

City of Coral Gables, Florida
Conceptual Solutions Report



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Raising the Bar in Radio Communications

City of Coral Gables

800 MHz Radio Consulting Services Conceptual Solutions Report



September 17, 2014

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1.0 Introduction

Tusa Consulting Services II, LLC (TCS), a radio consulting firm experienced in the field of public safety radio communications, was retained by the City of Coral Gables, Florida, to provide consulting services associated with the development, design, procurement, award and implementation of an 800 MHz APCO Project 25 Simulcast Trunked Digital public safety grade radio communications system. TCS' contracted scope of services included an assessment of user agency needs, development of conceptual solutions and recommendations for a new interoperable radio communications configuration.

As is often the case with older public safety communication infrastructures, radio coverage and reliability needs within an owner's operational borders tend to expand in step with ongoing population and business growth. Most areas in the City have seen modest growth in both population and business growth within the past twenty years. Thus, it is not uncommon to find public safety agencies now searching for new ways to improve their older network's coverage, reliability and capacity characteristics.

Additionally, federally sponsored interoperability initiatives and recent grant opportunities have been structured to favor the deployment of standards-based, spectrum efficient digital radio technologies. Thus, conceptual solutions to enhance the City's radio performance must be geared to support existing and future federal goals for interoperable public safety digital radio networks, while achieving user agency performance expectations.

The first significant step taken by TCS in the course of this enhancement project was its completion of user interview sessions with the City's key public safety user agencies. The purpose of conducted interview sessions was for TCS to gain a general understanding of agency mission roles as well as those operational and functional characteristics desired to support existing field and departmental operations. Interview questions and discussion topics initially focused on identification of coverage, capacity and reliability shortfalls within the existing infrastructure configuration. Later, discussions focused on user equipment and vendor support. Finally, we investigated interoperability needs and potential agency expansions/changes whose scope could potentially impact coverage and capacity needs.

Second, our work's attention turned toward those specific technologies and configuration schemes that could offer potential improvements to current as well as future public safety operations. The subject matter contained in subsequent portions of this Report provides a general overview of technologies currently available as well as conceptual solutions. In those cases where an immediate low-cost and easily implemented corrective action was apparent to TCS personnel, such information is likewise included.

Additionally, within this Report we have included radio coverage predictions for the various conceptual solution alternative, as well as rough order of magnitude costs estimates for the proposed solution's implementation. By so doing, Coral Gables can make informed decisions on how to best develop the City's current communication capabilities into a seamless, high-performance network.

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Based on the information gathered during the needs assessment, TCS' will develop design standards to be used toward the procurement of the community-wide 800 MHz Digital Trunked (P-25) Simulcast system. These design standards cover the voice system requirements, coverage analysis, microwave path analysis, antenna configurations, site configurations and equipment specifications. The City's intent is to leverage existing and planned communication assets in a manner that facilitates a seamless regional communications network supporting public safety professionals at all levels.

Whereas enhanced operability is a key component of this network's functional vision, the long term goal envisioned by this Report entails the integration of separate system components that facilitate seamless user roaming throughout South Florida. That is, while the radio network would function and provide the user equivalency as a single communications "cloud", it in fact could be constructed of infrastructures and user equipment procured from multiple vendor sources. Each of these radio components would fully comply with APCO (The Association of Public-Safety Communications Officials) Project 25 standards particularly with respect to inter sub-system switch interoperability (ISSI). Compliance with Project 25 switch interoperability standards, both existing and as they continue to evolve, is key to preserving a competitive procurement environment and ensuring the network's ability to support large numbers of outside user radios in the event of a catastrophic natural or terrorist initiated incident.

While user-radio interoperability is an obvious goal of this investigative action, an often overlooked and underappreciated aspect of interoperable radio communications is the reliability, capacity and security of facilities used to integrate separate radio systems into one cohesive network. In commercial radio networks, infrastructure interconnectivity is usually accomplished through leased telephone T-1 or fiber circuits. Yet, these commercially available sources, while relatively low in both initial and operational costs, are often unreliable or disrupted in the immediate aftermath of weather related catastrophes such as, tornadoes, hurricanes or floods.

Fortunately, the decision makers for Coral Gables recognized the critical importance of secure, reliable backhaul communications and embrace licensed microwave technology for the 800 MHz digital trunked (P-25) simulcast radio communication system. This investigation continues that approach and suggests the potential of data networking between City facilities through the concept of enhanced, high-capacity microwave SONET ring connectivity.

In this Report, we discuss a scheme to provide for an enhanced, interoperable microwave transport subsystem vital to ensuring necessary connectivity between the City's various public safety radio systems. We also describe potential ways in which these capabilities can be leveraged and enhanced to support more users and agencies, and that ultimately can be structured into a single, comprehensive shared communications resource.

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2.0 Existing Network Configuration

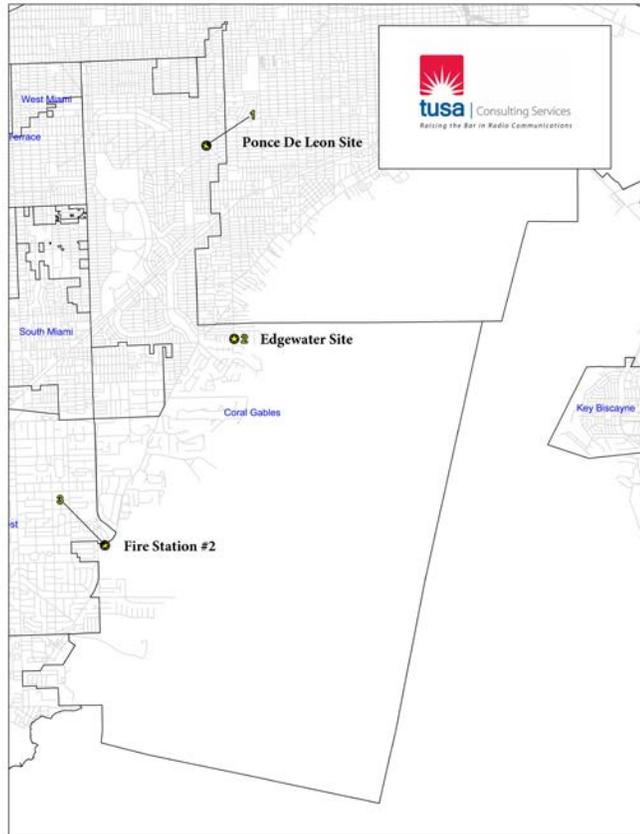
During the week of August 4th, 2014, TCS performed an inspection of the sites containing critical infrastructure components. These inspections involved the City of Coral Gables' E911 Dispatch Centers, control point, and the three existing tower sites.

The City currently operates on a ten channel proprietary, analog trunked EDACS Provoice 800 MHz radio system. This system supports the operational needs of the Police Department, Fire Department, Public Works, Parking and other local government agencies.

There is also a backup conventional system located at the Biltmore hotel. This site is out of service and the microwave system is no longer active.

This system consists of three sites (Ponce De Leon, Edgewater and Fire Station#3) which perform both transmit and receive operations. The control point, located at the Police Department, is connected by fiber to the Ponce De Leon site across the street.

Dispatch for police and fire operations, as well as for local government, is handled by the E911 Dispatch Center located at Police Department headquarters. The backup dispatch center is located at City maintenance facility on 72nd street. Fire alerting is provided over IP/LAN through a Locution system, with a backup Zetron FAS system provided over RF by control station. The City has no plans to replace either FAS system.



Coral Gables' agencies, both public safety and non-public safety, rarely experience issues with radio coverage or system capacity. When coverage issues do occur, it is typically in the south end or extreme north end of City limits. A particular area of concern for future radio coverage is the onset of LEED (Leadership in Energy & Environmental Design) construction practices in new high-rise buildings currently planned for construction in the northwest section of Coral Gables. LEED standards, intended to promote "green" construction, include building materials and design methodologies that prevent the transmission of radio waves through the building. This causes a lack of sufficient radio wave penetration into these

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buildings and could severely inhibit emergency responses and daily operations, placing both residents and first responders at risk.

City of Coral Gables Frequencies

800 MHz - Currently Licensed by Coral Gables

WPCJ404 (Trunked)

Frequency	Ponce De Leon	Edgewater	Fire Station	Control St.	Mobile
851.2000 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
851.2250 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
851.6750 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
851.7000 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.0500 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.0750 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.5500 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
858.9125 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.7750 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.8000 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W

WPCJ297 (Conventional)

Frequency	Location	Max ERP
806.0125 MHz	Ponce DeLeon	70.0 W
806.5125 MHz	Ponce DeLeon	70.0 W
807.0125 MHz	Ponce DeLeon	70.0 W
807.5215 MHz	Ponce DeLeon	70.0 W
807.6250 MHz	Mobile	35.0 W
807.6250 MHz	Ponce DeLeon	70.0 W
808.0125 MHz	Ponce DeLeon	70.0 W
852.3250 MHz	Repeater	58.0 W
852.6052 MHz	Mobile	35.0 W

WPCT408 (Conventional)

Frequency	Location	Max ERP
812.4357 MHz	Dispatch	70.0 W
812.4375 MHz	Mobile	35.0 W
857.4375 MHz	Ponce DeLeon	589.0 W
857.4375 MHz	Biltmore	500.0 W

WYQ412 (Conventional)

Frequency	Location	Max ERP
809.4875 MHz	Dispatch	70.0 W
809.4875 MHz	Mobile	35.0 W
854.4875 MHz	Biscayne Blvd	200.0 W
854.4875 MHz	PD	617.0 W
854.4875 MHz	Biltmore	617.0 W

700 MHz - Currently Licensed by Coral Gables

No 700 MHz channels are licensed at this time.

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Active Agencies

<u>Agency</u>	<u>Dispatch</u>	<u>System</u>	<u>Radio Assignment</u>
Police Department	E911 Dispatch	800 EDACS	Vehicle/Individual
Fire Department	E911 Dispatch	800 EDACS	Vehicle/Individual
Public Works	Self (Hand-Held)	800 EDACS	Individual
Parking	E911 Dispatch	800 EDACS	Individual

Subscriber Unit Quantities by Agency

Agency

Police Department (Public Safety)	Mobiles:	122
	Portables:	147
	Control Stations:	0
Fire Department (Public Safety)	Mobiles:	42
	Portables:	20
	Control Stations:	0
E911 Dispatch	Positions:	11
	Consoles:	8
	Control Stations:	28
Public Works (Non-Public Safety)	Mobiles:	0
	Portables:	12
	Control Stations:	0
Sanitation (Non-Public Safety)	Mobiles:	5
	Portables:	44
	Control Stations:	0
Parking (Non-Public Safety)	Mobiles:	15
	Portables:	39
	Control Stations:	0
Cached Radios (Public Safety)	Mobiles:	0
	Portables:	30-40
	Control Stations:	0
Spare Radios (Public Safety)	Mobiles:	0
	Portables:	15-20
	Control Stations:	0

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Total Subscriber Unit Quantities

Public Safety Grade

Total Mobiles:	179
Total Portables:	144
Total Control Stations:	28
Total Consoles:	8

Non-Public Safety Grade

Total Mobiles:	20
Total Portables:	155
Total Control Stations:	0
Total Consoles:	0

System Equipment

EDACS Provoice GPS Simulcast
GETC (Trunking Card)
IEA Alarm Computer
Windows NT 4.0 Maestro Consoles
Windows NT 4.0 CSD
Alcatel MDR6000 Microwave
Locution Primary Fire Alerting System
Zetron Backup Fire Alerting System
A-VOX Logging Recorder

System Maintenance

The City of Coral Gables performs in house preventative maintenance and repair/replacement (depot level) for portable radios and system infrastructure, as well as site inspections as necessary.

Communications International (CI) provides as needed repair/replacement support for the system infrastructure and microwave system.

Radio accessories are acquired directly from various vendors as needed.

