs than other options with partner
- Higher CAPEX than shared options
- Higher cost to replace radios than TETRA option

Harris County, Georgia Radio
Consulting Services Supplemental Report

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Raising the Bar in Critical Communications

Harris County Conceptual Sol. #2 - Project 25 800 Standalone System	
Pricing Summary	
Description	**Total**
Voice Infrastructure	$10,857,890
Systems Integration	$3,365,946
Training and Interop	$450,000
Voice Infrastructure Total	**$14,673,836**
Site Construction	$7,560,000
Site Construction Contingency	$1,134,000
Site Construction Total	**$8,694,000**
Microwave	$3,492,780
Microwave System Integration	$1,082,762
Microwave Contingency	$349,278
Microwave Total	**$4,924,820**
Customer Dispatch Centers	$652,657
Dispatch Center Total	**$652,657**
Customer Subscribers	**$1,924,869**
Customer Grand Total	**$30,870,182**
Competitive Procurement Process	
Infrastructure	$21,219,492
Dispatch	$489,493
Subscribers	$1,539,895
Competitive Process Grand Total	**$23,248,880**

Harris County, Georgia Radio
Consulting Services Supplemental Report

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Raising the Bar in Critical Communications

Harris County Conceptual Sol. #2 - Project 25 800 Standalone System																
Infrastructure Site Budget																
	Ellerslie	Goat Rock	Hamilton	Hopewell	Waverly	NW Harris	Pine Mountain	Mulberry	GF01	GF02	GF03	L01	L03	L05	L06	Total
Channels	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
Repeater Eq.	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$6,480,000
Primary & Secondary Controller							$750,000		$250,000							$1,000,000
Simulcast Control Point Eq.							$368,945		$368,945							$737,890
Rx Antenna System(antenna, multicoupler, TTA)	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$450,000
Tx Antenna System (antenna, combiner)	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$315,000
Installation Services	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$1,875,000
Voice Infrastructure Total	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$1,726,945**	**$608,000**	**$1,226,945**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$10,857,890**
Systems Integration																**$3,365,946**
Voice Infrastructure Grand Total																**$14,523,836**
Site Construction																
Shelter - Foundation	$0	$0	$350,000	$0	$0	$0	$0	$0	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$2,800,000
Tower-Foundation	$0	$0	$0	$0	$0	$0	$0	$0	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$2,800,000
Generator Subsystem	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$705,000
UPS or Battery Subsystem	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$525,000
Site Development	$0	$0	$0	$0	$0	$0	$0	$0	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$490,000
Site Upgrades / Water Tower Upgrades	$0	$50,000	$50,000	$0	$50,000	$0	$40,000	$50,000	$0	$0	$0	$0	$0	$0	$0	$240,000
Site Construction Total	**$82,000**	**$132,000**	**$482,000**	**$82,000**	**$132,000**	**$82,000**	**$122,000**	**$132,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$7,560,000**
Site Construction Contingency																**$1,134,000**
Site Construction Grand Total																**$8,694,000**
Microwave Radio Equipment	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$1,434,480

LAN/WAN Equipment	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$375,000
DC Power System	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$525,000
Antenna Systems	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$675,000
Path Surveys	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$75,000
Installation Services	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$408,300
Microwave Total	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	$3,492,780
Microwave Systems Integration																**$1,082,762**
Microwave Contingency																**$349,278**
Microwave Grand Total																**$4,924,820**
Administrator Training	$50,000															$50,000
ISSI (one gateway)	$250,000															$250,000
Critical Building BDA Solution Contingency (x6)	$100,000															$100,000
Broadband Gateway (100 user license)	$50,000															$50,000
Training and Interop Grand Total																**$450,000**
Site Infrastructure Grand Total																**$28,592,656**

Harris County Conceptual Sol. #2 - Project 25 800 Standalone System		
Dispatch (4 Primary, 2 Backup)		
	Harris County PSAP	**Dispatch**
Dispatch Positions	4	4
Desktop	$252,600	$ 252,600
Microphone	$1,300	$ 1,300
Headset	$5,120	$ 5,120
Auxiliary Speaker (Qty. 2)	$1,400	$ 1,400
Backup Control Stations	$29,415	$ 29,415
Interoperability Control Stations (Multiband Qty. 4)*	$29,412	$ 29,412
LAN/WAN	$25,000	$ 25,000
Radio Network Manager	$20,000	$ 20,000
Logging Recorder*	$75,000	$ 75,000
Alarm Monitoring	$100,000	$ 100,000
Installation Services	$88,410	$ 88,410
Training	$25,000	$ 25,000
	$652,657	
Dispatch Equipment Total		**$652,657**

