Land Mobile and Microwave Radio Conceptual Design and Recommendations Report

Final

October 22, 2018

Executive Summary

The County of Santa Barbara (County) Fire, Sheriff, Emergency Medical Systems (EMS), and Local Government (LG) land mobile radio (LMR) systems, and the Public Safety Microwave Radio System are all at the end of their lifecycle and need replacement. The end of a product lifecycle indicates that the technology in use has reached obsolescence, major system components lack manufacturer support, and repair parts are in limited supply in the marketplace.

The County contracted with Federal Engineering (***FE***) to assess existing County LMR systems and the Public Safety Microwave Radio System, and to assist the County in determining the best course of action for the upgrade or replacement of the systems.

In Phase 1 of this project, ***FE*** performed an assessment of the existing systems and identified stakeholder needs and system requirements. The findings of this assessment are documented in the *County of Santa Barbara Existing System Assessment and Needs Analysis Report,* delivered July 20, 2018. In addition to the County LMR systems being at end of life, ***FE*** identified several other issues and system vulnerabilities including:

- Insufficient radio coverage for all four primary LMR systems
- Inadequate channel capacity on the Sheriff's LMR system
- Unsatisfactory redundancy, existence of single points of failure, and facility issues that could result in entire systems being inoperative
- No backup dispatch center
- Most County departments mentioned the inability to interoperate with Santa Maria as major issue. Other radio interoperability issues were mentioned, primarily due to other responding agencies operating on a different frequency band
- Inadequate funding for upgrading/replacing the existing systems and operational costs

In this Phase 2 report titled, *County of Santa Barbara Land Mobile and Microwave Radio Conceptual Design and Recommendations Report,* ***FE*** identifies and analyzes potential LMR alternatives. Following a discussion of the attributes for each alternative, ***FE*** provides a recommendation for the County's consideration.

FE completed several tasks in our analysis of potential LMR system alternatives to address the issues and system vulnerabilities identified in the Phase 1 report. Primary tasks completed by ***FE*** included:

- Performing a computer-based radio coverage analysis to identify the specific sites and equipment required to meet the County's coverage requirements
- Identifying the required number of radio channels to meet the County's operational needs
- Developing a conceptual design, including the design criteria for LMR and microwave radio system architecture
- Assessing how effective each alternative would be in meeting the County's radio interoperability needs
- Developing migration strategies for the LMR and microwave radio systems, describing the required activities in a logical sequence
- Developing projected implementation schedules for the LMR and microwave radio systems, showing the sequence, estimated duration and interdependencies of all major tasks, beginning with the completion of this report and ending with the Final System Acceptance
- Calculating estimated system and lifecycle costs
- Comparing the functionality, features, operational characteristics and cost for the three LMR system alternatives
- Recommending an alternative that best meets the County's stakeholder needs and LMR system requirements

LMR Upgrade Alternatives Comparison

Based on the stakeholder's stated needs and the LMR and microwave radio system requirements established in Phase 1 of this project, ***FE*** and the County agreed to the following three LMR upgrade alternatives for evaluation in Phase 2:

- **Alternative 1** - Upgrade the Fire VHF, Sheriff UHF and LG 800 MHz systems (EMS to shift operations to Fire 1 channel) with conventional analog and conventional digital technology. The Fire VHF system would continue to use conventional analog technology. The Sheriff and LG systems would transition from

conventional analog to conventional digital technology. The County would replace the conventional analog standalone repeaters on Med 5, 6, 7 and 8 channels for EMS communications with the hospitals

- **Alternative 2** – Replace the existing Sheriff, EMS, and LG LMR systems with a shared UHF Project 25 (P25) digital trunked radio system. The County would upgrade the existing Fire VHF system with like technology for use by Fire and EMS. EMS communications with the hospitals would shift to the UHF trunked system

- **Alternative 3** – Replace the existing Sheriff, EMS and LG LMR systems with a shared dual-band (UHF and 700/800 MHz) P25 digital trunked radio system. The County would upgrade the Fire VHF system with like technology for use by Fire and EMS. EMS communications with the hospitals would shift to the dual-band trunked system

Each LMR alternative includes new equipment (i.e. radios, antenna systems and DC power), additional sites to provide the necessary radio coverage and site improvements (i.e. new towers/equipment shelters and grounding and lightning protection system upgrades) to support the new LMR and microwave radio systems. The conceptual design for each alternative also addresses issues and vulnerabilities identified in Phase 1 by:

- Improving radio coverage for mobile radios and on-street portable radios

- Providing additional channel capacity for the Sheriff

- Removing the Comm Center as an LMR site

- There will be two dispatch centers, one for Sheriff and one for Fire, each with the capability to back up the other

- Redesigning the Public Safety Microwave Radio System architecture to provide redundant paths to key LMR sites and to provide connectivity to new LMR sites

- Adding a geographically diverse backup simulcast control and/or trunked system core site

- Adding a network management system to remotely monitor and troubleshoot LMR and microwave radio sites, and for equipment configuration, software updates and alarm reporting

- Providing options for improved interoperability

Table 1 compares key attributes for the three LMR upgrade alternatives.

Table 1 – Comparison of LMR Upgrade Alternatives[1]

	Alternative 1	Alternative 2	Alternative 3
Channel Congestion	• Use conventional systems with specific channel assignments that often results in some channels being very busy while others are lightly loaded. For example, the Sheriff has two channels, Ops 1 and Ops 2. Ops 1 is the primary operations channel that can be very busy and Ops 2 is an administrative channel that is not used as heavily. Because of this, the Sheriff has requested two additional channels, for North and South County operations.	√ • Use trunked technology which assigns channels on demand, resulting in more efficient channel use and avoids the scenario where some channels are heavily loaded while others are lightly loaded	
Technology Type	• Fire would continue to use analog conventional technology • Sheriff and LG systems would use digital conventional technology providing some additional features	√ • Fire system would continue to use analog conventional technology • Sheriff and current LG system users would use a P25 trunked radio system (single-band UHF for Alternative 2, dual-band UHF and 700/800 MHz for Alternative 3	
Features	• The P25 digital conventional systems used for the Sheriff and LG systems would provide some additional features, such as encryption	√ P25 trunked radio systems would provide many additional features over the County's existing analog systems, such as: • Over-the-air programming (OTAP) • Over-the-air rekeying (OTAR) • GPS location (GPS) • User authentication • Remote radio inhibit	
Interoperability	• Fire, Sheriff and LG system users would continue to use shared channels with interoperability partners	√ • Use P25 trunked radio systems that provide the highest level of interoperability, allowing full interoperability between all system users • The County P25 system could be connected to other P25 systems for interoperability (i.e. Santa Maria 700 MHz system) and could connect to analog conventional systems (i.e. City of Santa Barbara) • The County's P25 trunked radio system could expand to include other agencies in the County in the future	
Radio Coverage	• Includes additional sites for improved radio coverage, with the primary focus on mobile and on-street portable coverage	• Includes additional sites for improved radio coverage, with the primary focus on mobile and on-street portable coverage	√ • Includes additional sites for improved radio coverage, with the primary focus on mobile and on-street portable coverage • Includes additional 700/800 MHz sites in urban areas to improve in-building portable coverage