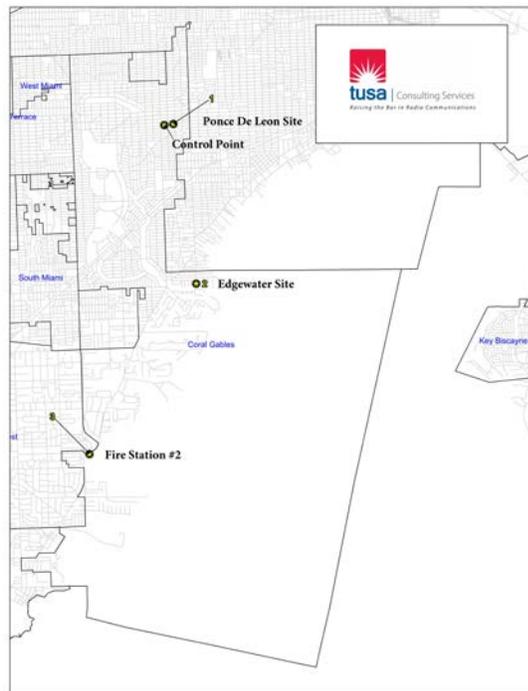
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Existing Site Locations

Control Point/ Police Department

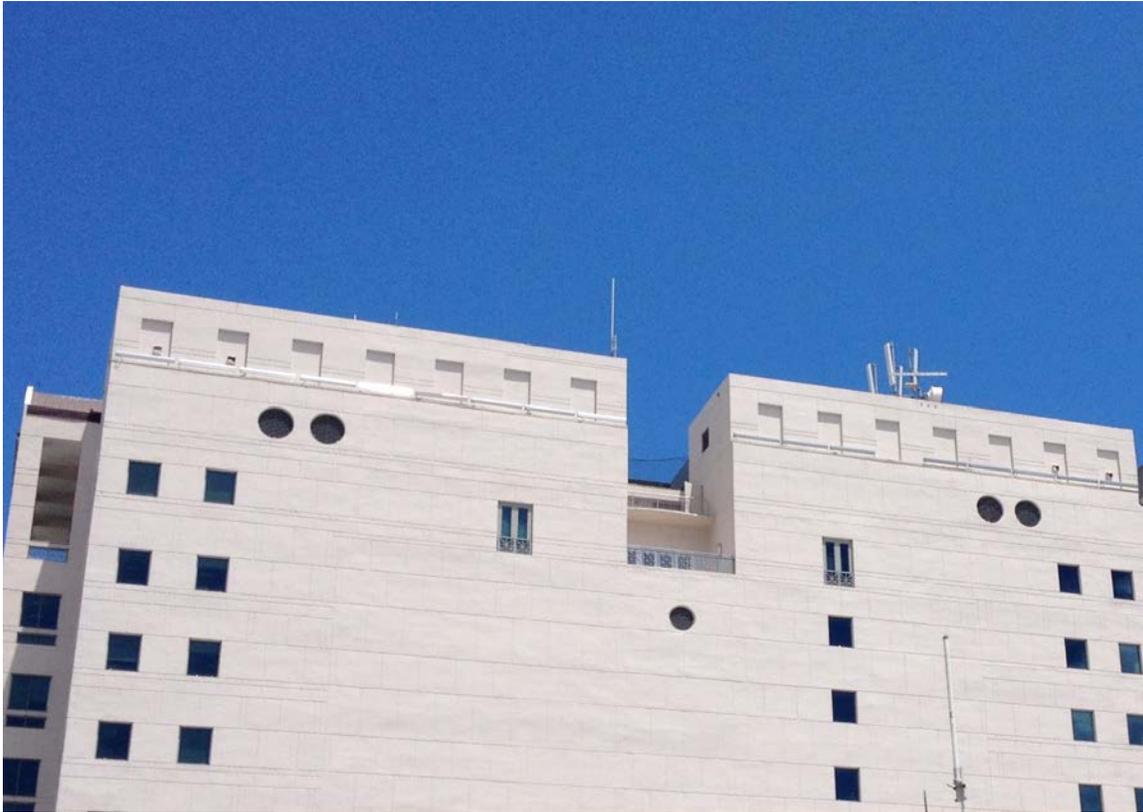


Lat: 25°44'45.52"N
Long: 80°15'37.48"W
Site Type: Roof Top
Site Build Date: N/A
TIA-222 Revision: N/A
Owner: City of Coral Gables



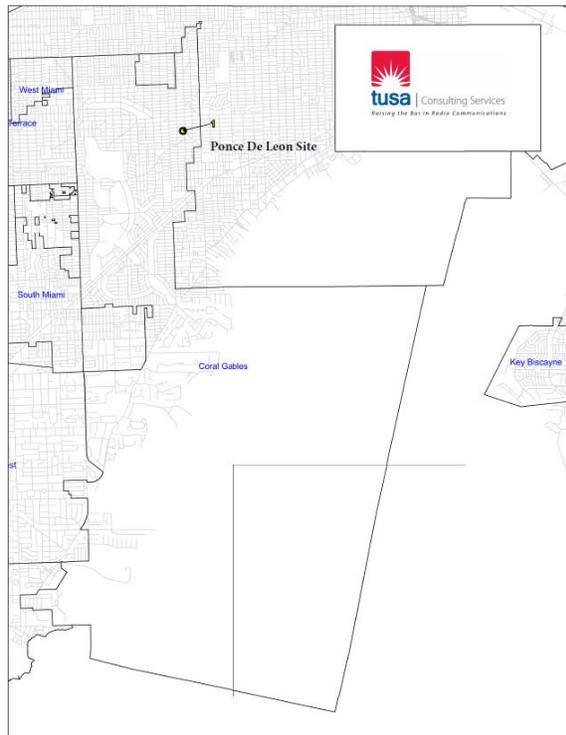
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Ponce DeLeon Site



Lat: 25°44'45.10"N
Long: 80°15'32.90"W
ASR#: N/A
AGL: 225' (Antenna Mount)
Site Elevation: 24'
Tower Type: Roof Top
Build Date: N/A
TIA-222 Revision: N/A
Owner: Regions Bank

10 channels
2 five channel combiners
2 TX antennas, 1 RX antenna



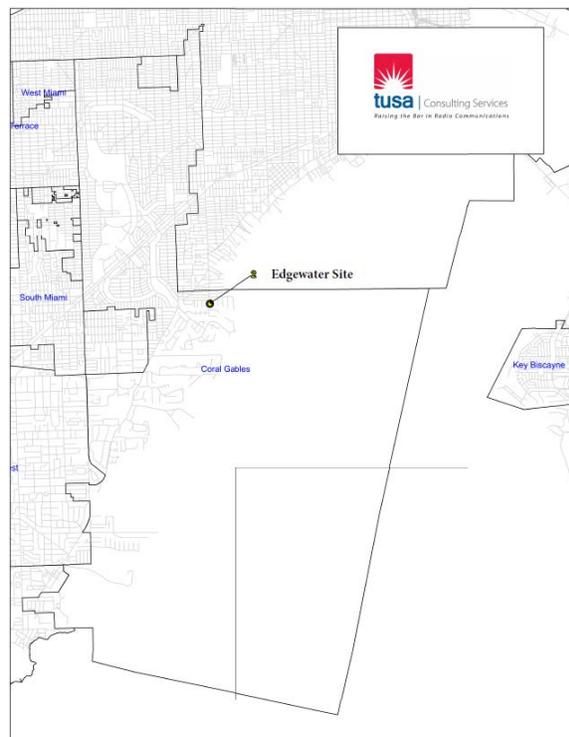
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Edgewater Site



TX Lat: 25°42'20.80"N
TX Long: 80°15'9.58"W
RX Lat: 25°42'23.53"N
RX Long: 80°15'9.58"W
ASR#: N/A
AGL: 245' (Antenna Mount)
Site Elevation: 16'
Tower Type: Roof Top
Build Date: N/A
TIA-222 Revision: N/A
Owner: Edgewater Condominium

10 channels
2 five channel combiners
2 TX antennas, 1 RX antenna



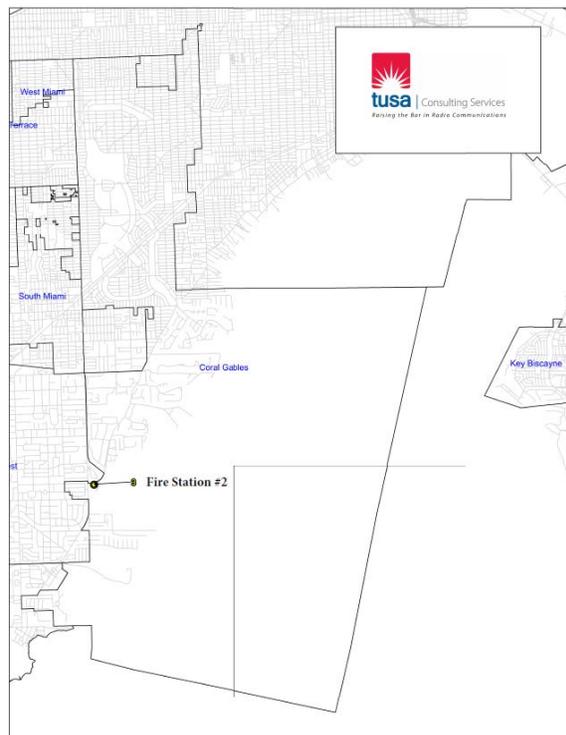
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Fire Station #3 Site



Lat: 25°39'47.54"N
Long: 80°16'56.07"W
ASR#: N/A
AGL: 180' (Antenna Mount)
Site Elevation: 25'
Tower Type: SST (SSMV)
Build Date: 1993
TIA-222 Revision: E
Owner: City of Coral Gables

10 channels
2 five channel combiners
2 TX antennas, 1 RX antenna



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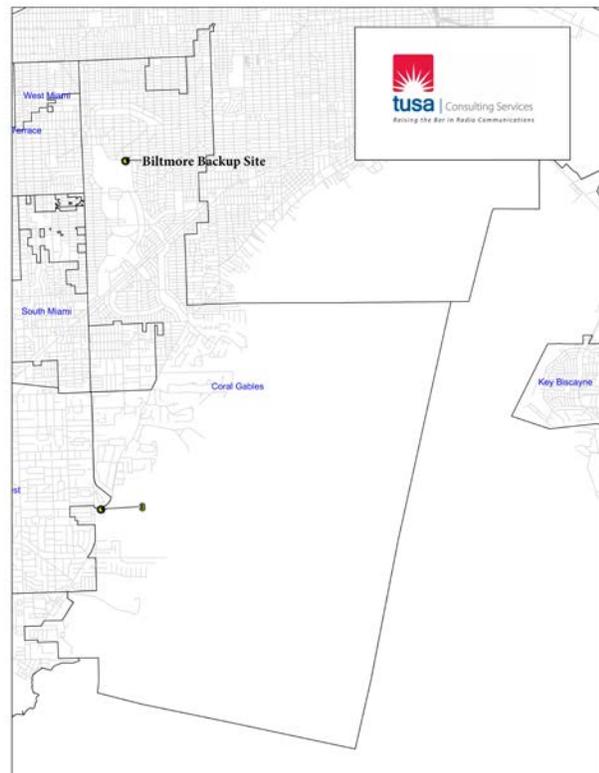
Biltmore Backup Site



Lat: 25°44'27.57"N
Long: 80°16'40.58"W
ASR#: N/A
AGL: 100'
Site Elevation: 28'
Site Type: Roof Top
Build Date: N/A
TIA-222 Revision: N/A
Owner: Biltmore Hotel

Conventional channels only.

*Site is no longer active

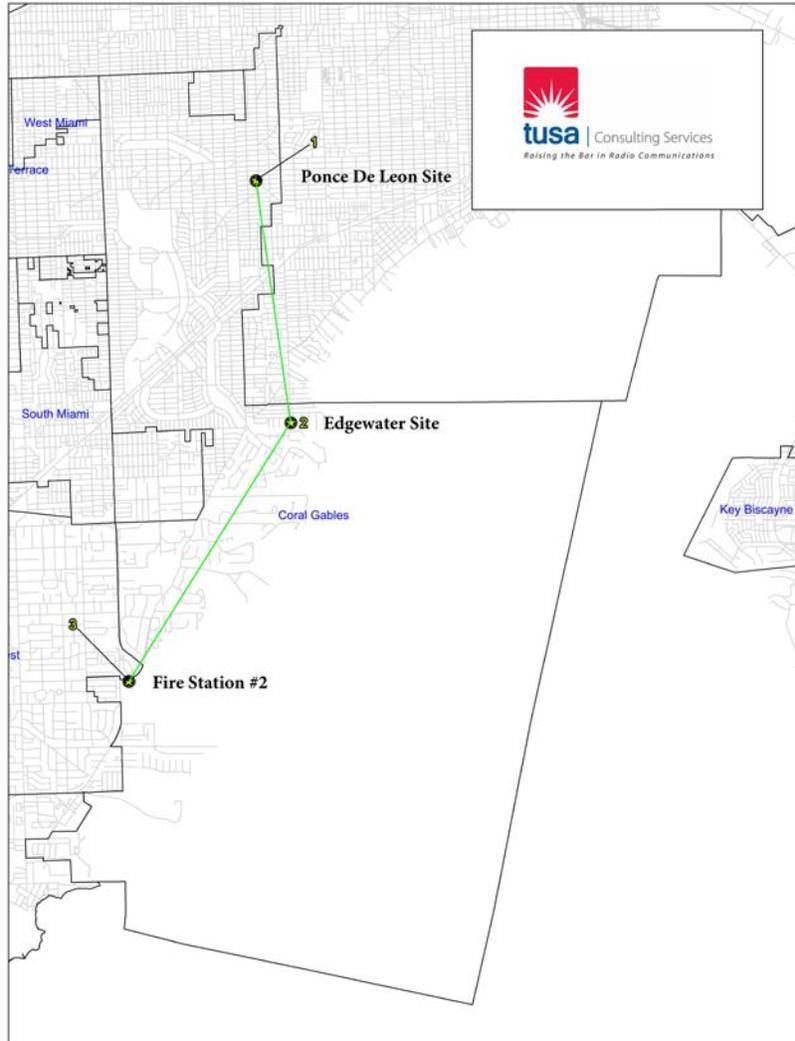


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Existing Microwave System

The existing microwave design includes a single dish, dual hot-standby, linear path (non-loop) that includes the following site locations:

- The Ponce De Leon Site to the Edgewater Site
- The Edgewater Site to the Fire Station #3 Site



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3.0 Technology Options Available to Coral Gables

In order to fully understand the pros and cons of the various options available to Coral Gables, it is important to recognize the benefits and limitations presented by the technologies used in these conceptual system designs. Following is a brief overview of these technologies. This summary in no way attempts to touch on all of the aspects of any of these technologies, but instead focuses on the features and limitations of each that directly relate to Coral Gables' situation. The discussion 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 the support wide-area coverage desired by Coral Gables, i.e., multisite, simulcast and hybrid systems.

Analog vs. Digital Systems



Since the late 1930's, public safety radio communication has used analog Frequency Modulation (FM) almost exclusively as its wireless communications technology. This is the technology currently being used by Coral Gables. 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 are able to 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

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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.

Digital systems 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. 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 City's current 800 MHz system is an analog system, and is not capable of digital operation without a major overhaul. As discussed in further detail below, Project 25 (P-25) systems are digital only although some vendors offers a combined P-25 and analog technology.

Proprietary vs. Open Standard Systems

To provide needed call capacity, the Coral Gables radio system uses multiple channels, each which consist of a pair of frequencies. Users wishing to make calls are assigned a frequency, or set of frequencies, as directed by the radio system. The current Motorola SmartNet II radio system operates with proprietary, conventional repeaters and is not considered an open standard.

Older trunked systems, as well as some currently available ones, utilize proprietary signaling protocols in their design. Examples of such systems are Motorola SmartNet/SmartZone, Harris EDACS, and Harris OpenSky. While these proprietary protocols do significantly increase the system's 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 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, a very limited number of vendors. Historically, this has resulted in a significant increase in the cost of a system over its lifetime.