Harris County Conceptual Sol. #2 - Project 25 800 Standalone System												
Subscriber Budget												
		Total	List Price	HCSO	Antioch VFD	Hamilton VFD	Ellerslie VFD	Pine Mnt VFD	HC EMS	911	Hamilton PD	Waverly Hall PD
Mobile												
	Qty.			0	0	0	0	0	0	0	0	0
Public Works/Schools - Dash Mount - w/ P25 - Single Band	Total	**$0**	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			0	0	0	0	0	0	0	0	0
Public Works/Schools - Remote Mount - w/ P25 - Single Band	Total	**$0**	$ 3,100	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			60	12	2	5	4	8	0	3	4
Law/Fire/EMS - Remote Mount - w/ P25 - Single Band	Total	**$456,680**	$ 4,660	$ 279,600	$ 55,920	$ 9,320	$ 23,300	$ 18,640	$ 37,280	$ -	$ 13,980	$ 18,640
	Qty.			0	0	0	0	0	0	0	0	0
Law/Fire/EMS - Dual-Head Mount - w/ P25 - Single Band	Total	**$0**	$ 5,660	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			0	0	0	0	0	0	0	0	0
Law/Fire/EMS - Remote Mount - w/ P25 - Multi-band	Total	**$0**	$ 7,650	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			0	0	0	0	0	0	0	0	0
Law/Fire/EMS - Dual-Head Mount - w/ P25 - Multi-band	Total	**$0**	$ 8,650	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation & Programming	Total	**$22,750**	$250	$15,000	$3,000	$500	$1,250	$1,000	$2,000	$0	$750	$1,000
Removal Old Equipment	Total	**$6,825**	$75	$4,500	$900	$150	$375	$300	$600	$0	$225	$300
		$ 486,255	$ 32,545	$ 299,160	$ 59,832	$ 9,972	$ 24,930	$ 19,944	$ 39,888	$ -	$ 14,958	$ 19,944
Options / Accessories												
Lights and Siren Control	Total	**$0**	$350	0	0	0	0	0	0	0	0	0
Status / Messaging Control Box	Total	**$0**	$250	0	0	0	0	0	0	0	0	0
Undercover / Low Profile Handheld Controller	Total	**$0**	$675	0	0	0	0	0	0	0	0	0
In- Cab Headset	Total	**$0**	$1,300	0	0	0	0	0	0	0	0	0
Other: AES Single Key	Total	**$5,265**	$195	20	0	0	0	0	0	0	3	4
Other: AES Multi-key	Total	**$48,510**	$495	60	12	2	5	4	8	0	3	4
Other: GPS Location Service	Total	**$38,710**	$395	60	12	2	5	4	8	0	3	4
Other: OTAR	Total	**$19,110**	$195	60	12	2	5	4	8	0	3	4
Other: OTAP	Total	**$19,110**	$195	60	12	2	5	4	8	0	3	4
		$130,705										
Portable												
Public Works/Schools - Limited/No Keypad - w/ P25 - Single Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$2,560	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Law - Limited/No Keypad - w/ P25 - Single Band	Qty.			60	0	0	0	0	0	0	4	5
	Total	**$336,375**	$4,875	$ 292,500	$ -	$ -	$ -	$ -	$ -	$ -	$ 19,500	$ 24,375
Law - Full Keypad - w/ P25 - Single Band	Qty.			0	0	0	0	0	0	0	0	0