[1] Checkmarks placed under the alternative(s) represent the best alternative for each of the comparison criteria.

	Alternative 1	Alternative 2	Alternative 3
LMR Upgradeability	• All three systems would most likely require a complete equipment changeout to transition to a standards-based P25 trunked system in the future	√ • Upgrading from the UHF trunked system in Alternative 2 to the dual-band trunked system in Alternative 3 would require additional 700/800 MHz RF sites in the urban areas	• A potential upgrade that may be required for the lifespan of the system would be additional 700/800 MHz sites to further improve in-building portable radio coverage
Subscriber Units	• Systems require single-band subscriber units	√ • Trunked system requires single-band subscriber units	• Trunked system requires more expensive multi-band (UHF and 700/800 MHz) subscriber units
Cost	√ $41,046,000	$48,679,000	$59,308.000

Recommendation

Based on the existing system assessment, requirements analysis and understanding of the County's long-term planning goals, ***FE*** recommends the County of Santa Barbara consider implementing Alternative 2. As additional funding becomes available, the County could add 700/800 MHz sites for improved in-building coverage in urban areas, as described for Alternative 3. ***FE's*** recommendation is based on the following factors:

- The UHF P25 trunked system in Alternative 2 is the latest, standards-based LMR technology
- The shared UHF P25 trunked radio system in Alternative 2 would have less channel congestion (i.e. busies) than the conventional systems in Alternative 1. A P25 Phase 2 trunked radio system provides two talk paths per channel as compared to one talk path per channel for conventional systems and due to system automation, trunked radio systems are more efficient in the way that they assign radio channels
- Migration from the conventional systems in Alternative 1 to the P25 trunked radio system in Alternative 2 in the future would most likely require a full system changeout
- Alternative 2 substantially addresses stakeholder requirements for an estimated cost of $48.7 million, which is $10.6 million less than Alternative 3
- Alternative 2 allows for a phased approach for the County to move towards Alternative 3, where the County implements new technology for the UHF trunked and microwave radio systems; and after an evaluation period, can expand the system for improved in-building coverage as identified in Alternative 3

Next Steps

Once the County chooses an upgrade alternative and obtains approval from the County Board of Supervisors, the next step would be for the County to commit funding for the selected alternative and prepare a Request for Proposals (RFP) for the procurement, installation and testing of the new system.

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1. Project Background

1.1 Introduction

Santa Barbara County (County) contracted with Federal Engineering (***FE***) to assess existing County land mobile radio (LMR) and microwave radio systems, and to assist the County in determining the best course of action for the upgrade or replacement of the systems. ***FE*** completed this *County of Santa Barbara Land Mobile and Microwave Radio Conceptual Design and Recommendations Report* to document the results of Phase 2 tasks. This report addresses only the scope of work outlined in Phase 2 of the project and our analysis is based on the County's needs and requirements identified in the Phase 1 report, *County of Santa Barbara Existing System Assessment and Needs Analysis.*

1.2 Existing Systems

The County has multiple LMR and microwave radio systems to meet specific operational needs of County departments, as described below (the *County of Santa Barbara Existing System Assessment and Needs Analysis Report* includes a detailed description of each system):

- Fire has a six-channel VHF High Band analog simulcast system. Fire 1 is the main dispatch channel used for paging out units and for station alerts. Fire 6 is for administrative traffic and Fire 2 through 5 are spare command channels assigned by dispatch, as needed

- The Sheriff has a two-channel UHF analog simulcast system. Ops 1 is the primary operations channel and Ops 2 is for administrative traffic

- Emergency Medical Systems (EMS) has a 5-channel UHF analog simulcast system. Med 10 is the primary operations channel. Med 5, 6, 7 and 8 channels utilize standalone repeaters for direct communications between ambulances and hospitals

- The Local Government (LG) radio system is a two-channel 800 MHz analog conventional simulcast system. Animal Services, Floods, Parks, and General Services and the City of Goleta use the LG 1 channel and Roads uses the LG 2 channel

- The Public Safety Microwave Radio System provides connectivity between the Sheriff Dispatch Center (Dispatch) and the Fire, Sheriff, EMS, and LG LMR systems

The County Sheriff dispatches for all County departments on the Fire, Sheriff, EMS, and LG radio systems.

1.3 LMR System Alternatives

Based on the needs assessment performed in Phase 1 of this project, ***FE*** and the County agreed that ***FE*** would analyze the following three LMR system alternatives, each presented in detail in the sections to follow:

- **Alternative 1** – Upgrade the existing Fire, Sheriff, and LG LMR systems. Alternative 1 does not include the upgrade of the EMS UHF system (Med 10 channel) because EMS operations is moving to the Fire 1 channel. However, Alternative 1 includes the replacement of the standalone repeaters for the Med 5, 6, 7 and 8 channels

- **Alternative 2** – Replace the existing Sheriff, EMS and LG LMR systems with a countywide shared UHF Project 25 (P25) digital trunked radio system and upgrade the existing 6-channel Fire system for use by Fire and EMS. EMS communications with the hospitals shifts to the UHF trunked system

- **Alternative 3** – Replace the existing Sheriff, EMS and LG LMR systems with a countywide shared dual-band P25 digital trunked radio system and upgrade the existing 6-channel Fire system for continued use by Fire and EMS. EMS communications with the hospitals shifts to the UHF trunked system

1.4 Project Approach

FE performed the following steps to analyze each LMR system upgrade alternative and present a recommended solution.