Initially, all trunking systems developed 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 of the system. If a neighboring agency purchased a system from a different vendor, direct interoperability between the two was impossible. 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 a decade 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.

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While still not complete, sufficient progress has been made such that P-25 compliant systems and user equipment are available today from multiple vendors. If adjacent agencies purchase P-25 compliant systems from different vendors, users from each system will be able to communicate directly with each other and on each others' system infrastructure. In addition, each agency would be free to purchase from any vendor providing P-25 compliant equipment, based on required features and budget.

It should be noted that many of the Federal public safety communications grants available now, or in the future, either explicitly define P-25 systems and equipment as a requirement, or heavily favor applications from agencies defining P-25 in their requests. An agency applying for such a grant based on proprietary, non-P-25 technology will be at a significant disadvantage in the competition for the available funds.

TDMA vs. FDMA/ Phase I vs. Phase II P-25

Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) are both multiplexing technologies that determine how the radio uses available channel bandwidth to transfer calls between radios. Both methods are used extensively in Land Mobile Radio for public safety radio systems.

TDMA divides the channel into time slots with a user occupying a portion of the channel for a specific block of time. For example, 12.5 kHz of bandwidth provides two time slots per frame per user, allowing two simultaneous calls. FDMA on the other hand divides the channel by frequency. Using the same example as before, the 12.5 kHz of bandwidth is split into two 6.25 kHz calls, also occurring simultaneously.

With respect to radio performance, the 6.25 kHz FDMA channel requires a much smaller intermediate frequency (IF) bandwidth and therefore has better sensitivity than TDMA based radios. In a well-designed system, this equates to improved coverage.

Within the APCO P-25 set of standards, the use of channel bandwidth is further segregated into two Phases, I and II. Phase I employs a 12.5 KHz, TDMA channel. Phase II reduces the single 12.5 KHz channel used in Phase I, into two 6.25 KHz channels operating with FDMA technology.

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 single site, as is the case in Coral Gables. Simply adding sites will increase radio coverage, but adding sites alone will not result in a cohesive public safety communications system. Without a means of connecting these additional sites together, the result would be an uncoordinated collection of multiple independent coverage zones where users within the coverage area of one site are isolated from users covered by another.

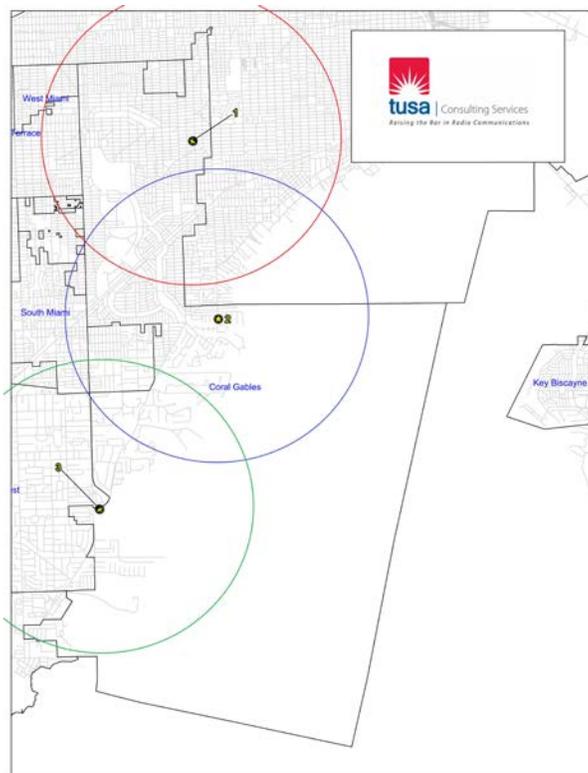
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What is needed is the capability for users operating on one site to communicate with the users operating on the others along with seamless switching between zones when traveling in the City. That capability is provided by wide-area technology. The industry has developed several approaches to accomplishing this task, three of which are available to Coral Gables. Those three available options are Multisite Networks, Simulcast Systems, 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. A specific conceptual designs using one of these system types, as appropriate to Coral Gables, is presented in a subsequent section of this Report.

Multisite Networks

In order to allow communication between users operating in different 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. Within a multisite network, each tower site in the system encompasses its own unique set of frequencies. Communication between users operating on different sites is accomplished through an intelligent central “switch” that monitors the site activity of every operational unit in the system and 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 switch determines which sites and frequencies are available to be assigned for that call and connects them all together via leased lines or microwave circuits.



Multisite Systems Design - Each site has its own set of frequencies.

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The key characteristic of this type network is that a completely separate set of frequencies 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, or shut down completely. A multisite network can continue to operate at full capacity in the event of such a failure, although with reduced wide area 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 site is also a multisite network's primary weakness. The frequencies available for public safety use are extremely limited. Of concern to Coral Gables specifically, many of the available 800 MHz public safety frequencies in Florida are already in use. The limited availability of frequencies effectively blocks a multisite system's capability for 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. The limited number of frequencies available to Coral Gables is a critical system design constraint blocking a simple solution to the coverage and capacity problems that Coral Gables could face in the future.

Another issue to consider is the effect of transitioning from one site to another when traveling throughout the City. 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 be always operating on the optimum site. From the user's perspective, system coverage is less than expected.

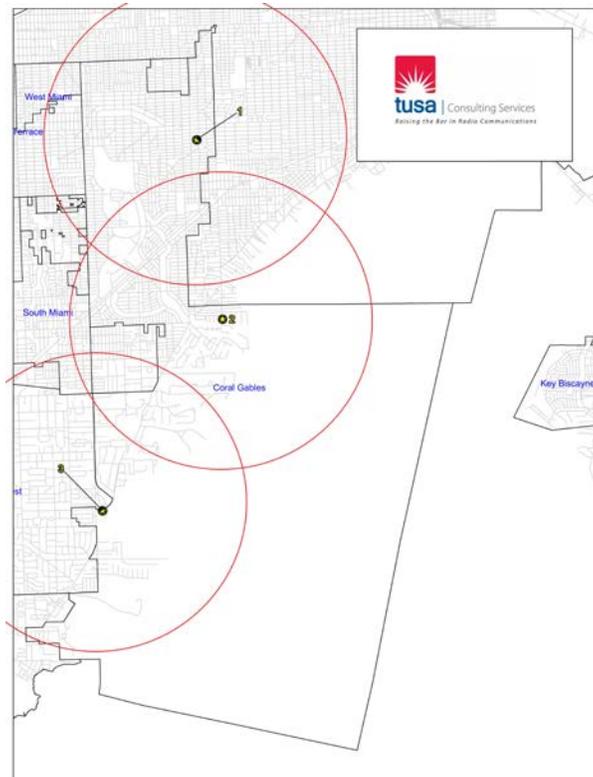
Simulcast Systems

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 networks differs from a multisite network in that the same frequencies are used throughout the system. With a simulcast system, the transmitter at each site broadcasts the same information simultaneously on the same RF channel as the other sites, hence the name.

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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.



Simulcast System Design - All three sites share the same set of frequencies.

However, as a result of multiple sites transmitting on the same frequency, each site's transmit frequency, phase and timing must be precisely controlled to prevent the 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 interference 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.

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

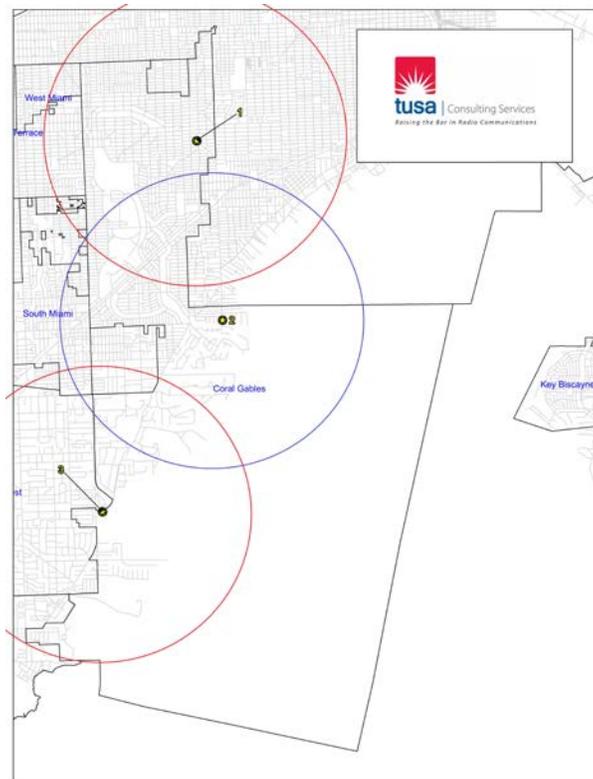
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circuits, even leased fiber, are not recommended for simulcast, and some vendors will not support simulcast systems utilizing them. From the standpoint of reliability, microwave has proved to be far more reliable and robust than leased circuits in the face of severe storms.

Hybrid Simulcast/Multisite Systems

The final wide area system configuration 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.



Hybrid System Design - A combination of multisite and simulcast systems.

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Extended RF Coverage

Although hopefully unnecessary for the City of Coral Gables with the new radio system design, a radio system's coverage can be extended through the use of devices designed to receive and retransmit the system's signals, much like a repeater. These options are typically reserved for worse case environments, such as the Fontainebleau, or for very dense structures, such as Mt. Sinai Medical Center which commonly has radio penetration issues.

Digital Vehicular Repeater System (DVRS)

A cost effective solution to extending RF coverage is accomplished through the use of 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 little or no coverage in buildings and remote areas.

A DVRS accomplishes this "repeating" function by using two radios tied together with a hardware controlling device. One of the radios would be programmed into the trunked radio system with the appropriate talk groups. The second radio (usually supplied with the repeater) 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 with these types of systems. Anytime there are two DVRS at the same location, a protocol must be established so a portable radio doesn't activate two or more DVRS.

Bi-Directional Amplifier (BDA)

The Bi-Directional Amplifier (BDA) amplifies and repeats the 800 MHz trunked signal from a donor antenna located in an area where coverage is available. The amplified signal is then repeated toward an area where there is little or no coverage. Likewise, the signal from a subscriber radio is repeated back to the donor antenna which directs it back to the infrastructure sites.

An important difference between BDAs and Digital Vehicular Repeater System (DVRS) is that BDAs do not change the frequency of the signal. This simplifies the operation of the BDA however BDAs used in outdoor locations have a major drawback in this design. Because both the donor and the radio system antennas operate on the same frequencies they must be carefully separated by some type of structure. The more 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 gain. Other types of structures that will also work are buildings where antennas are installed on opposite sides.

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Indoor BDAs do not typically suffer the same design issues, but their benefit is limited to a single building, rather than a group of buildings.

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4.0 Project 25 ISSI – The Key to User Roaming

As Florida's cities and counties move forward with their deployments of APCO Project 25 radio systems, the groundwork is being set for user radio roaming. First, of course, all radios in the Region must be capable of operation on P-25 equipped infrastructures. This means that owners of proprietary Project 16 radio systems using either Motorola SmartNet or Harris EDACS technologies should be planning to purchase radios that are capable of dual mode operations (proprietary and P-25).

Additionally, all new public safety trunked radio purchases should require radios that are operable on both 800 MHz and the new 700 MHz voice channels. These new radios must be fully compatible with Project 25's Phase I (12.5 KHz FDMA) and the recently accepted Phase II (12.5 KHz, two-slot TDMA) functional and operable requirements. By so doing, user radios purchased in the near future will be fully compatible with the State's future Phase I/II rollout for 700/800 MHz and will experience significantly longer service lives than those having only Phase I capabilities.

While equipping users with P-25 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 requires instantaneous and continuous connectivity of the various radio system controllers (called switches) between various jurisdictions.

Prior to P-25, connectivity standards between compliant radio systems did not exist. These standards exist today at a base level in which user IDs, talk group and transaction audio can be instantaneously routed between radio systems. These new switch interoperability standards are termed: **ISSI** - Inter RF Subsystem Interface.

Project 25 ISSI defines the types of functionality that can be supported between radio network/system switches. The ISSI Standard is vendor neutral such that radio systems designed and deployed by competing radio vendors will 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 in the various deployed radio systems. All switches in a network must support ISSI or interoperability cannot occur. Yet, nothing happens 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.

Finally, in order for users to roam between disparate P-25 radio systems, for example from Coral Gables to Miami-Dade County and vice versa, each system's managers need to plan accordingly and develop the appropriate communications plans, policies and agreements - *before* the need arises.

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5.0 Interoperability/Roaming Considerations

The State of Florida is very advanced with respect to interoperable communications and mutual support during emergencies. Emergency communications are supported through multiple levels of communications between systems on several platforms. This excerpt from the Florida Statewide Communications Interoperability Plan (SCIP) explains in detail:

There are many different technologies utilized by the public safety entities in Florida for their communications networks. These communications networks operate across almost every known public safety frequency band. They range from privately owned single channel conventional systems, citywide or shared trunked radio systems to the State Law Enforcement Radio System (SLERS) which is a statewide communications network that provides services for state law enforcement agencies, Florida National Guard and other local public safety entities. This statewide network is a public-private partnership between the State of Florida and its vendor. The vendor owns the infrastructure and the State of Florida has use of the system through contractual agreements. Operational security is provided through agency controlled encryption key management. Many local agencies make use of citywide or shared systems in their respective areas.