	Total	**$0**	$5,075	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fire/EMS - Limited/No Keypad - w/ P25 - Single Band - C1D2	Qty.			0	37	20	30	15	9	10	0	0
	Total	**$626,175**	$5,175	$ -	$ 191,475	$ 103,500	$ 155,250	$ 77,625	$ 46,575	$ 51,750	$ -	$ -
Fire/EMS - Full Keypad - w/ P25 - Single Band - C1D2	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$5,375	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Law - Limited/No Keypad - w/ P25 - Multi-Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$5,875	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Law - Full Keypad - w/ P25 - Multi-Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$6,075	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fire/EMS - Limited/No Keypad - w/ P25 - Multi-Band - C1D2	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$6,175	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fire/EMS - Full Keypad - w/ P25 - Multi-Band - C1D2	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$6,375	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Programming (1 each)	Qty.			60	37	20	30	15	9	10	4	5
	Total	**$9,550**	$50	$3,000	$1,850	$1,000	$1,500	$750	$450	$500	$200	$250
		$ 972,100		$ 295,500	$ 193,325	$ 104,500	$ 156,750	$ 78,375	$ 47,025	$ 52,250	$ 19,700	$ 24,625
Options/Accessories												
Carry Case - Hard Shell - with Belt Loop - D-swivel	Total	**$0**	$ 215	0	0	0	0	0	0	0	0	0
Carry Case - Nylon Shell - with Belt Loop - D-swivel	Total	**$0**	$ 195	0	0	0	0	0	0	0	0	0
Carry Case - Leather Shell - with Belt Loop - D-swivel	Total	**$0**	$ 275	0	0	0	0	0	0	0	0	0
Carry Case - Hard Shell - with Shoulder Strap	Total	**$0**	$ 265	0	0	0	0	0	0	0	0	0
Carry Case - Nylon Shell - with Shoulder Strap	Total	**$0**	$ 245	0	0	0	0	0	0	0	0	0
Carry Case - Leather Shell - with Shoulder Strap	Total	**$0**	$ 325	0	0	0	0	0	0	0	0	0
Belt Clip	Total	**$5,700**	$ 30	60	37	20	30	15	9	10	4	5
Single Bank Desktop Changer (1 each)	Total	**$0**	$ 110	0	0	0	0	0	0	0	0	0
Single Bank Vehicular Charger	Total	**$0**	$ 250	0	0	0	0	0	0	0	0	0
Multi-Unit Charger (6 bay) (1% rounded to whole number)	Total	**$0**	$ 660	0	0	0	0	0	0	0	0	0
Multi-Unit Charger Wall Mounting Bracket	Total	**$0**	$ 50	0	0	0	0	0	0	0	0	0
Speaker Mic - Basic - w/ Emergency Button	Total	**$0**	$ 200	0	0	0	0	0	0	0	0	0
Speaker Mic - Rugged - w/ Emergency Button (Law)	Total	**$0**	$ 350	0	0	0	0	0	0	0	0	0
Speaker Mic - Rugged - High Temp - w/ Emergency Button (Fire)	Total	**$0**	$ 700	0	0	0	0	0	0	0	0	0
Spare Battery (1 each)	Total	**$0**	$ 140	0	0	0	0	0	0	0	0	0
Spare Antenna (5% rounded to whole number)	Total	**$0**	$ 90	0	0	0	0	0	0	0	0	0
Other: Ear Piece	Total	**$0**	$ 50	0	0	0	0	0	0	0	0	0
Other: AES Single Key	Total	**$15,405**	$ 195	60	0	0	0	0	0	10	4	5
Other: AES Multi-key	Total	**$0**	$ 495	0	0	0	0	0	0	0	0	0

Other: GPS Location Service	Total	**$0**	$ 395	0	0	0	0	0	0	0	0	0
Other: OTAR	Total	**$0**	$ 195	0	0	0	0	0	0	0	0	0
Other: OTAP	Total	**$0**	$ 195	0	0	0	0	0	0	0	0	0
		$ 21,105										
Control Station (non-dispatch)												
	Qty.	22		1	1	1	1	1	14	1	1	1
Control Station /Destop Radio	Total	$ 134,728	$6,124	$6,124	$6,124	$6,124	$6,124	$6,124	$85,736	$6,124	$6,124	$6,124
	Qty.	22		1	1	1	1	1	14	1	1	1
Antenna System (1 each)	Total	$ 18,150	$825	$825	$825	$825	$825	$825	$11,550	$825	$825	$825
Installation & Programming	Total	$ 24,706	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$15,722	$1,123	$1,123	$1,123
		$ 177,584	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$113,008**	**$8,072**	**$8,072**	**$8,072**
		$0										
	Qty.	132		0	33	33	33	33	0	0	0	0
Unication Pager	Total	$ 87,120	$660	$0	$21,780	$21,780	$21,780	$21,780	$0	$0	$0	$0
Training		**$50,000**										
Subscriber Total		**$1,924,869**										