1.4.1 Radio Coverage Analysis

FE performed a computer-based radio coverage analysis to identify the specific sites and equipment required to meet the County's coverage requirements, as follows:

- Worked with County stakeholders to define their radio coverage requirements and to identify existing radio coverage problem areas

- Identified potential radio sites to meet the County's coverage requirements
- Produced radio coverage maps and developed a preliminary list of sites for each alternative
- Conducted a radio coverage workshop with the County to present the initial results and obtain feedback on ***FE's*** initial choice of radio sites, and to identify other radio sites to cover specific areas
- Based on input received from the County at the coverage workshop, ***FE*** completed the coverage analysis and developed a final list of radio sites for each LMR system alternative

1.4.2 Channel Capacity

FE used existing and projected subscriber unit quantities and input received from County stakeholders to estimate the required number of channels for each LMR system upgrade alternative. ***FE*** typically uses historical radio system traffic statistics (i.e. call types, total number of calls and the average time per call) to predict the number of channels required, however, this data was not available for the existing County LMR systems.

1.4.3 LMR Conceptual Design

FE developed the conceptual design for each of the three LMR alternatives, including the design criteria and a system architecture diagram. The architecture diagram shows the connectivity between LMR system sites, the Sheriff and Fire[2] dispatch centers, and the microwave backhaul system. Also included is a description of all equipment and how it functions as part of the system.

1.4.4 Microwave Radio Conceptual Design

FE analyzed alternatives to upgrade the County's existing Public Safety Microwave Radio System to provide connectivity between Dispatch and key LMR sites, with additional paths for increased system reliability. ***FE*** produced radio path profiles and calculations for all proposed microwave paths using ATDI ICS Telcom software and 30-meter (United States Geological Survey (USGS) terrain data, and identified the type, location and

[2] Based on a decision by the Santa Barbara County Board of Supervisors, a new dispatch center will be established for Fire and EMS, separate from Sheriff Dispatch. The Sheriff and Fire dispatch centers will back up each other. Location of each dispatch center is to be determined.

approximate height of potential path obstructions using Google Earth and clutter data from the 2011 National Land Cover Database (NLCD).

Note: ***FE*** did not perform physical radio path surveys to identify the exact location and height of potential obstructions. The RFP for the procurement and installation of the new microwave radio system should require the contractor to perform final path design, including physical path surveys.

1.4.5 Interoperability

FE described the Department of Homeland Security (DHS) Interoperability Continuum as it applies to radio communications and assessed where on the Interoperability Continuum each upgrade alternative falls and how effective each alternative would be in meeting the County's interoperability needs.

1.4.6 Migration Strategy

FE presented migration strategies for each LMR alternative and the microwave radio backhaul system, presenting the required activities in a logical sequence to allow the County to plan for the upgrade well in advance of vendor contract award.

1.4.7 Cost

FE analyzed and presented the potential cost of each alternative based on our experience with the design of LMR and microwave radio systems and publicly available industry information.

1.4.8 Implementation Schedule

FE developed projected implementation schedules for each of the LMR upgrade alternatives, showing the sequence, estimated duration and interdependencies of all major tasks, beginning with the completion of this report and ending with Final System Acceptance.

1.4.9 LMR Alternatives Comparison and Recommendation

FE compared the functionality, features, operational characteristics and cost for the three LMR system alternatives and recommended an alternative that would best meet the County's needs and requirements.

2. LMR Alternative 1 – Upgrade Existing Sheriff, Fire and LG Systems

Alternative 1 includes the replacement of all existing equipment and the addition of radio sites and equipment to provide the additional radio coverage that Fire, Sheriff and LG LMR system users need, as follows:

- Replace the six-channel Fire VHF conventional analog simulcast system with a six-channel conventional analog simulcast system for both Fire and EMS (EMS operations is moving to the Fire 1 channel)
- Replace the two-channel Sheriff UHF conventional analog simulcast system with a four-channel UHF conventional digital simulcast system that would support additional features (i.e. encryption). One of the new channels would be allocated to North County operations and the other for South County operations
- Replace the two-channel LG 800 MHz conventional analog simulcast system with a two-channel 800 MHz conventional digital simulcast system
- Replace the existing standalone repeaters for communications between EMS and County hospitals (Med 5, 6, 7 and 8 channels)

2.1 Radio Coverage Analysis

FE performed a computer-based radio coverage assessment to identify the specific sites and equipment required to meet the County's coverage requirements.

2.1.1 Required Coverage

Fire, Sheriff, EMS and LG radio system users require mobile, on-street portable and in-building portable radio coverage throughout the County. However, because of the mountainous terrain and dense trees through much of the County it would not be economically feasible to "blanket" the County with radio coverage. Providing in-building portable radio coverage in all buildings in the County would also be very expensive. Based on this, ***FE's*** primary focus was to choose the sites for each LMR alternative that would provide mobile and on-street portable radio coverage in the most populous areas of the County, the most highly traveled highways, and other areas of the County identified as important by the stakeholders, as shown in Table 2.

Table 2. Primary Focus Areas for Radio Coverage

Population Centers	Highways	Other
Santa Barbara Area (i.e. Santa Barbara, Goleta, Montecito, Carpinteria and Summerland)	Highway 101 through the County	Cachuma Lake County Park
Santa Maria Area (i.e. Santa Maria, Guadalupe, Orcutt and Sisquoc)	Highway 1 through the County	Jalama Beach
Santa Ynez Valley (i.e. Santa Ynez, Los Olivos, Buellton and Solvang)	Highway 166 from Santa Maria to Cuyama	Ocean Park (northwest of Lompoc)
Los Alamos	Hwy 154 from Los Olivos to Santa Barbara	Dunes west of Guadalupe
Lompoc	Hwy 246 from Buellton to Lompoc	South County coastline
Vandenberg Air Force Base and Village	Roads through the hills north of Santa Barbara and Montecito	
Cuyama Valley, including Ventucopa	Highway 33 south from Cuyama	
Casmalia	Highway 1 and San Antonio Road (NE of Vandenberg AFB and SE of Casmalia)	

2.1.2 Methodology

FE modeled mobile, on-street portable and in-building portable radio talk-out (base station to mobile or portable radio) and talk-in (mobile or portable radio to base station) for each system.