These technologies include swapping radios, gateways, shared channels and proprietary shared systems. Listed below are some of the systems currently deployed around the State:

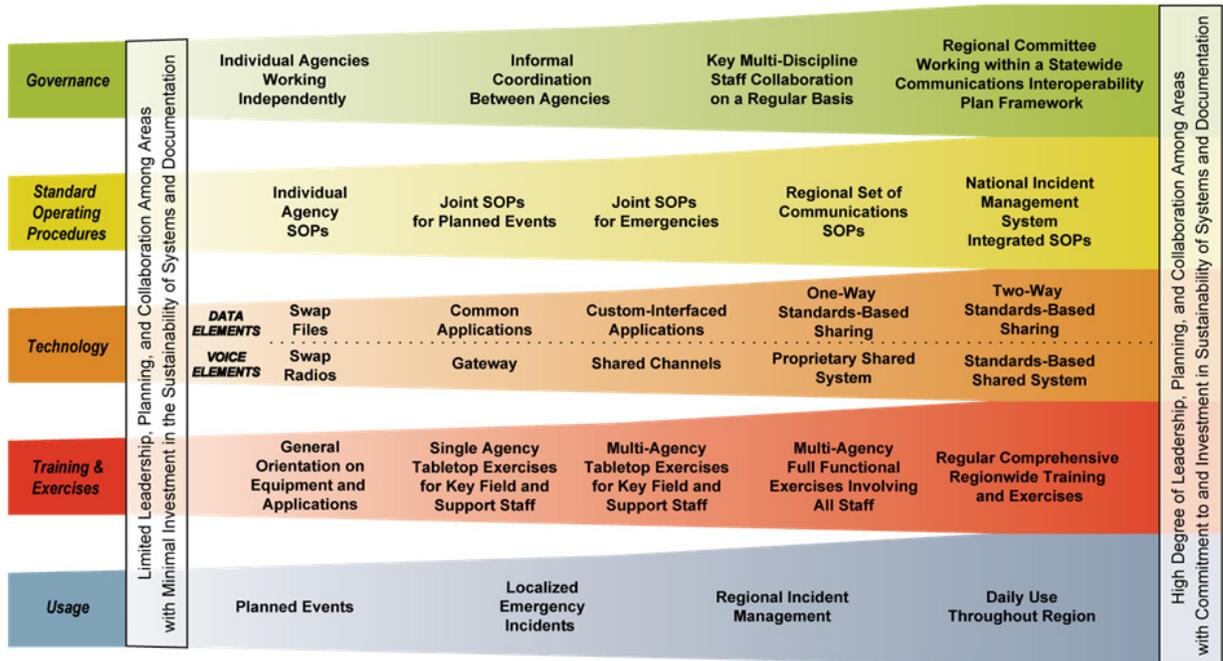
- Statewide Law Enforcement Radio System (SLERS)
- Florida Interoperability Network (FIN)
- Mutual Aid Channels (Statewide)
- Emergency Deployable Interoperable Communications System (EDICS)
- Emergency Deployable Wide Area Remote Data System (EDWARDS)
- Mobile Trunked Radio Systems
- Mutual Aid Radio Cache (MARC)
- Mobile Command Post Standardization
- Mobile Command Posts
- Radio Caches

Coral Gables' radio manager has taken great interest in aligning with local, regional and state interoperable communication capabilities. The State of Florida's vision for statewide interoperability requires connecting 700/800 MHz wide area trunked radio systems. Coral Gables will be able to support and increase interoperability in South Florida through the modernization of their system to a new APCO P-25 standardized radio system.

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Interoperability Continuum



Interoperability with the surrounding counties and agencies will be done either by direct connection through ISSI equipment, as explained in Section 4.0, or by link radios for each channel that these groups operate on. These radios would be directly interfaced to Coral Gables' radio system's network controller and would appear on radio dispatcher console screens as talk groups/ channels. This is done by interfacing these dedicated radios directly to the console switch which enables trunked system users to incorporate conventional repeater channels into their dispatch operations without the need for a separate hardware network and channel banks.

NPSPAC Mutual Aid System

Most public safety agencies in the State of Florida 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 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:

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- 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 type 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 submitted a proposal for a new ANSI (American National Standards Institute) Standard for Channel Naming for Public Safety Interoperability Channels to APCO’s ANSI Standard Development Committee (SDC). This standard is expected to be approved as an ANSI standard sometime during the 1st quarter of 2010 and FCC approval would follow soon afterwards.

The following table shows 8TAC naming conventions recommended by the APCO and NPSTC.

Non-Federal 800 MHz National Mutual aid Repeater Channels			
Description	NPSTC ID	Mobile TX (MHz)	Mobile RX (MHz)
Calling	8CALL90	821.0125(806.0125*)	866.0125(851.0125*)
Calling - Direct	8CALL90D	866.0125(851.0125*)	866.0125(851.0125*)
Tactical	8TAC91	821.5125(806.5125*)	866.5125(851.5125*)
Tactical - Direct	8TAC91D	866.5125(851.5125*)	866.5125(851.5125*)
Tactical	8TAC92	822.0125(807.0125*)	867.0125(852.0125*)
Tactical - Direct	8TAC92D	867.0125(852.0125*)	867.0125(852.0125*)
Tactical	8TAC93	822.5125(807.5125*)	867.5125(852.5125*)
Tactical - Direct	8TAC93D	867.5125(852.5125*)	867.5125(852.5125*)
Tactical	8TAC94	823.0125(808.0125*)	868.0125(853.0125*)
Tactical - Direct	8TAC94D	868.0125(853.0125*)	868.0125(853.0125*)
Default operation should be carrier squelch receive, CTCSS 156.7(5A) transmit. If the user can enable/disable CTCSS without reprogramming the radio, the indicated CTCSS tone should also be programmed for receive, and the user instructed how and when to enable/disable. *The frequency in parenthesis, which is 15MHZ lower, will be the frequency used after rebanding.			

APCO/NPSTC proposed ITAC naming convention.

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Some agencies have already adopted and implemented these new standards in order to avoid any additional subscriber reprogramming. It has also been reported that some agencies have already rebanded with improper naming convention such as “new ITAC”. It is the State’s goal to have all 800 MHz ITAC/8TAC channels changed to the new naming convention as soon as possible. This will require agencies to work closely with their radio shop technicians as well as mutual aid partners to insure interoperability is maintained during this time.

Neighboring City/City Interoperability

According to the Florida Statewide Communications Interoperability Plan (SCIP), Florida’s Region 7 “consists of four counties: Palm Beach, Broward, Miami-Dade and Monroe. This region covers 6,122 sq. miles and has a population of 5,538,594 people. The Miami-Dade, Broward and Palm Beach counties are the sixth largest Metropolitan Statistical Area (MSA) in the country”.

Miami-Dade County and most of the cities surrounding Coral Gables have some degree of interoperable capabilities through mutual aid channels to support radio communications during regional disaster responses. Unfortunately, at this time the majority of agencies in South Florida operate on proprietary Project 16 technology that does not allow for direct connection between systems of differing vendors. For example, a Harris EDACS system cannot directly connect to a Motorola SmartNet system. The Project 25 (P-25) standard was created to facilitate interoperable communications between disparate vendor systems.



Florida Regional Domestic Security Task Force Regions

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The following list provides a status of public safety radio systems for surrounding agencies:

State of Florida - SLERS

800 MHz	EDACS	Harris	P-25 upgrade pending 2016-2021
700 MHz	P-25		Project 25 (Phase I)

Miami-Dade County

800 MHz (System A)	EDACS	Harris	P-25 upgrade in progress
800 MHz (System B)	P-25		

Broward County

800 MHz	SmartZone	Motorola	P-25 upgrade pending 2015-2016
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Aventura

800 MHz	P-25		
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Hialeah

800 MHz	EDACS	Motorola	P-25 upgrade pending 2014-2015 (RFP to release soon)
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Miami Beach

800 MHz	SmartNet	Motorola	P-25 upgrade pending 2015-2016 (RFP to release soon)
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North Miami Beach

800 MHz	EDACS	Harris	
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Mutual-Aid Talk Around

800 MHz	854.6375 MHz		
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Miami Interops Channel 4

800 MHz			
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Police Inner-City	155.370 MHz, PL103.5 (Replaced by 8CALL90)		
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State of Florida Mutual-Aid

MA-CALL	853.3875 PL 210.7		
8CALL90	851.0125 PL 156.7		
8TAC91	851.5125 PL 156.7		
8TAC92	852.0125 PL 156.7		
8TAC93	852.5125 PL 156.7		
8TAC94	853.0125 PL 156.7		

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Agency to Agency Interoperability

The following matrix outlines current/desired interoperability between agencies within the City of Coral Gables and with agencies immediately surrounding Coral Gables.

	Coral Gables Police	Coral Gables Fire	Coral Gables EOC	Coral Gables PW	Coral Gables Sanitation	Coral Gables Parking	Aventura Police	Miami Dade Fire	North Miami Beach Police	Florida Hwy Patrol	Local Fire Depts	State of Florida	Mutual-Aid
Coral Gables Police		X	X	X	X	X	X		X	X			X
Coral Gables Fire	X		X	X	X	X		X			X		X
Coral Gables EOC	X	X		X	X	X	X	X	X	X	X	X	X
Coral Gables PW	X	X	X		X	X							
Coral Gables Sanitation	X	X	X	X									
Coral Gables Parking	X	X	X	X									
Aventura Police	X		X										
Miami Dade Fire		X	X										
North Miami Beach Police	X		X										
Florida HWY Patrol	X		X										
Local Fire Depts		X	X										
State of Florida			X										
Mutual-Aid	X	X	X										

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6.0 Regulatory Considerations for 700/800 MHz Channels

As ordered by the FCC, a major bandwidth reduction is required for radio systems operable on 700 MHz. By Year 2017, the FCC requires all public safety 700 MHz radio systems to be converted to 6.25 KHz operations. Currently, 700 MHz public safety radio systems are operable using Project 25 Phase I standards (with 12.5 KHz channels). The Year 2017 bandwidth rules will require, at a minimum, software changes to existing Phase I infrastructures.

Existing 700 MHz portable and mobile radios operable only on Phase I bandwidths will require replacement in order to operate on 6.25 KHz bandwidth systems. Early users of 700 MHz may have purchased user radio equipment that is not adaptable to Project 25 Phase II bandwidths/ technology. Thus, many agencies now considering the purchase of user radios operable on 700 MHz systems are encouraged to secure written assurance from potential radio vendors that any proposed/ supplied equipment is capable of a software upgrade to support APCO Project 25 Phase II operations.

The FCC mandate above only applies to 700 MHz frequencies and does currently impact 800 MHz channels. This includes the ten 800 MHz channels that Coral Gables is currently licensed to operate on. Further, the FCC has not publicly made any statement regarding intent to require 800 MHz channels to reduce channel bandwidth from 12.5 KHz to 6.25 KHz like 700 MHz frequencies.

At the time of the writing of this report, only two public safety grade radio manufacturers offer 700/800 MHz Phase II capable radio hardware and software, Motorola Solutions and Harris Corporation. Tait Radio currently offers Phase II radio equipment, and will begin shipping Phase II capable software in Feb-March 2015. Tait is currently testing a pilot Phase II software based system in Idaho.

Several additional vendors offer mobile and portable radios that will operate in Phase II, but they do not yet have the software required to operate the available equipment.

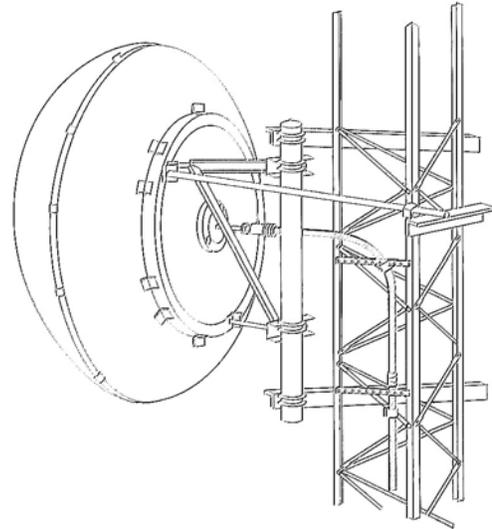
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7.0 Microwave Subsystem and Site Reliability

Immediate attention has been given by the federal government in driving the convergence of new public safety and federally operated radio systems toward the APCO 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, but proprietary and, thus, 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 consideration 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 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.

Coral Gables replaced its current microwave system, within the past two years, with a new loop/ring based system design capable of supporting the needs of a new P-25 public safety radio system. If maintained properly, microwave systems have an expected useful lifespan of 15-20 years. As such, this conceptual design recommends the re-use of this system. However, this system is only configured in a single radio (per MW hop) design instead of a dual hot-standby configuration. A loss of microwave connectivity between the Control Point and any of the antenna sites would create a large area of operations with no simulcast capabilities or connection to dispatch. Assuming the site retained power, the site could continue to operate as a repeater for users in range of that particular site.

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Using the lessons learned from these recent events, our investigation considered the development of a highly robust, protected public safety digital microwave network supportive of the City's range of needs. In this envisioned configuration, broadband microwave technology would provide resilient, seamless interconnectivity with the principal radio dispatch E911 center as well as linkages to the City's 800 MHz trunked radio system sites. This microwave system could be easily scaled to include linkages to other P-25 radio systems as desired (i.e. Miami-Dade or Broward Counties for mutual support and redundancy).

Consideration must be given to the expansion of the current microwave system into a high performance OC-3 loop-protected microwave network (equivalent to 100 T-1 circuits). By so doing, the City would greatly increase the reliability and redundancy of the radio system.

General Configuration

The existing Coral Gables microwave system interconnects its 800 MHz trunked simulcast towers to the radio network's Control Point located at the E911 Dispatch Center. The control point maintains the precise frequency, phase and amplitude stability necessary to preserve simulcast transmitter functionality. The control point additionally houses the radio network's dispatch console switch, receiver voting equipment, voice encryption and related radio subsystems. Additionally this site supports the various radio gateways to outside radio systems such as Miami-Dade County and the Statewide Law Enforcement Radio System (SLERS).

The microwave subsystem is configured in a monitored hot-standby mode. Each transmitter, receiver and power supply used in the total microwave network has a fully redundant and operational spare component. The microwave system continuously monitors the condition of all of these various elements and automatically deactivates failed equipment and switches to spare equipment in a manner fully transparent to users.