16.4. Conceptual Solution #3 - P25 System 800 MHz – Joined System

The following budget shows the anticipated procurement costs for Conceptual Solution #3 – P25 System 800 MHz – Join Existing System. Included in this budget is

- New Transmit and Receive RF equipment to all sites
- New antennas and lines at each new site
- New additional sites, including towers, to reach minimum of 95% coverage countywide portable on-hip, with the other stipulations in coverage requirements
- New shelters at all new sites and at Hamilton existing site
- New Edge controller for loss of connection to primary core
- New user P25 800 MHz radios
- New IP technology at new sites (Microwave and correlated network devices)
- DC Power plants and generators at all sites to allow for 8 hours back up for RF equipment and 18 hours back-up for microwave and network equipment
- 15 years of support and maintenance

CONCEPTUAL SOLUTION #3 - TOTAL COST OF OWNERSHIP

There are pros and cons associated with this conceptual solution that can be defined as follows:

Pros

- Ability to use federal grant funding
- Easier interoperability with neighboring counties and state agencies
- Shared administration and control of the system with public safety partner
- Designed to avoid intermodulation and interreference issues
- Tower-top amplifiers available to balance talk-in and talk-out coverage requiring fewer sites than UHF
- Lower cost of In-building BDAs than UHF
- Radios available with public safety features and functions
- Shared OPEX maintenance costs
- Lower CAPEX cost than standalone option with shared Core

Cons

- Higher cost to replace radios than TETRA option
- Requirement to keep RF sites firmware and hardware current with partner's core which may increase OPEX

Harris County Conceptual Sol. #3 - Project 25 800 Join Existing System	
Pricing Summary	
Description	**Total**
Voice Infrastructure	$10,107,890
Systems Integration	$3,133,446
Training and Interop	$450,000
Voice Infrastructure Total	**$13,691,336**
Site Construction	$7,560,000
Site Construction Contingency	$1,134,000
Site Construction Total	**$8,694,000**
Microwave	$3,492,780
Microwave System Integration	$1,082,762
Microwave Contingency	$349,278
Microwave Total	**$4,924,820**
Customer Dispatch Centers	$652,657
Dispatch Center Total	**$652,657**
Customer Subscribers	**$1,924,869**
Customer Grand Total	**$29,887,682**
Competitive Procurement Process	
Infrastructure	$20,482,617
Dispatch	$489,493
Subscribers	$1,539,895
Competitive Process Grand Total	**$22,512,005**

Harris County Conceptual Sol. #3 - Project 25 800 Join Existing System	
Maintenance Budget	
Description	**Total**
Competitive Process Grand Total	**$22,512,005**
Maintenance Services (2-5 yr plan)/Estimated	
Corrective Maintenance and Software/Hardware Maintenance	$1,653,386
Preventative Maintenance	$88,000
Subscriber Depot & Return	$127,296
Microwave Maintenance	incl
HVAC	$32,000
Generators	$72,000
Battery Plants & UPS	$60,000
Logging Recorder	$25,000
Year 2-5 Maintenance Services Plan Total	**$2,057,682**
Average Yearly Total	**$514,421**
Maintenance Services (6-10 yr plan)/Estimated	
Corrective Maintenance and Software/Hardware Maintenance	$2,182,470
Preventative Maintenance	$117,040
Subscriber Depot & Return	$212,160
Microwave Maintenance	incl
HVAC	$36,800
Generators	$82,800
Battery Plants & UPS	$69,000
Logging Recorder	$25,000
Year 6-10 Maintenance Services Plan Total	**$2,725,270**
Average Yearly Total	**$545,054**
Maintenance Services (11-15 yr plan)/Estimated	
Corrective Maintenance and Software/Hardware Maintenance	$2,488,016
Preventative Maintenance	$134,596
Subscriber Depot & Return	$265,200
Microwave Maintenance	incl
HVAC	$55,200
Generators	$124,200
Battery Plants & UPS	$79,350
Logging Recorder	$25,000
Year 11-15 Maintenance Services Plan Total	**$3,171,562**