2.1.2.1 Coverage Maps

FE produced radio coverage studies using high-resolution elevation and land use/land cover data from the USGS and ***FEPerformancePro***™, which uses ATDI's ICS Telecom network planning software. ***FE*** conducted the radio coverage studies for each alternative using specifications from available public-safety grade radio equipment. The coverage displayed on the maps in this report indicate the areas predicted to have audio quality greater than or equal to Delivered Audio Quality (DAQ) 3.4 and 95% reliability.

DAQ quantifies audio quality over a transmission medium, including LMR systems. Table 3 describes DAQ levels.

Table 3 – Delivered Audio Quality Levels

DAQ Level	Description
1.0	Unusable. Speech present but not understandable
2.0	Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion
3.0	Speech understandable with slight effort. Requires occasional repetition due to noise or distortion
3.4	Speech understandable without repetition. Some noise or distortion present. DAQ 3.4 is the minimum Channel Performance Criterion (CPC) used for public safety agencies.
4.0	Speech easily understandable. Little noise or distortion
5.0	Perfect. No distortion or noise discernible

Reliability is a measure of confidence in areas shown as covered on the maps and is based on recommendations from the Telecommunications Industry Association (TIA) TSB-88-D[3] suite of documents. TSB-88 recommends a 95% reliability level for public safety radio systems, which means that radio users should be able to transmit and receive audio at DAQ 3.4 or better in covered areas at least 95% of the time.

The maps use the following color key to model coverage that meets or exceeds audio quality levels of DAQ 3.4 at 95% reliability:

- Green represents in-building portable coverage (i.e. inside light-density and/or residential buildings)
- Yellow represents on-street portable coverage (on-street portable coverage should also exist in all green areas)
- Purple represents mobile coverage (mobile coverage should also exist in all green and yellow areas)

Note: The radio coverage portrayed by maps in this report may vary slightly from actual system coverage. Computer modeling cannot account for all variables that would exist in the final system implementation. Coverage differences would exist due to many factors such as individual radio performance, terrain, foliage, noise floors, adjacent and co-channel interference, and other variables.

[3] TIA TSB-88 Wireless Communications Systems - *Performance in Noise and Interference-Limited Situations*

2.1.2.2 Coverage Workshop

FE conducted a remote coverage workshop with the County to present the initial results for each of the three LMR alternatives and obtain feedback from the County regarding the accuracy of the initial predictions, ***FE's*** initial choice of radio sites and other potential radio sites. ***FE*** also demonstrated the impact of removing site(s) and/or adding new site(s) to obtain consensus on the sites that would best meet the County's coverage requirements.

2.1.2.3 Finalize LMR Site List

Based on input received from the County at the coverage workshop, ***FE*** completed the coverage analysis and developed a final list of radio sites for each LMR system alternative.

2.1.3 Fire VHF System Results

FE modeled the Fire VHF system radio coverage assuming a conventional analog simulcast system, with 12.5 kHz channel bandwidth and 13 dB building loss for in-inbuilding portable radio coverage (consistent with light-office/residential building loss[4] at VHF).

2.1.3.1 Selected Radio Sites

Based on the results of the coverage study and input received from the County at the coverage workshop, ***FE*** developed the final list of sites needed to meet the County's coverage requirements. When selecting new sites for radio coverage improvement, ***FE*** prioritized existing County, existing non-County and greenfield (i.e. new sites without existing tower and shelter) sites, in order of preference.

Table 4 is a proposed list of sites for the Fire VHF analog conventional simulcast system and the site information and antenna type/heights used for the radio coverage analysis. Sites identified as "proposed new" in the Site Status column are sites which are currently not being used for any of the County LMR systems, but ***FE*** has included in the conceptual design for radio coverage improvement. Proposed new sites are highlighted in the table.

[4] Residential structures are typical wood-frame buildings, and light office would be typical strip-mall and/or stand-alone office buildings.

Table 4 – Sites for Fire VHF Conventional Analog Simulcast System

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Chumash Casino (Hotel)	Existing Rx	34.60858	-120.08658	None / ANT150F2	VHF Rx Only	NA / 155
Chumash Casino (Parking Garage)	Existing Tx/Rx	34.60802	-120.08757	SD210-SF2P4SNM / SD210-SF2P4SNM	VHF Simulcast	40 / 52
Dispatch	Proposed New Rx	34.44409	-119.77607	None / Telewave ANT150D (25)	VHF Rx Only	NA / 40
Figueroa	Proposed New Tx/Rx	34.74340	-119.98496	ANT150F2 / ANT150F2	VHF Simulcast	40 / 40
Fire Station 24	Proposed New Tx/Rx	34.74523	-120.27980	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Simulcast	80 / 100
Foster	Existing Rx	34.88231	-120.44933	None / Telewave ANT150D3 (25)	VHF Rx Only	NA / 90
GATR	Proposed New Tx/Rx	34.55206	-120.50238	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Simulcast	25 / 25
Gaviota	Existing Tx/Rx	34.51368	-120.23116	Telewave ANT150D (25) / Telewave ANT150D (25)	VHF Simulcast	42 / 42
Harris Grade	Existing Tx/Rx	34.73856	-120.44578	Telewave ANT150D3 (25) / ANT150F2	VHF Simulcast	66 / 155
Hwy 246 Tank	Proposed New Tx/Rx	34.62864	-120.26819	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Simulcast	30 / 30
La Cumbre Peak	Existing Tx/Rx	34.50030	-119.72112	Telewave ANT150D (25) / Telewave ANT150D3 (25)	VHF Simulcast	36 / 78
Los Alamos	Existing Rx	34.77225	-120.32797	None / Telewave ANT150D (25)	VHF Rx Only	NA / 6
Mount Solomon	Existing Tx/Rx	34.83475	-120.38319	Telewave ANT150D (25) / Telewave ANT150D (25)	VHF Simulcast	60 / 85
Mt. Abel	Proposed New Tx/Rx	34.82907	-119.20385	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Stand-Alone	40 / 40
Plowshare	Existing Tx/Rx	35.05006	-120.04102	Telewave ANT150D3 (25) / ANT150F2	VHF Simulcast	32 / 89
Rincon	Existing Tx/Rx	34.37286	-119.42106	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Simulcast	35 / 75
San Antonio	Existing Tx/Rx	34.84197	-120.49917	ANT150F2 / ANT150F2	VHF Simulcast	20 / 20
Santa Ynez	Existing Tx/Rx	34.52663	-119.97845	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Simulcast	40 / 90
Solvang	Proposed New Rx	34.59658	-120.13550	None / Telewave ANT150D3 (25)	VHF Rx Only	NA / 43