Reliability Attributes

The Coral Gables area is susceptible to many natural weather events that play havoc with commercial telecommunication services. These events include hurricanes, lightning storms, rainstorms and, of course, floods. Microwave radio antennas are relatively large and unless proper precautions are taken, are vulnerable to wind-related events. Therefore, each antenna system in the network should be equipped with a radome cover and antenna brackets designed for high winds and violent physical vibratory effects. Transmission lines, the single-most critical network component, are most vulnerable where they are routed away from the tower to the antenna. Fortunately, all Coral Gables sites are located on rooftops and damage to the transmission lines is not likely. In cases where the transmission lines are exposed across a horizontal span, grated shields are installed directly above the lines to protect the transmission lines from potential damage.

Many public safety radio installations use a common battery backup system that supplies power to both 700/800 MHz base stations and the microwave subsystems. We feel this practice should be discouraged. The loss of normal electrical power (main and standby)

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will result in a rapid depletion of a site's common battery supply, due to the comparatively large electrical current demands of the 700/800 MHz base stations. Once the battery plant's capacity is exhausted, an agency loses not only the effectiveness of that one radio site, but the critical microwave interconnectivity piece as well. Our recommendation is to incorporate separate and properly sized battery backup systems for the basestations and the microwave radios separately, for all infrastructure facilities.

During emergencies, it is important to keep the microwave backhaul functional even though site-specific mobile radio services may be curtailed. Thus, it is good practice to design microwave backhaul elements to survive extended periods of electrical outage (at least 24 hours but in some cases as long as 72 hours depending upon local circumstances).

Interoperability and Security Attributes

It is likely, as more suppliers enter the marketplace that future radio networks could be furnished by more than one equipment vendor. Therefore strict functional compliance with APCO standards for interoperability between system controllers will become critically important. An expansive Coral Gables microwave network concept, if adopted, would allow the seamless sharing of radio unit IDs, talk groups and other necessary call attributes required to allow users to roam between radio systems. This would support full unit-to-unit interoperability between agencies. Long-term electrical outages and multiple tower failures would have little consequence to core operations due to the self-healing aspects of the envisioned loop microwave approach.

One of the more exciting features of this enhanced microwave solution is its inherently private broadband capacity. The microwave network's excess capacity could be used to support the City'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.

Access points are limited to the network's 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.

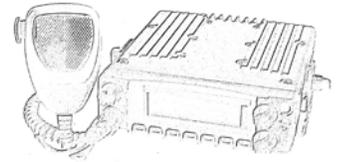
Finally, there is the issue of telephony and video conferencing connectivity. The excess bandwidth provided in a microwave network approach can be efficiently and securely used to support emergency telephone or video conference communications between dispatch centers and/or Emergency Operation Centers (EOC's) in support of response coordination. Thus, the loss of commercial telecommunication services could no longer potentially disrupt the operations of radio communication centers at the time when communications and coordination was most needed.

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8.0 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.



These requirements greatly exceed the needs of 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, 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.

Environment	Category	Environment Loss	Building Loss
Water	Lakes	0 dB	0 dB
Snow & Ice	Snow Pack	0 dB	0 dB
Wetland	Non-forested	3 dB	0 dB
Open Land	Bare Land	5 dB	21 dB
Range Land	Herbaceous	3-7 dB	21 dB
Transportation	Roadways	5 dB	21 dB
Agricultural	Grassland	7 dB	21 dB
Residential	Suburban	12 dB	21 dB
Forest	Pine (>30')	15-21 dB	21 dB
Mixed Urban/Buildings	Apartments (<4 stories)	15 dB	21 dB
Commercial/Industrial	Commercial Services	19 dB	21 dB
High Density Urban	Skyscrapers	28 dB	21 dB

How users intend to operate radio communications systems and equipment 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.

The dispatch and coordination of Coral Gables emergency communications resources is principally through the City’s E911 Dispatch Center. Officers are directed to specific incidents/ locations in response to citizen calls placed via the City’s 911 Emergency telephone network.

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Only a handful of the City's existing subscriber units are P-25 capable. In order to operate on the new system, Coral Gables will need to replace all but a few portable radios.

At the request of the City, additional mobile (27) and portable (100) radios will be required in order to bring the Public Works Department onto the same system as all other City agencies.

It is also recommended that the City purchase an additional 5% of both mobiles and portables to facilitate repairs and limit operational down time. Therefore, the City will need to purchase the following quantities:

Total Existing Subscriber Unit Quantities (from Section 2.0)

Public Safety Grade

Existing Mobiles:	179
Existing Portables:	144
Existing Control Stations:	28
Existing Consoles:	8

Non-Public Safety Grade

Existing Mobiles:	20
Existing Portables:	95
Existing Control Stations:	0

Total Recommended Subscriber Unit Quantities

Public Safety Grade

New Mobile Radios:	188
New Portable Radios:	152
New Control Stations:	30
New Consoles:	8

Non-Public Safety Grade

New Mobile Radios:	50
New Portable Radios:	110

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9.0 Conceptual Solution

Prior to entering the conceptual design phase, TCS performed a thorough evaluation of the existing Coral Gables public safety radio system. This included site visits and inspections of the E911 Dispatch Center, control point, and all three antenna sites. In addition, TCS conducted user interviews, and met with executive staff for Police, Fire, Public Works and Parking. Finally, in order to further expand the information and data gathered to develop the conceptual design recommendation for the City, TCS spent numerous hours researching State and Federal databases for additional licensing and system design information. The accumulated materials were then used to design, through dozens of iterations, the appropriate level of propagation loss models and coverage reliability required to meet current and future needs.

To summarize, two key deficiencies exist today: the limited capacity provided by ten 800 MHz channels and limited coverage, as a result of increased building density and population growth over the past ten years, in the southern and northern ends of the City. Any potential solution must address deficiencies, both immediately and in the long term.

In consideration of a solution that can best meet the needs of all agencies and potential users within Coral Gables, an analysis the 700/800 MHz bands was necessary. 800 MHz is currently used throughout the City. As directed by Coral Gables, the focus of this conceptual solution is the development of an APCO Project 25 standards based radio system. In addition, a new system design must start with Phase II APCO compliance, and should include a distributed control point, redundant design philosophies, for both antenna and microwave systems, and in-house test equipment to support radio shop capabilities. A system designed to provide citywide coverage and in-building penetration will most effectively meet the user's needs through the continued use of digital simulcast technology.

With the 700/800 MHz bands, the allocation of spectrum has been categorized by the FCC and is further coordinated by each state, on behalf of the FCC. With 800 MHz, the channels were assigned by categories of use (General, Public Safety, etc.) with public safety channels being allotted in the National Public Safety Planning Advisory Committee (NPSPAC) group. Depending on the State, larger Cities are typically assigned a number of channels determined by population and potential need. In some cases, channels can be re-allocated to other agencies if they have not been used by the City to which they have been assigned. The categorization of 800 MHz frequencies has been altered and convoluted through the rebanding of channels for Sprint/Nextel, but is still far more advanced compared to UHF and VHF frequency coordination.

Like 800 MHz, channel allocation for the 700 MHz band has already been established. In Florida, the Region 9 Planning Committee has apportioned channel use by County and level of government (county and state). In Miami-Dade County, there are no longer any 700 MHz channels available for licensing. All 700 MHz channels have been licensed either by the County or have been reserved for use by the RDSTF.

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In order to support simulcast capabilities, the system would need approximately 20 channels to account for all agencies and future system growth. The number of channels was determined according to current system capacity and the conceptual system design requirements for four tower sites. As shown in Section 2.0 above, Coral Gables currently only has ten 800 MHz channels. Therefore the City will need to acquire ten additional channels. Although it is possible, despite the 800 MHz band congestion in Miami-Dade County, that additional available 800 MHz channels can be acquired it will likely be very costly (based on industry accepted channel acquisition costs). Therefore, TCS recommends that the City of Coral Gables install an APCO P-25 800 MHz Phase II compliant system.

The final number of required channels will depend on the design of the chosen vendor.

Minimum Standards for Coverage

While there are no universally accepted minimum standards for either coverage or capacity for a Public Safety radio system, the objectives defined by Tusa Consulting for coverage and capacity follow those generally employed in the industry. Specifically, any potential solution should provide no less than 95% City-wide portable indoor coverage with a Delivered Audio Quality (DAQ) level of at least 3.4, and no less than 95% coverage in 40dB buildings in critical coverage areas, also at DAQ level of 3.4. The table below provides a definition of DAQ levels. Critical coverage areas are areas other than high-rise or high building density.

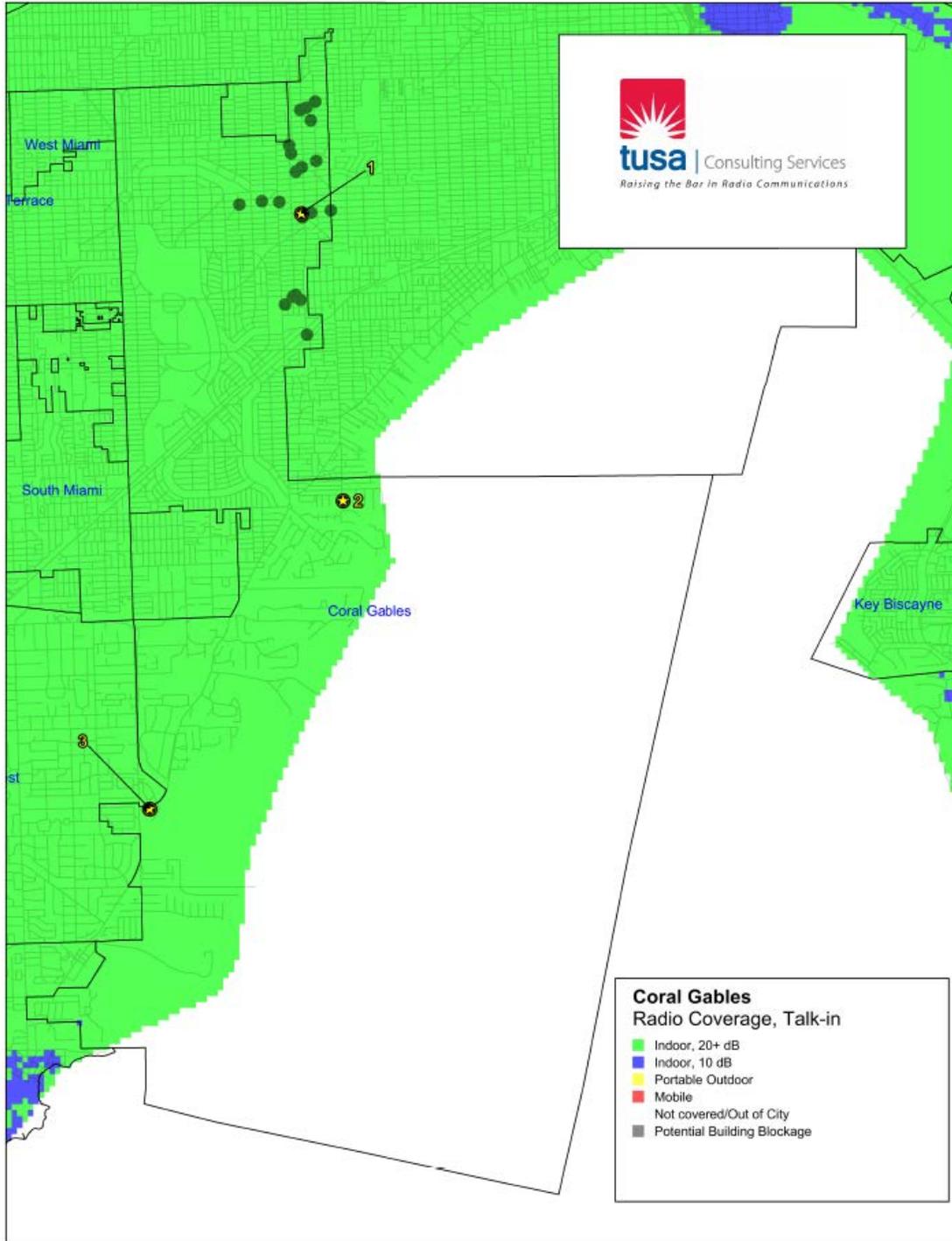
DAQ Delivered Audio Quality	Subjective Performance Description	SINAD equivalent intelligibility ^{1,2}
1	Unusable, Speech present but unreadable	<8 dB
2	Understandable with considerable effort. Frequent repetition due to Noise/Distortion	12 ± 4 dB
3	Speech understandable with slight effort. Occasional repetition required due to Noise/Distortion	17 ± 5 dB
3.4	Speech understandable with repetition only rarely required. Some Noise/Distortion	20 ± 5 dB
4	Speech easily understood. Occasional Noise/Distortion	25 ± 5 dB
4.5	Speech easily understood. Infrequent Noise/Distortion	30 ± 5 dB
5	Speech easily understood.	>33 dB