Average Yearly Total	$634,312
Lease Cost Estimate Years 1-15 (4 lease sites)	$1,440,000
Total Cost of Ownership 15 years	$30,466,519

Harris County, Georgia Radio
Consulting Services Supplemental Report

tusa | Consulting Services
Raising the Bar in Critical Communications

Harris County Conceptual Sol. #3 - Project 25 800 Join Existing System																
Infastructure Site Budget																
	Ellerslie	**Goat Rock**	**Hamilton**	**Hopewell**	**Waverly**	**NW Harris**	**Pine Mountain**	**Mulberry**	**GF01**	**GF02**	**GF03**	**L01**	**L03**	**L05**	**L06**	**Total**
Channels	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
Repeater Eq.	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$6,480,000
Primary & Secondary Controller							$250,000		$0							$250,000
Simulcast Control Point Eq.							$368,945		$368,945							$737,890
Rx Antenna System(antenna, multicoupler, TTA)	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$450,000
Tx Antenna System (antenna, combiner)	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$21,000	$315,000
Installation Services	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$1,875,000
Voice Infrastructure Total	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$1,226,945**	**$608,000**	**$976,945**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$608,000**	**$10,107,890**
Systems Integration																**$3,133,446**
Voice Infrastructure Grand Total																**$13,541,336**
Site Construction																
Shelter - Foundation	$0	$0	$350,000	$0	$0	$0	$0	$0	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$2,800,000
Tower-Foundation	$0	$0	$0	$0	$0	$0	$0	$0	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$2,800,000
Generator Subsystem	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$47,000	$705,000
UPS or Battery Subsystem	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$525,000
Site Development	$0	$0	$0	$0	$0	$0	$0	$0	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000	$490,000
Site Upgrades / Water Tower Upgrades	$0	$50,000	$50,000	$0	$50,000	$0	$40,000	$50,000	$0	$0	$0	$0	$0	$0	$0	$240,000
Site Construction Total	**$82,000**	**$132,000**	**$482,000**	**$82,000**	**$132,000**	**$82,000**	**$122,000**	**$132,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$902,000**	**$7,560,000**
Site Construction Contingency																**$1,134,000**
Site Construction Grand Total																**$8,694,000**
Microwave (Cells highlighted in blue indicate lease circuit needed. Price listed is estimated annual cost)																
Microwave Radio Equipment	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$95,632	$1,434,480

LAN/WAN Equipment	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$375,000
DC Power System	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$525,000
Antenna Systems	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$675,000
Path Surveys	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$75,000
Installation Services	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$27,220	$408,300
Microwave Total	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	**$232,852**	$3,492,780
Microwave Systems Integration																**$1,082,762**
Microwave Contingency																**$349,278**
Microwave Grand Total																**$4,924,820**
Administrator Training	$50,000															$50,000
ISSI (one gateway)	$250,000															$250,000
Critical Building BDA Solution Contigency (x6)	$100,000															$100,000
Broadband Gateway (100 user license)	$50,000															$50,000
Training and Interop Grand Total																**$450,000**
Site Infrastructure Grand Total																**$27,610,156**

Harris County Conceptual Sol. #3 - Project 25 800 Join Existing System		
Dispatch (4 Primary, 2 Backup)		
	Harris County PSAP	**Dispatch**
Dispatch Positions	4	4
Desktop	$252,600	$ 252,600
Microphone	$1,300	$ 1,300
Headset	$5,120	$ 5,120
Auxiliary Speaker (Qty. 2)	$1,400	$ 1,400
Backup Control Stations	$29,415	$ 29,415
Interoperability Control Stations (Multiband Qty. 4)*	$29,412	$ 29,412
LAN/WAN	$25,000	$ 25,000
Radio Network Manager	$20,000	$ 20,000
Logging Recorder*	$75,000	$ 75,000
Alarm Monitoring	$100,000	$ 100,000
Installation Services	$88,410	$ 88,410
Training	$25,000	$ 25,000
	$652,657	
Dispatch Equipment Total		**$652,657**