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Sudden	Existing Tx/Rx	34.56625	-120.50006	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Simulcast	120 / 120
Tepusquet	Existing Tx/Rx	34.91507	-120.18269	Telewave ANT150D (25) / Telewave ANT150D3 (25)	VHF Simulcast	70 / 115
Valley Peak	Existing Tx/Rx	33.99893	-119.68361	Telewave ANT150D3 (25) / Telewave ANT150D3 (25)	VHF Stand-Alone	40 / 60
Vic Trace	Proposed New Rx	34.40564	-119.71505	None / Telewave ANT150D3 (25)	VHF Rx Only	NA / 60
White Hills	Existing Rx	34.57022	-120.35450	None / Telewave ANT150D3 (25)	VHF Rx Only	NA / 54

2.1.3.2 Coverage Maps

Figures 1 and 2 show the predicted coverage for the proposed Fire VHF conventional analog simulcast system.

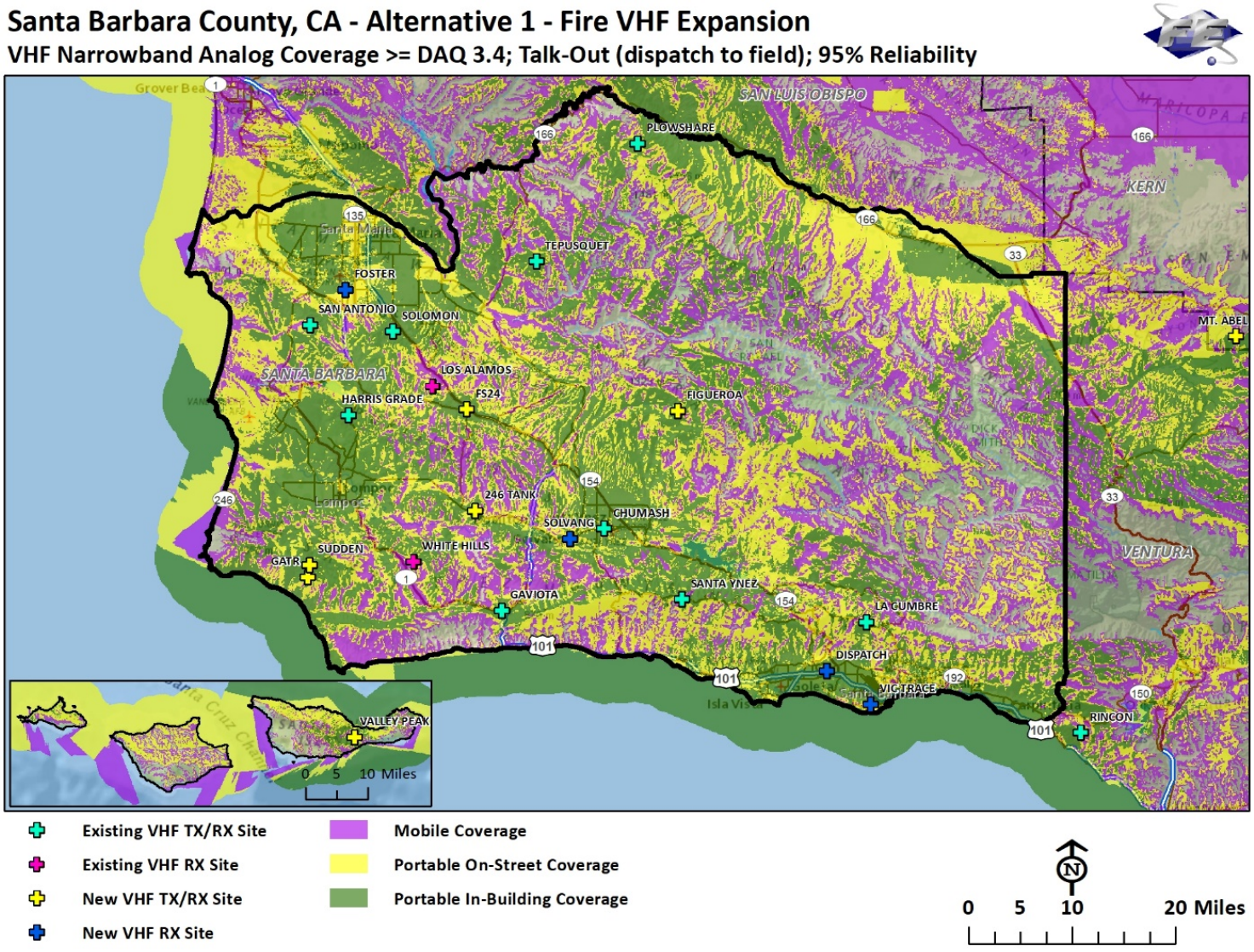

Figure 1 – Fire VHF Conventional Analog Simulcast – Talk-Out

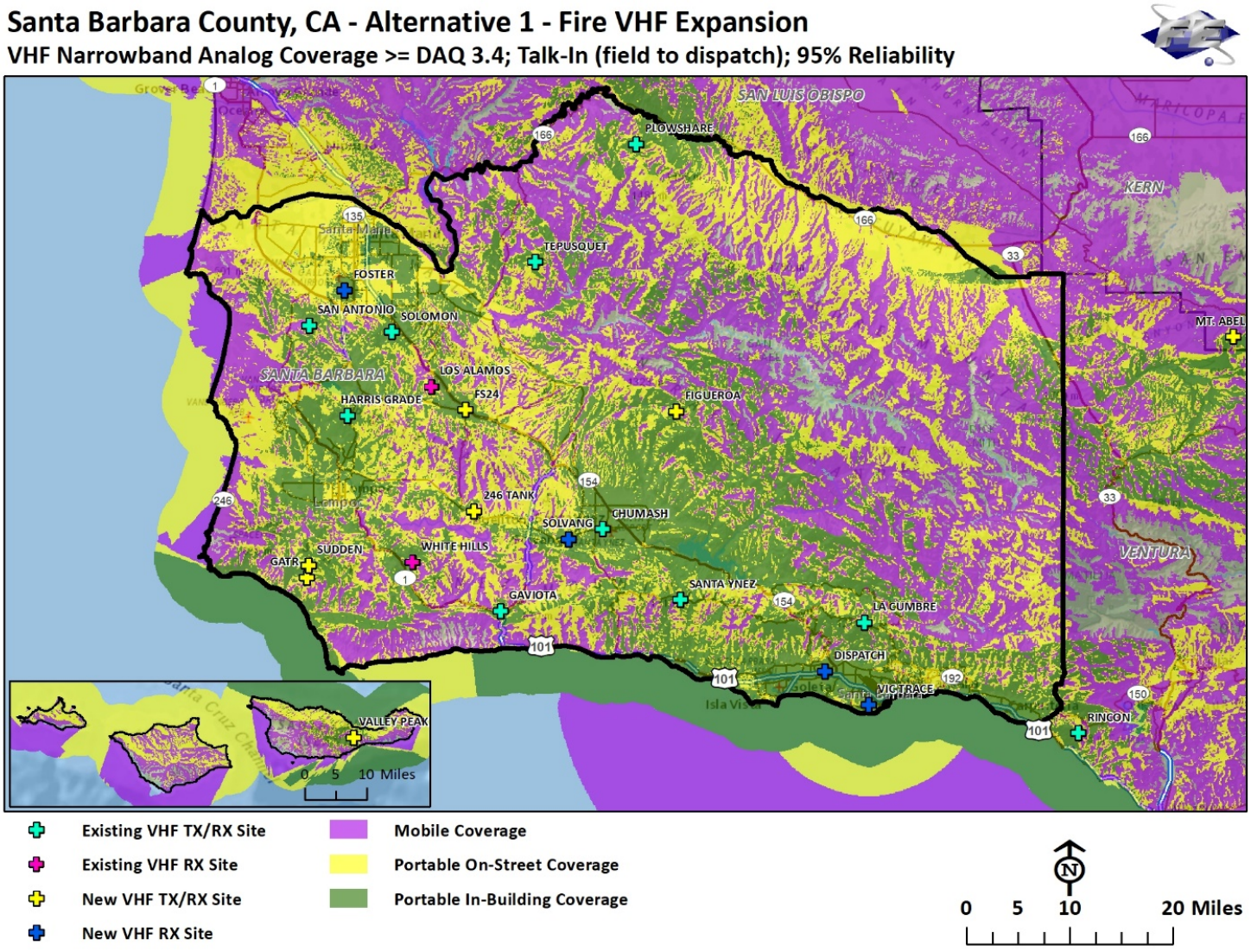

Figure 2 – Fire VHF Conventional Analog Simulcast – Talk-In

2.1.3.3 Simulcast Cells and Interference

The coverage maps and percentages presented in this section account for the possibility of time-delay interference (TDI) within the simulcast cells. Thus, ***FE*** believes that the specified radio sites can provide the displayed coverage, provided the awarded vendor practices sound engineering to mitigate the possibility of TDI within the simulcast environment.

2.1.4 Sheriff UHF System Results

FE modeled the Sheriff UHF system radio coverage assuming a UHF digital P25 conventional simulcast system, with 12.5 kHz channel bandwidth and 12 dB building loss for in-inbuilding portable radio coverage (consistent with light-office/residential building loss at UHF).

2.1.4.1 Selected Radio Sites