1 CPC is set to the midpoint of the range.

2 SINAD values are NOT to be used for system performance assessment.

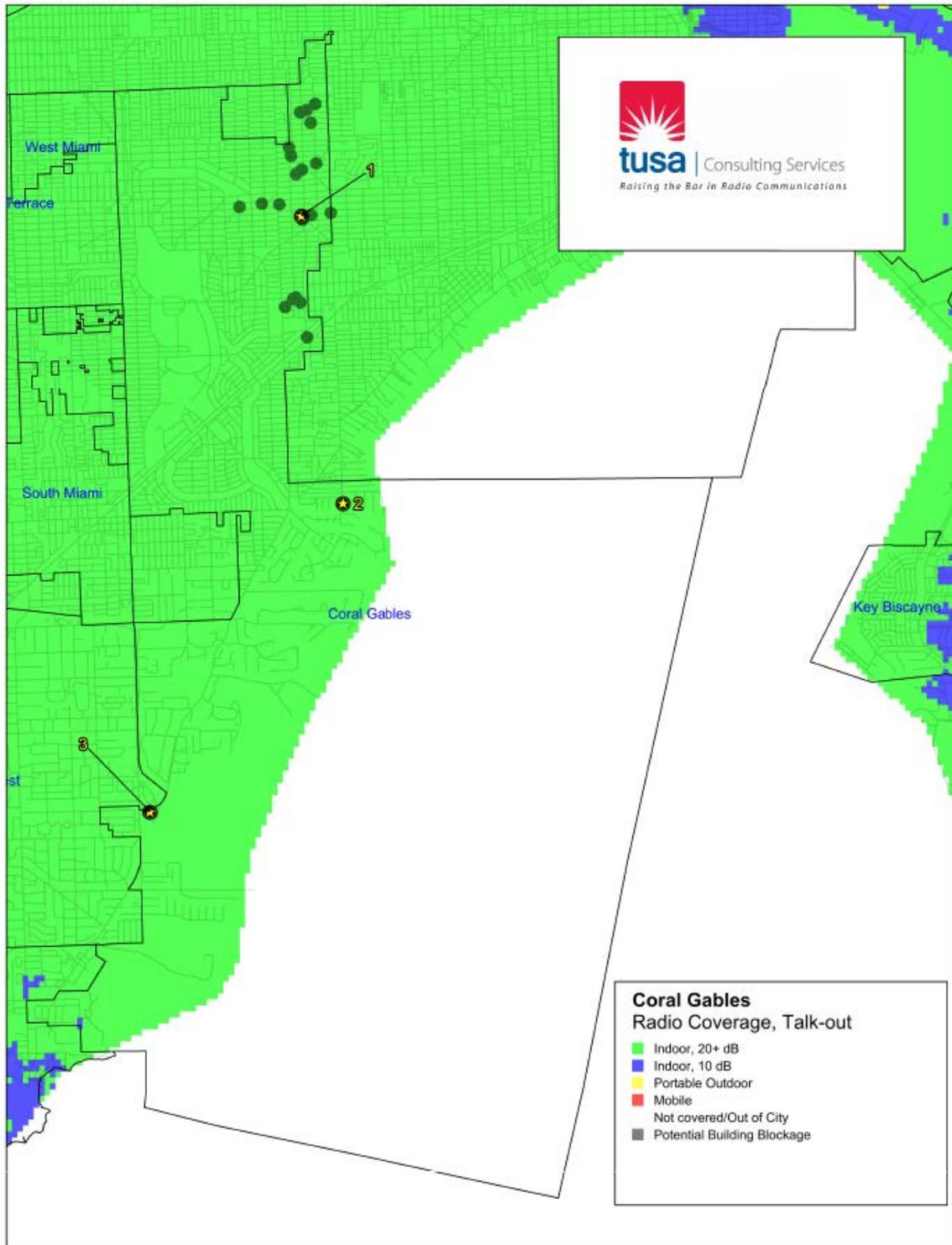
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Minimum capacity requirements are defined as better than a Grade of Service (GOS) .01, which is statistically defined as less than 10 in 1,000 calls could be delayed as a result of insufficient system capacity and the delay, itself, should not exceed 0.5 seconds.



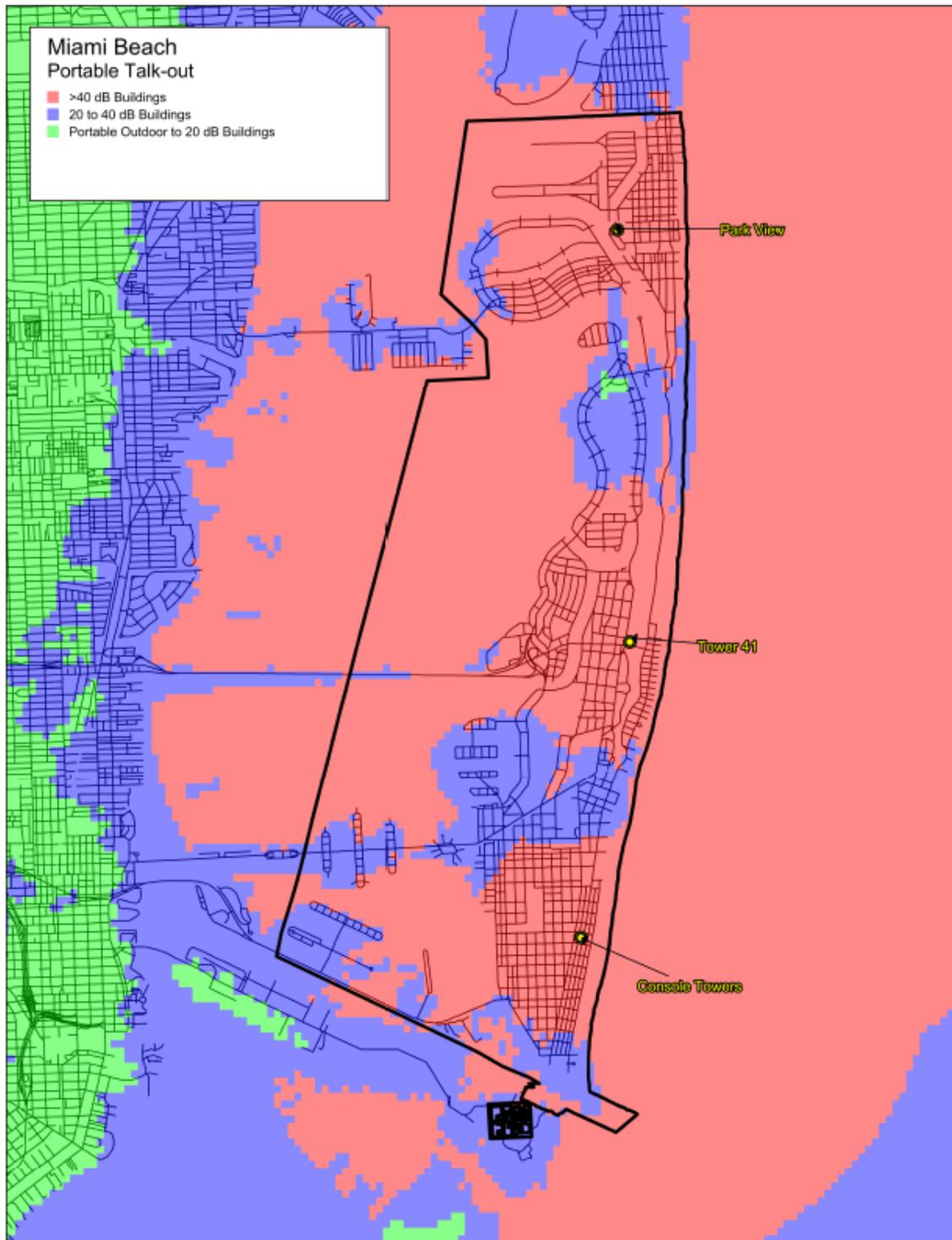
20 dB loss requirements for Coral Gables portable talk-back coverage.

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20 dB loss requirements for Coral Gables portable talk-out coverage.

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For Comparison: 40 dB loss requirements for Miami Beach portable talk-back coverage.

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Pending /Recent High Rise Building Construction

The following list of buildings are in various stages of planning and development. All are expected to follow LEED construction practices. As discussed in Section 2.0, this initiative designed to support energy conservation also has the potential to block radio signal transmissions.

On December 31, 2014, The Florida State Fire Marshal's Office, the new code, FFPC 1: 11:10, will require that public safety radio communications radios receive a minimum level of signal strength in *new and existing* buildings. Structures whose construction design and materials prevent the minimum signal level will be required to have a "two-way radio communication enhancement system" installed, i.e. a bi-directional amplifier (BDA) system.

While this is a groundbreaking step forward for first responders, some caution is warranted. The requirement of providing these systems will likely be placed on building owners, who have no radio experience or interest in expending the cost required to keep these systems properly maintained or routinely tested. Further, BDAs only support communications inside of these structures. The radio frequency 'shadows' created by these buildings may inhibit communications when operating outside, in close proximity to these buildings.

As a result, first responders operating within these buildings or within the outside vicinity of these buildings need to be aware of potential degradations in public safety radio communications.

List of Currently Planned LEED Construction Buildings

- | | |
|-------------------------------|------------------------------|
| 1. 4133 LeJeune Road | 10 Story Building |
| 2. 300 Bird Road | Bank Building |
| 3. 231 Dixie Highway | 9 Story Building |
| 4. University of Miami campus | Various Buildings |
| 5. 2900 Ponce De Leon Blvd | 7 Story Building |
| 6. 401 Valencia | 10 Story Building |
| 7. 1500 Sunset Road | 6 Story Building |
| 8. 2801 Ponce De Leon Blvd | 3 Buildings, 12 - 16 Stories |
| 9. 1200 E Ponce De Leon Blvd | 8 Story Building |
| 10. 2020 Salzedo Street | 16 Story Building |
| 11. 2020 Salzedo St | 4 Story Building |
| 12. 2020 Salzedo St | 7 Story Parking Garage |
| 13. 1091 Galiano Street | 7 Story Residential Building |
| 14. 250 Bird Road | 10 Story Building |
| 15. 700 Valencia Avenue | 8 Story Residential Building |
| 16. 00 Santilane Avenue | 7 Story Residential Building |
| 17. 4800 LeJeune Road | 8 Story Building |
| 18. 2 Alhambra Circle | |

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- | | |
|-----------------------------|--------------------------|
| 19. 100 Alhambra Circle | |
| 20. 4100 Aurora Street | |
| 21. 2800 Douglas Road | |
| 22. 301 Majorca Avenue | |
| 23. 515 Valencia Avenue | |
| 24. 120 Salamanca Avenue | |
| 25. 5600 Merrick Drive | 845 Space Parking Garage |
| 26. 1200 Ponce De Leon Blvd | 16 Story Building |
| 27. 2551 LeJeune Road | 18 Story Building |
| 28. 2551 LeJeune Road | 4 Story Parking Garage |
| 29. 2551 LeJeune Road | Publix Supermarket |

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Available Licensing Options

800 MHz - Currently Licensed by City of Coral Gables

WPCJ404 (Trunked)

Frequency	Ponce De Leon	Edgewater	Fire Station	Control St.	Mobile
851.2000 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
851.2250 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
851.6750 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
851.7000 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.0500 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.0750 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.5500 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
858.9125 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.7750 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W
853.8000 MHz	58.0 W	28.0 W	195.0 W	70.0 W	35.0W

WPCJ297 (Conventional)

Frequency	Location	Max ERP
806.0125 MHz	Ponce De Leon	70.0 W
806.5125 MHz	Ponce De Leon	70.0 W
807.0125 MHz	Ponce De Leon	70.0 W
807.5215 MHz	Ponce De Leon	70.0 W
807.6250 MHz	Mobile	35.0 W
807.6250 MHz	Ponce De Leon	70.0 W
808.0125 MHz	Ponce De Leon	70.0 W
852.3250 MHz	Repeater	58.0 W
852.6052 MHz	Mobile	35.0 W

WPCT408 (Conventional)

Frequency	Location	Max ERP
812.4357 MHz	Dispatch	70.0 W
812.4375 MHz	Mobile	35.0 W
857.4375 MHz	Ponce De Leon	589.0 W
857.4375 MHz	Biltmore	500.0 W

WYQ412 (Conventional)

Frequency	Location	Max ERP
809.4875 MHz	Dispatch	70.0 W
809.4875 MHz	Mobile	35.0 W
854.4875 MHz	Biscayne Blvd	200.0 W
854.4875 MHz	PD	617.0 W
854.4875 MHz	Biltmore	617.0 W

As noted in the Region 9 Plan excerpts below, acquiring additional 700 MHz or 800 MHz channels in South Florida is very difficult and extremely expensive. Therefore, to address current and future system loading and capacity issues, it is recommended that the new system narrowband the existing ten 800 MHz channels under license# WPCJ404 to an FDMA based, 6.25 kHz channel, APCO P-25 Phase II standard, as described in Section 3.0. This will provide the City with ten additional channels, for a total of 20, while reducing potential interference issues.