Harris County Conceptual Sol. #3 - Project 25 800 Join Existing System												
Subscriber Budget												
		Total	List Price	HCSO	Antioch VFD	Hamilton VFD	Ellerslie VFD	Pine Mnt VFD	HC EMS	911	Hamilton PD	Waverly Hall PD
Mobile												
	Qty.			0	0	0	0	0	0	0	0	0
Public Works/Schools - Dash Mount - w/ P25 - Single Band	Total	**$0**	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			0	0	0	0	0	0	0	0	0
Public Works/Schools - Remote Mount - w/ P25 - Single Band	Total	**$0**	$ 3,100	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			60	12	2	5	4	8	0	3	4
Law/Fire/EMS - Remote Mount - w/ P25 - Single Band	Total	**$456,680**	$ 4,660	$ 279,600	$ 55,920	$ 9,320	$ 23,300	$ 18,640	$ 37,280	$ -	$ 13,980	$ 18,640
	Qty.			0	0	0	0	0	0	0	0	0
Law/Fire/EMS - Dual-Head Mount - w/ P25 - Single Band	Total	**$0**	$ 5,660	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			0	0	0	0	0	0	0	0	0
Law/Fire/EMS - Remote Mount - w/ P25 - Multi-band	Total	**$0**	$ 7,650	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Qty.			0	0	0	0	0	0	0	0	0
Law/Fire/EMS - Dual-Head Mount - w/ P25 - Multi-band	Total	**$0**	$ 8,650	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation & Programming	Total	**$22,750**	$250	$15,000	$3,000	$500	$1,250	$1,000	$2,000	$0	$750	$1,000
Removal Old Equipment	Total	**$6,825**	$75	$4,500	$900	$150	$375	$300	$600	$0	$225	$300
		$ 486,255	$ 32,545	$ 299,160	$ 59,832	$ 9,972	$ 24,930	$ 19,944	$ 39,888	$ -	$ 14,958	$ 19,944
Options / Accessories												
Lights and Siren Control	Total	**$0**	$350	0	0	0	0	0	0	0	0	0
Status / Messaging Control Box	Total	**$0**	$250	0	0	0	0	0	0	0	0	0
Undercover / Low Profile Handheld Controller	Total	**$0**	$675	0	0	0	0	0	0	0	0	0
In- Cab Headset	Total	**$0**	$1,300	0	0	0	0	0	0	0	0	0
Other: AES Single Key	Total	**$5,265**	$195	20	0	0	0	0	0	0	3	4

Other: AES Multi-key	Total	**$48,510**	$495	60	12	2	5	4	8	0	3	4
Other: GPS Location Service	Total	**$38,710**	$395	60	12	2	5	4	8	0	3	4
Other: OTAR	Total	**$19,110**	$195	60	12	2	5	4	8	0	3	4
Other: OTAP	Total	**$19,110**	$195	60	12	2	5	4	8	0	3	4
		$130,705										
Portable												
Public Works/Schools - Limited/No Keypad - w/ P25 - Single Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$2,560	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Law - Limited/No Keypad - w/ P25 - Single Band	Qty.			60	0	0	0	0	0	0	4	5
	Total	**$336,375**	$4,875	$ 292,500	$ -	$ -	$ -	$ -	$ -	$ -	$ 19,500	$ 24,375
Law - Full Keypad - w/ P25 - Single Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$5,075	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fire/EMS - Limited/No Keypad - w/ P25 - Single Band - C1D2	Qty.			0	37	20	30	15	9	10	0	0
	Total	**$626,175**	$5,175	$ -	$ 191,475	$ 103,500	$ 155,250	$ 77,625	$ 46,575	$ 51,750	$ -	$ -
Fire/EMS - Full Keypad - w/ P25 - Single Band - C1D2	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$5,375	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Law - Limited/No Keypad - w/ P25 - Multi-Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$5,875	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Law - Full Keypad - w/ P25 - Multi-Band	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$6,075	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fire/EMS - Limited/No Keypad - w/ P25 - Multi-Band - C1D2	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$6,175	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fire/EMS - Full Keypad - w/ P25 - Multi-Band - C1D2	Qty.			0	0	0	0	0	0	0	0	0
	Total	**$0**	$6,375	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Programming (1 each)	Qty.			60	37	20	30	15	9	10	4	5