Based on the results of the coverage study and input received from the County at the coverage workshop, ***FE*** developed the final list of sites needed to meet the County's coverage and design targets. When selecting sites, ***FE*** prioritized existing County, existing non-County and greenfield (i.e., brand new) sites, in order of preference.

Table 5 is a proposed list of sites for the Sheriff UHF digital P25 conventional simulcast system and the site information and antenna type/heights used for the radio coverage analysis. Sites identified as "proposed new" in the Site Status column are sites which are currently not being used for any of the County LMR systems, but ***FE*** has included in the conceptual design for radio coverage improvement. Proposed new sites are highlighted in the table.

Table 5 – Sites for Sheriff UHF P25 Conventional Simulcast System

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Buellton Sheriff	Proposed New Rx	34.61373	-120.19594	None / ANT450D3 (25)	UHF Rx Only	NA / 15
Chumash Casino (PG)	Existing Tx/Rx	34.60802	-120.08757	ANT450D / ANT450D (25)	UHF Simulcast	37 / 48
Dispatch	Proposed New Rx	34.44409	-119.77607	None / ANT450D6 (50)	UHF Rx Only	NA / 40
Figueroa	Proposed New Tx/Rx	34.74340	-119.98496	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	40 / 40
Fire Station 24	Proposed New Tx/Rx	34.74523	-120.27980	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	80 / 100
Foster	Existing Tx/Rx	34.88231	-120.44933	ANT450D (25) / ANT450D (25)	UHF Simulcast	39 / 39
GATR	Proposed New Tx/Rx	34.55206	-120.50238	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	25 / 25
Gaviota	Existing Tx/Rx	34.51368	-120.23116	ANT450D9 (25) / ANT450F2	UHF Simulcast	86 / 110
Harris Grade	Existing Tx/Rx	34.73856	-120.44578	None / Laird FG4500	UHF Rx Only	NA / 32
Hwy 246 Tank	Proposed New Tx/Rx	34.62864	-120.26819	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	30 / 30