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700 MHz - Region 9 Plan Channel Allotment for Miami-Dade County (30 channels)

Class	Band Width	Channel	Base Freq	Mobile Freq	Notation
General Use	Voice 25.0KHz	13-16	769.0875	799.0875	Miami-Dade Application Pending
General Use	Voice 12.5KHz	17-18	769.10625	799.10625	Miami Shores relicense
General Use	Voice 12.5KHz	45-46	769.28125	799.28125	Miami Shores relicense
General Use	Voice 25.0KHz	57-60	769.3625	799.3625	Miami-Dade Application Pending
General Use	Voice 12.5KHz	81-82	769.50625	799.50625	Miami Shores B/W Fix
General Use	Voice 12.5KHz	93-94	769.58125	799.58125	Miami Shores relicense
General Use	Voice 25.0KHz	97-100	769.6125	799.6125	Miami-Dade Application Pending
General Use	Voice 12.5KHz	121-122	769.75625	799.75625	Miami Shores B/W fix
General Use	Voice 25.0KHz	137-140	769.8625	799.8625	Miami-Dade Application Pending
General Use	Voice 12.5 KHz	161-162	770.00625	800.00625	Miami Shores B/W fix
General Use	Voice 25.0KHz	177-180	770.1125	800.1125	Miami-Dade Application Pending
General Use	Voice 25.0KHz	217-220	770.3625	800.3625	Miami-Dade Application Pending
General Use	Voice 25.0KHz	257-260	770.6125	800.6125	Miami-Dade Application Pending
General Use	Voice 25.0KHz	297-300	770.8625	800.8625	RDSTF Project Reserved
General Use	Voice 25.0KHz	337-340	771.1125	801.1125	Miami-Dade Application Pending
General Use	Voice 25.0KHz	377-380	771.3625	801.3625	Miami-Dade Application Pending
General Use	Voice 25.0KHz	437-440	771.7375	801.7375	Miami-Dade Application Pending
General Use	Voice 25.0KHz	477-480	771.9875	801.9875	RDSTF Project Reserved
General Use	Voice 25.0KHz	521-524	772.2625	802.2625	Miami-Dade Application Pending
General Use	Voice 25.0KHz	561-564	772.5125	802.5125	RDSTF Project Reserved
General Use	Voice 25.0KHz	601-604	772.7625	802.7625	Miami-Dade Application Pending
General Use	Voice 25.0KHz	621-624	772.8875	802.8875	Miami Dade Licensed WQNH643
General Use	Voice 25.0KHz	669-672	773.1875	803.1875	Miami Dade Licensed WQNH643
General Use	Voice 25.0KHz	717-720	773.4875	803.4875	Miami Dade Licensed WQNH643
General Use	Voice 25.0KHz	785-788	773.9125	803.9125	Miami Dade Licensed WQNH643
General Use	Voice 25.0KHz	793-796	773.9625	803.9625	Miami Dade Licensed WQNH643
General Use	Voice 25.0 KHz	829-832	774.1875	804.1875	Miami Dade Licensed WQNH643
General Use	Voice 25.0KHz	833-836	774.2125	804.2125	RDSTF Project Reserved
General Use	Voice 25.0KHz	873-876	774.4625	804.4625	Miami Dade Licensed WQNH643
General Use	Voice 25.0KHz	913-916	774.7125	804.7125	Miami Dade Licensed WQNH643

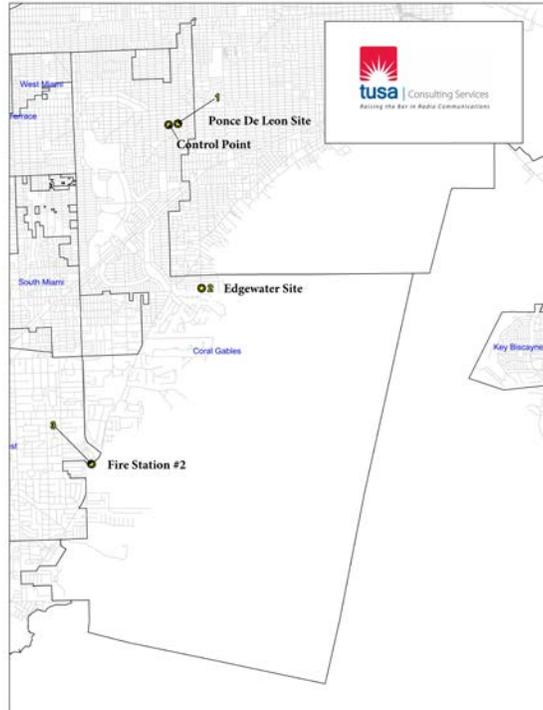
All 700 MHz channels assigned to Miami-Dade County have been acquired by the RDSTF, the County and by other local agencies.

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Proposed Existing Site Locations

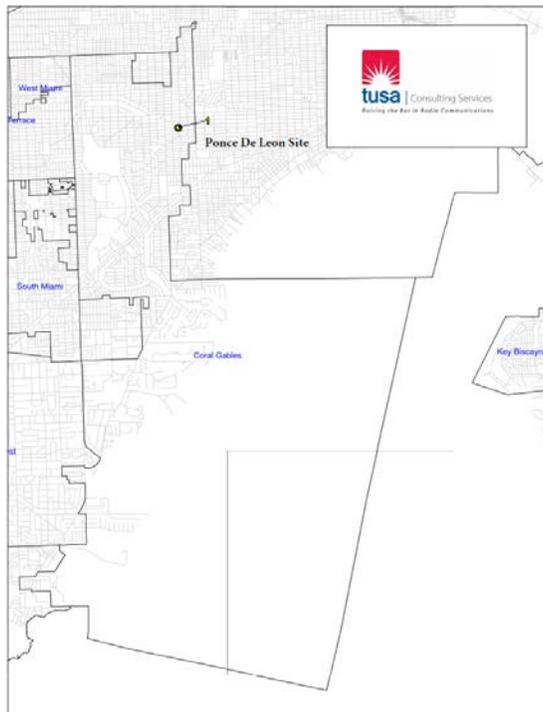
Control Point - Primary

- Upgraded site grounding system



Ponce De Leon Site

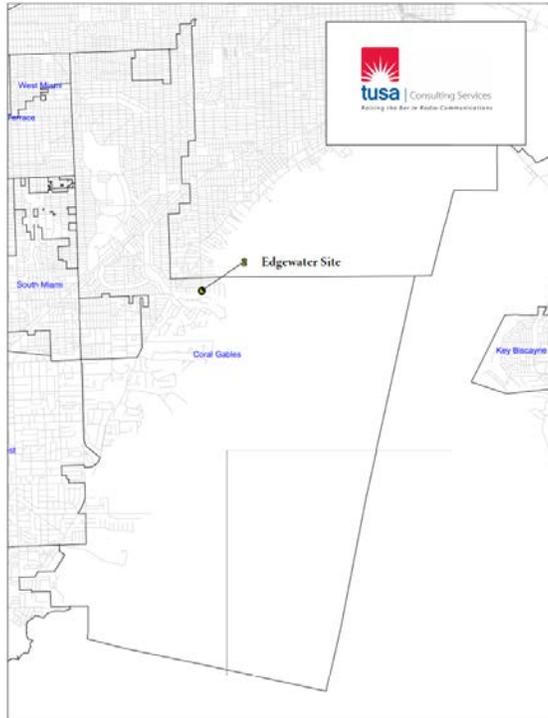
- Upgraded site grounding system



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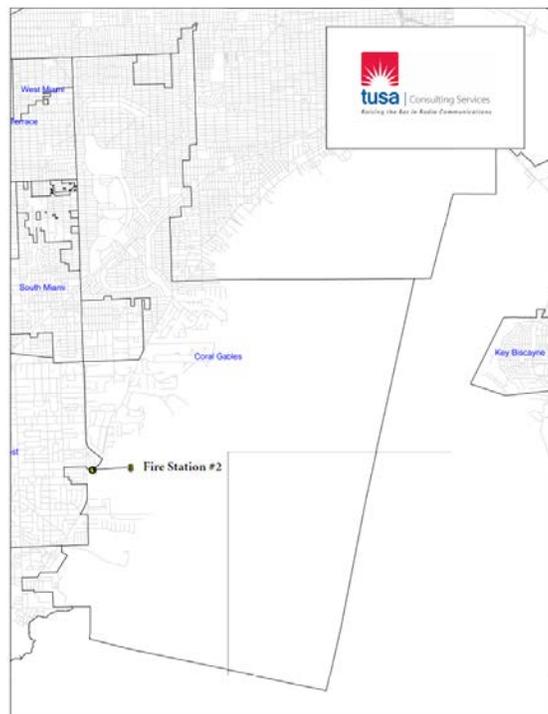
Edgewater Site

- Upgraded site grounding system



Fire Station #3 – Secondary Control Point

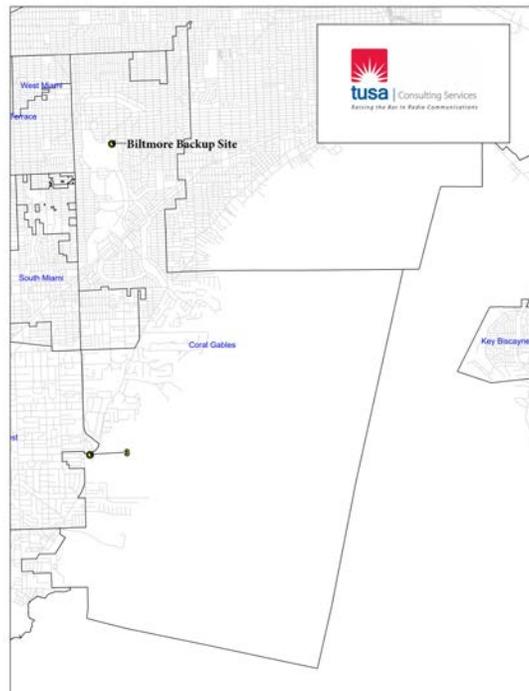
- New shelter
- New AC system
- Upgraded site grounding system



City of Coral Gables, Florida Conceptual Solutions Report

Biltmore Backup Site – Optional

The Biltmore Hotel could again serve as a backup location for radio services but would likely require substantial site upgrades/repairs to provide a public safety grade level of performance. Considering the system redundancy and reliability options proposed in the conceptual design and inherent to the new P-25 radio system, a backup site is less crucial than it was in the past. Regardless, the site could host other, disparate radio systems in operation in Coral Gables.



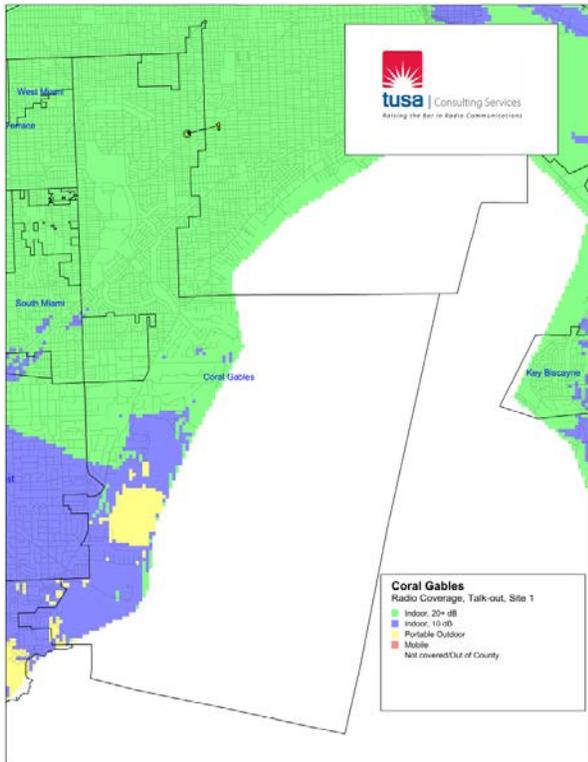
City of Coral Gables, Florida Conceptual Solutions Report

Conceptual Solution Coverage

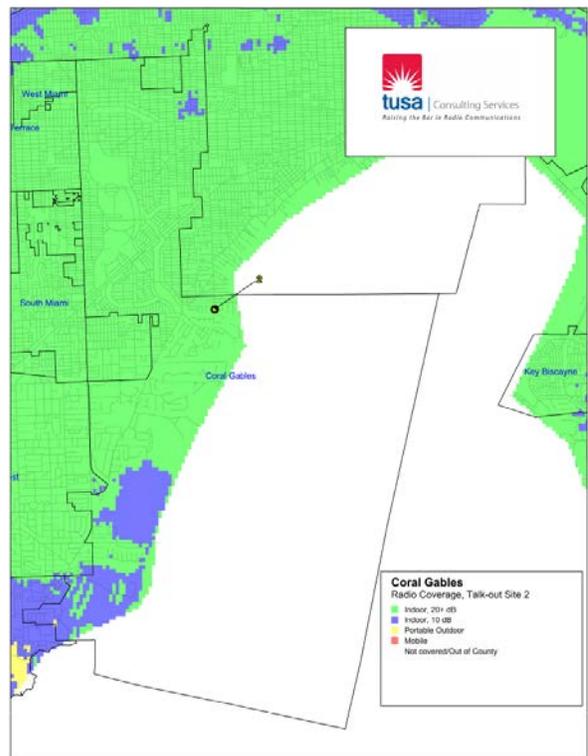
To confirm a conceptual approach, a coverage analysis was required to determine the number of sites needed to meet portable radio coverage objectives. The results of this analysis show that the three existing sites will best support current and future coverage at a minimum 95% (portable indoor talkback) coverage level.

Coverage by Site

The coverage maps below show the predicted overall coverage for each of the three antenna sites individually.