	Total	**$9,550**	$50	$3,000	$1,850	$1,000	$1,500	$750	$450	$500	$200	$250
		$ 972,100		$ 295,500	$ 193,325	$ 104,500	$ 156,750	$ 78,375	$ 47,025	$ 52,250	$ 19,700	$ 24,625
Options/Accessories												
Carry Case - Hard Shell - with Belt Loop - D-swivel	Total	**$0**	$ 215	0	0	0	0	0	0	0	0	0
Carry Case - Nylon Shell - with Belt Loop - D-swivel	Total	**$0**	$ 195	0	0	0	0	0	0	0	0	0
Carry Case - Leather Shell - with Belt Loop - D-swivel	Total	**$0**	$ 275	0	0	0	0	0	0	0	0	0
Carry Case - Hard Shell - with Shoulder Strap	Total	**$0**	$ 265	0	0	0	0	0	0	0	0	0
Carry Case - Nylon Shell - with Shoulder Strap	Total	**$0**	$ 245	0	0	0	0	0	0	0	0	0
Carry Case - Leather Shell - with Shoulder Strap	Total	**$0**	$ 325	0	0	0	0	0	0	0	0	0
Belt Clip	Total	**$5,700**	$ 30	60	37	20	30	15	9	10	4	5
Single Bank Desktop Changer (1 each)	Total	**$0**	$ 110	0	0	0	0	0	0	0	0	0
Single Bank Vehicular Charger	Total	**$0**	$ 250	0	0	0	0	0	0	0	0	0
Multi-Unit Charger (6 bay) (1% rounded to whole number)	Total	**$0**	$ 660	0	0	0	0	0	0	0	0	0
Multi-Unit Charger Wall Mounting Bracket	Total	**$0**	$ 50	0	0	0	0	0	0	0	0	0
Speaker Mic - Basic - w/ Emergency Button	Total	**$0**	$ 200	0	0	0	0	0	0	0	0	0
Speaker Mic - Rugged - w/ Emergency Button (Law)	Total	**$0**	$ 350	0	0	0	0	0	0	0	0	0
Speaker Mic - Rugged - High Temp - w/ Emergency Button (Fire)	Total	**$0**	$ 700	0	0	0	0	0	0	0	0	0
Spare Battery (1 each)	Total	**$0**	$ 140	0	0	0	0	0	0	0	0	0
Spare Antenna (5% rounded to whole number)	Total	**$0**	$ 90	0	0	0	0	0	0	0	0	0
Other: Ear Piece	Total	**$0**	$ 50	0	0	0	0	0	0	0	0	0
Other: AES Single Key	Total	**$15,405**	$ 195	60	0	0	0	0	0	10	4	5
Other: AES Multi-key	Total	**$0**	$ 495	0	0	0	0	0	0	0	0	0
Other: GPS Location Service	Total	**$0**	$ 395	0	0	0	0	0	0	0	0	0
Other: OTAR	Total	**$0**	$ 195	0	0	0	0	0	0	0	0	0
Other: OTAP	Total	**$0**	$ 195	0	0	0	0	0	0	0	0	0

		$ 21,105										
Control Station (non-dispatch)												
	Qty.	22		1	1	1	1	1	14	1	1	1
Control Station /Destop Radio	Total	$ 134,728	$6,124	$6,124	$6,124	$6,124	$6,124	$6,124	$85,736	$6,124	$6,124	$6,124
	Qty.	22		1	1	1	1	1	14	1	1	1
Antenna System (1 each)	Total	$ 18,150	$825	$825	$825	$825	$825	$825	$11,550	$825	$825	$825
Installation & Programming	Total	$ 24,706	$1,123	$1,123	$1,123	$1,123	$1,123	$1,123	$15,722	$1,123	$1,123	$1,123
		$ 177,584	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$8,072**	**$113,008**	**$8,072**	**$8,072**	**$8,072**
		$0										
	Qty.	132		0	33	33	33	33	0	0	0	0
Unication Pager	Total	$ 87,120	$660	$0	$21,780	$21,780	$21,780	$21,780	$0	$0	$0	$0
Training		**$50,000**										
Subscriber Total		**$1,924,869**										