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
La Cumbre Peak	Existing Tx/Rx	34.50030	-119.72112	ANT450D (25) / ANT450D (25)	UHF Simulcast	27 / 27
Los Alamos	Existing Rx	34.77225	-120.32797	None / ANT450D (25)	UHF Rx Only	NA / 12
Los Olivos	Existing Rx	34.66494	-120.11125	None / ANT450F2	UHF Rx Only	NA / 26
Mount Solomon	Existing Tx/Rx	34.83475	-120.38319	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	60 / 85
Mt. Abel	Proposed New Tx/Rx	34.82907	-119.20385	ANT450D6 (25) / ANT450D6 (25)	UHF Stand-Alone	40 / 40
Plowshare	Existing Tx/Rx	35.05006	-120.04102	ANT450D (25) / ANT450D6 (25)	UHF Simulcast	42 / 88
Purisima	Proposed New Rx	34.68482	-120.15157	None / ANT450F2	UHF Rx Only	NA / 40
Rincon	Existing Tx/Rx	34.37286	-119.42106	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	60 / 60
San Antonio	Existing Tx/Rx	34.84197	-120.49917	ANT450F2 / ANT450F2	UHF Simulcast	69 / 69
Santa Ynez	Existing Tx/Rx	34.52663	-119.97845	ANT450D (25) / ANT450D3 (25)	UHF Simulcast	60 / 80
Solvang	Existing Rx	34.59658	-120.13550	None / ANT450D9 (25)	UHF Rx Only	NA / 51
Sudden	Existing Tx/Rx	34.56625	-120.50006	ANT450D3 (25) / ANT450D3 (25)	UHF Simulcast	60 / 60
Tanglewood	Existing Rx	34.89553	-120.48359	None / ANT450D3 (25)	UHF Rx Only	NA / 31
Tepusquet	Existing Tx/Rx	34.91507	-120.18269	ANT450D (25) / ANT450D (25)	UHF Simulcast	96 / 128
Valley Peak	Existing Tx/Rx	33.99893	-119.68361	ANT450D6 (25) / ANT450D6 (25)	UHF Stand-Alone	40 / 60
Vic Trace	Proposed New Rx	34.40564	-119.71505	None / ANT450D6 (25)	UHF Rx Only	NA / 60
White Hills	Existing Tx/Rx	34.57022	-120.35450	ANT450D (25) / ANT450F2	UHF Simulcast	44 / 60

2.1.4.2 Coverage Maps

Figures 3 and 4 show the predicted countywide coverage for Sheriff UHF conventional digital P25 simulcast system. The maps also represent the coverage that would be achieved on the North and South County channels. The North County channel uses the sites north of the Santa Ynez mountain range and the South County channel uses the sites South of the Santa Ynez mountain range. Both the North and South County channels use the Santa Ynez and La Cumbre sites.