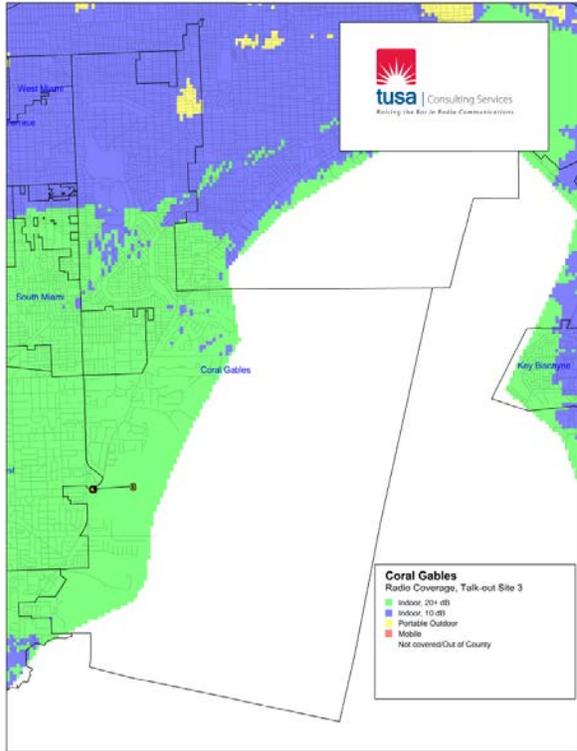


*Ponce De Leon - Portable Talk-Back
Indoor at 20dB*



*Edgewater - Portable Talk-Back
Indoor at 20dB*

City of Coral Gables, Florida Conceptual Solutions Report

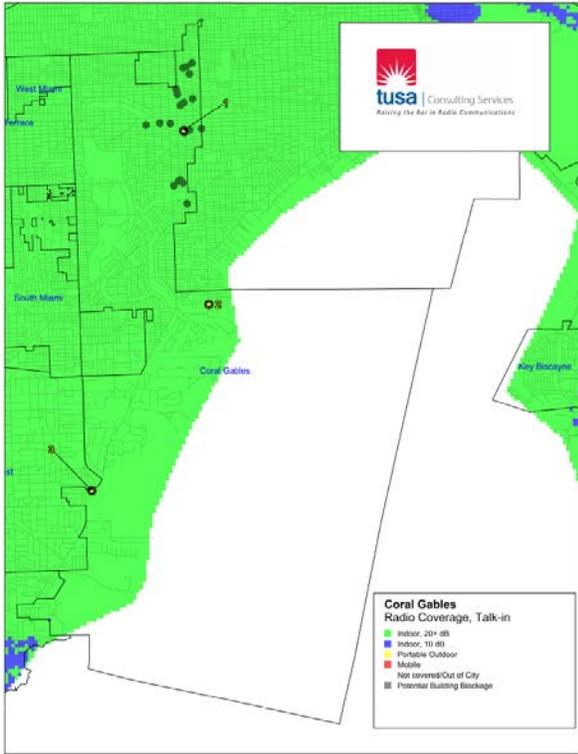


*Fire Station #3 - Portable Talk-Back
Indoor at 20 dB*

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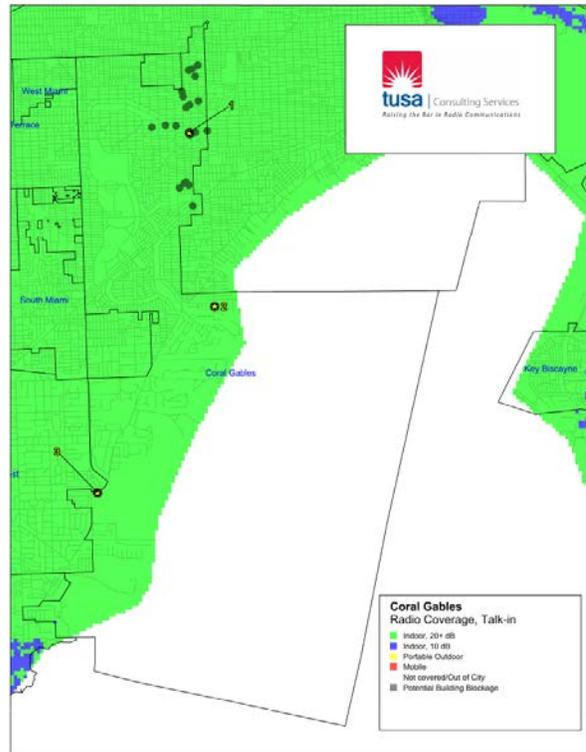
Composite Coverage

The coverage maps below show the predicted overall composite coverage for all sites combined.



*City of Coral Gables -
Portable Talk-Back Indoor @ 20 dB
With All Three Sites Combined*

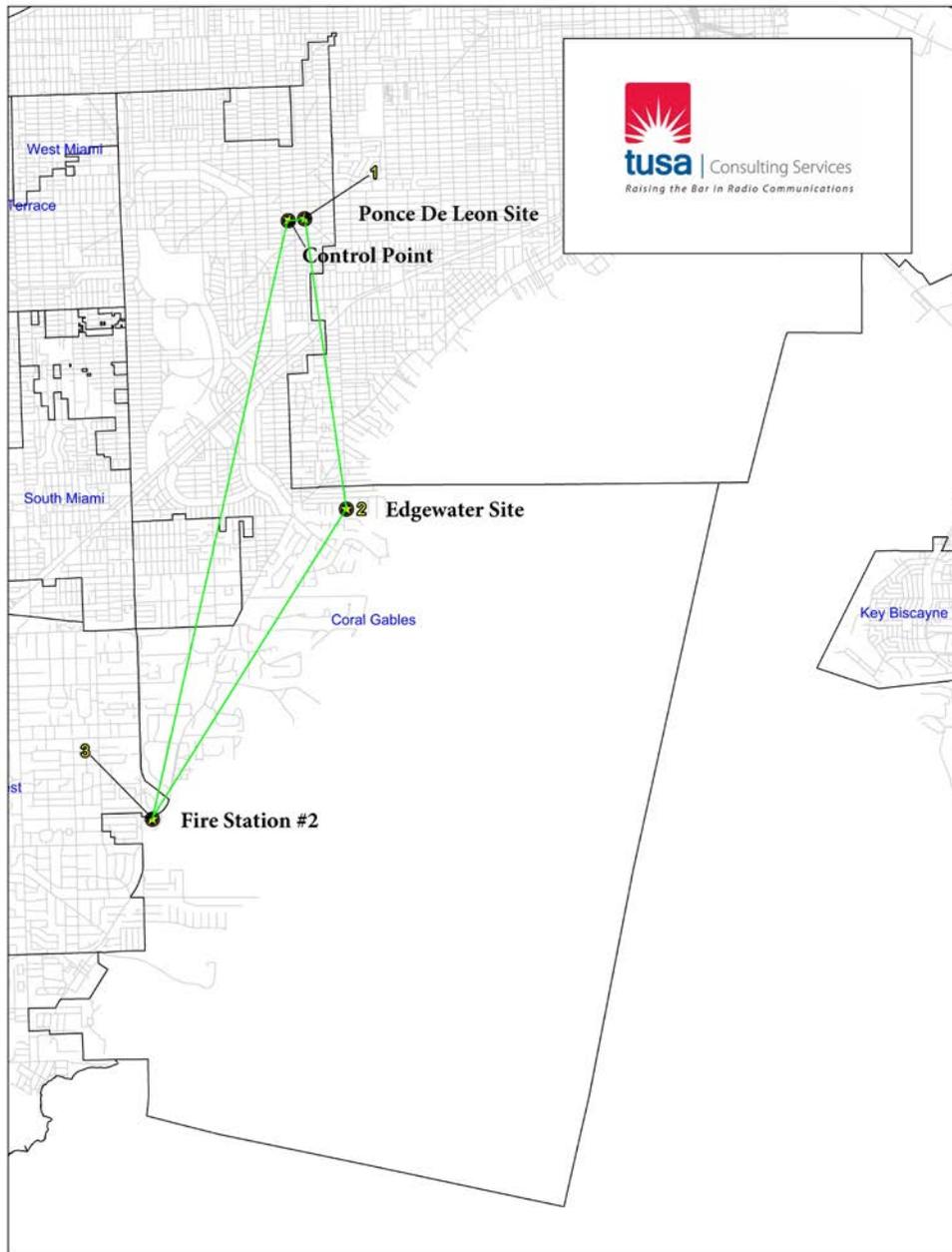
*City of Coral Gables -
Portable Talk-Back Indoor @ 20 dB
With All Three Sites Combined*



City of Coral Gables, Florida Conceptual Solutions Report

Proposed Microwave Backhaul Loop

The proposed microwave backhaul loop configuration shown below supports the proposed simulcast design and includes the E911 Dispatch Center/Control Point #1, and New City Halls shown below. For the purposes of this conceptual design, TCS envisions a combination loop protected (existing) and monitored hot-standby network (required).



Microwave Paths – Proposed Four Site Loop Design

City of Coral Gables, Florida

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Recommended Radio Department Test Equipment

The ability for the Coral Gables radio shop to continue providing direct and immediate support to system users and the radio system itself is critical and highly recommended by Tusa Consulting. Depot level radio maintenance service, as currently provided in-house, delivers multiple benefits to the City and more importantly to its first responders. For example, the radio shop reduces subscriber unit repairs, reprogramming and alignment cost, as well as the downtime to perform these maintenance procedures. To continue in-house maintenance on the P-25 radio system the following equipment, at a minimum, should be included in this system procurement:

- (1) P-25 Digital Radio Test Set w/ conventional operation package
- (1) Spectrum monitoring equipment/ software
- (2) Service monitors
- (2) High resolution frequency counters
- (1) Hand-held spectrum analyzer (up to 6GHz)

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Conceptual Solutions Report

P-25 Phase II 800 MHz Simulcast Trunked Digital Radio System

The proposed conceptual solution, designed to meet the needs Coral Gables' first responder and non-public safety users includes a three site, 20 channel, APCO P-25 Phase II 800 MHz, simulcast, trunked, digital radio system. This system will leverage advanced linear simulcast technology and incorporate 20dB building loss values to provide superior radio coverage throughout the City, indoor and out.

In addition, this solution will increase system redundancy and reliability by replacing the aged components of existing system and improving upon the current design.

This proposed solution includes the following:

- Immediate APCO P-25 Phase II compliance to increase capacity to 20 channels
- Distributed control point architecture (existing control point and Fire Station #3)
- Site upgrade of all three antenna sites and control point
- New radio system infrastructure
 - Base Stations/ Repeaters
 - Master Site/ Control Point
 - Frequency Standard
 - Combiners
- New antenna systems (antennas, TX lines) for all sites
- New shelter and AC system for Fire Station #3
- New loop designed microwave backhaul system, including control points
 - Dual OC-3, Hot Standby Radios
 - DC Backup Power System
- 11 new dispatch positions at the E911 Dispatch Center
 - Mic, Headphone, Headsets, Speakers
- 8 new dispatch consoles and radio equipment at the E911 Dispatch Center
 - Backup Control Stations
- 188 new public safety grade mobile radios
- 152 new public safety grade portable radios
- 30 new public safety grade control stations
- 50 new non-public safety grade mobile radios
- 110 new non-public safety grade portable radios
- Over the Air Rekeying (OTAR)
- New system test equipment for P-25 operations
- Training for all system managers, dispatchers, users and maintenance providers
- Installation, implementation, and testing of new system
- Decommission of old system

City of Coral Gables, Florida Conceptual Solutions Report

Conceptual Simulcast System Cost Estimate

Presented below is TCS' cost estimate for a P-25 simulcast conceptual design. The cost of the final system will be dependent upon the system requirements and features included in the final specification, but these estimates can be considered reasonably accurate for budgetary purposes. They are based upon TCS' understanding of Coral Gables' requirements, resources and upon recent competitive pricing for equipment and radios for similar scope and scale projects.

City of Coral Gables Pricing Summary	
Description	Total
Voice Infrastructure	\$3,770,000.00
Voice System Integration	\$600,000.00
Voice Contingency	\$754,000.00
Voice Infrastructure Total	\$5,124,000.00
Site Construction	\$280,000.00
Site Construction Contingency	\$56,000.00
Site Construction Total	\$336,000.00
Microwave System	\$425,500.00
Microwave System Integration	\$0.00
Microwave Contingency	\$85,100.00
Microwave Total	\$510,600.00
Dispatch Center Equipment	\$1,519,450.00
Dispatch Center Integration	\$59,400.00
Dispatch Total	\$1,578,850.00
PSG Subscribers Radios	\$1,744,196.00
NPSG Subscribers Radios/Control Stations	\$496,600.00
Re-Programming of P25 Capable Radios	\$17,250.00
Total Subscribers	\$2,258,046.00
Coral Gables Grand Total	\$9,807,496.00

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Negotiation Process	
Infrastructure (Voice, Construction and Microwave)	\$5,075,010.00
Dispatch Center	\$1,342,022.50
Mobile, Portable and Control Station Radios	\$1,919,339.10
Negotiated Contract Process Grand Total	\$8,336,371.60

Additionally, *estimated* yearly costs for annual maintenance of the system are included.

Maintenance Services (Yearly)	
Software Services	\$75,000.00
Infrastructure Equipment	\$25,000.00
Simulcast Control Point	\$2,500.00
Network Switching Center	\$2,500.00
Microwave	\$2,500.00
Subscribers	\$5,000.00
HVAC	\$12,000.00
Generators	\$1,500.00
UPS	\$2,500.00
Logging Recorder	\$10,000.00
Network Preventative Maintenance (twice annually)	\$7,500.00
Maintenance Services Plan Total	\$146,000.00

City of Coral Gables, Florida

Conceptual Solutions Report

10.0 Conclusion and Recommendation

TCS has determined that a complete 20 channel 800 MHz APCO P-25 Phase II linear simulcast trunked digital solution, as outlined in Section 9.0, will best meet the needs of the City of Coral Gables.

Recommended Solution and Plan

Tusa Consulting recommends that the City begin developing technical specifications to promote the procurement of a P-25 based simulcast radio network. The procurement requirements and system implementation should be comprehensive and include all aspects of the desired voice network, including the RF infrastructure, inter-site connectivity, dispatch subsystem, and user equipment. The City's intent should be for all fixed equipment to be upgraded to be fully compatible with the vendor's latest available 800 MHz P-25 Phase II infrastructure. Similarly, all user equipment should be upgraded or replaced to meet 800 MHz P-25 Phase II compatibility.

At the conclusion of this project, the City will have a fully modernized public safety wireless communications system that is compatible with industry standards, exceeds current requirements, is capable of expansion to support future growth, and is capable of being maintained and supported for the life of the system.

END OF REPORT.

City of Coral Gables, Florida

Conceptual Solutions Report

APPENDIX A - REFERENCE LIST

- 1) *Florida Region-9 Plan for Public Safety Radio Communications in the 806-809/851-854 MHz Bands*, Amendment #14, Region 9, Florida 800 MHz Regional Planning Committee, 2010.
- 2) *Computer Assisted Pre-Coordination Resource and Database System (CAPRAD)*, 2014.
- 3) *Florida Statewide Communication Interoperability Plan (SCIP)*, 2011.
- 4) *2014 Law Enforcement Communications Plan*, Division of Telecommunications, Florida Department of Management Services, 2014.
- 5) *The Florida 700 MHz Public Safety Interoperability Channel Plan*, Division of Telecommunications, Florida Department of Management Services, 2010.
- 6) *EMS Communications Plan, Volume I - 4th Edition*, Division of Telecommunications, Florida Department of Management Services, 2011.
- 7) *EMS Communications Plan, Volume II*, Division of Telecommunications, Florida Department of Management Services, 2013.
- 8) *TIA-222-G-2, Structural Standard for Antenna Supporting Structures and Antennas*, Telecommunications Industry Association, 2009.
- 9) *Radio Analysis and Propagation Tool Repository (RAPTR)*, Version 24.2.242, Harris, 2014.