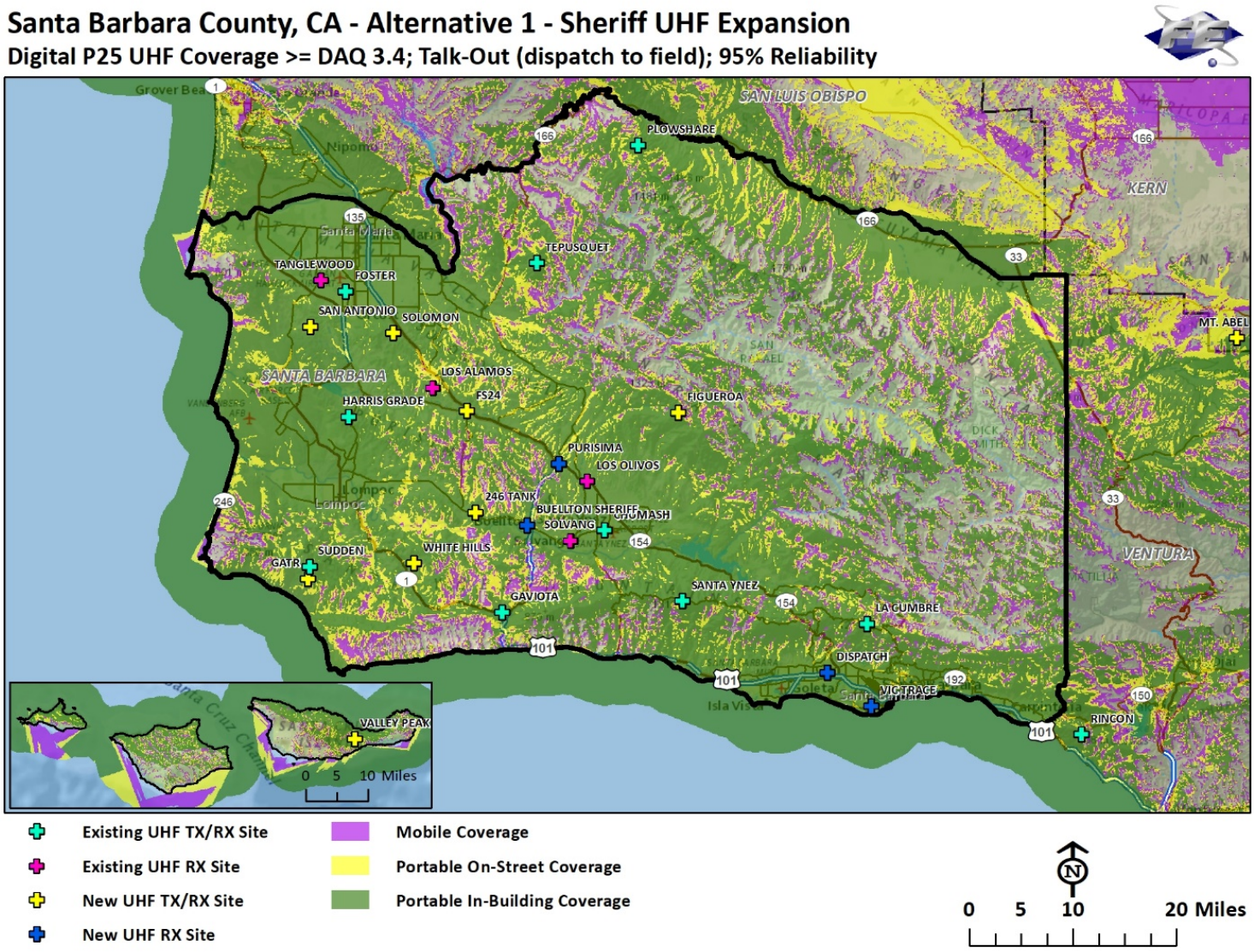

Figure 3 – Sheriff UHF P25 Conventional Simulcast – Talk-Out

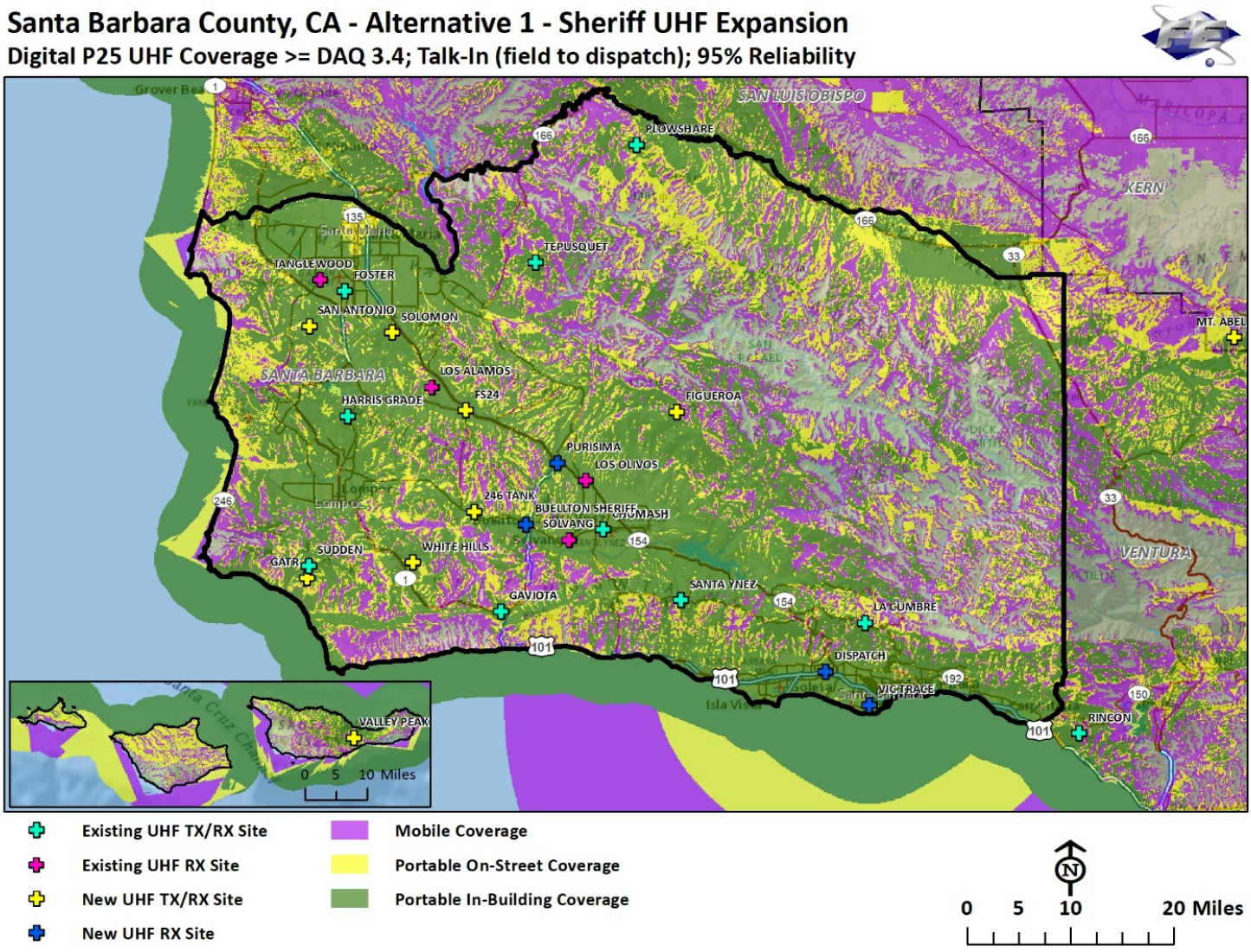

Figure 4 – Sheriff UHF P25 Conventional Simulcast – Talk-In

2.1.4.3 Simulcast Cells and Interference

The coverage maps and percentages presented in this section account for the possibility of TDI within the simulcast cells. Thus, ***FE*** believes that the specified radio sites can provide the displayed coverage, provided the awarded vendor practices sound engineering to mitigate the possibility of TDI within the simulcast environment.

2.1.5 Local Government 800 MHz System Results

FE modeled the LG 800 MHz system radio coverage assuming an 800 MHz digital P25 conventional simulcast system, with 12.5 kHz channel bandwidth and 10 dB building loss for in-inbuilding portable radio coverage (consistent with light-office/residential building loss at 800 MHz).

2.1.5.1 Selected Radio Sites

Based on the results of the coverage study and input received from the County at the coverage workshop, ***FE*** developed the final list of sites needed to meet the County's coverage and design targets. When selecting new sites, ***FE*** prioritized existing County, existing non-County and greenfield (i.e., brand new) sites in order of preference.

Table 6 is a proposed list of sites for the LG 800 MHz digital P25 conventional simulcast system and the site information and antenna type/heights used for the radio coverage analysis. Sites identified as "proposed new" in the Site Status column are sites which are currently not being used for any of the County LMR systems, but ***FE*** has included in the conceptual design for radio coverage improvement. Proposed new sites are highlighted in the table.

Table 6 – Sites for LG 800 MHz P25 Conventional Simulcast System

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Dispatch	Proposed New Rx	34.44409	-119.77607	Telewave ANT850F6 / Telewave ANT850F6	800 MHz Rx Only	40 / 40
Foster	Existing Rx	34.88231	-120.44933	None / Telewave ANT850F6	800 MHz Rx Only	NA / 13
Gaviota	Proposed New Tx/Rx	34.51368	-120.23116	Telewave ANT850F6 / Telewave ANT850F6	800 MHz Simulcast	40 / 40
Harris Grade	Existing Tx/Rx	34.73856	-120.44578	SC442D-HF1LDF / SC442D-HF1LDF	800 MHz Simulcast	25 / 25
La Cumbre Peak	Existing Tx/Rx	34.50030	-119.72112	Telewave ANT850F6 / Telewave ANT850F6	800 MHz Simulcast	63 / 63
Mount Solomon	Existing Tx/Rx	34.83475	-120.38319	SC442D-HF1LDF / SC442D-HF1LDF	800 MHz Simulcast	85 / 85
Mt. Abel	Proposed New Tx/Rx	34.82907	-119.20385	ANT850Y10-WR / ANT850Y10-WR	800 MHz Stand-Alone	40 / 40
Plowshare	Existing Tx/Rx	35.05006	-120.04102	SE414-SWBP2LDF(D00) / SE414-SWBP2LDF(D00)	800 MHz Simulcast	76 / 76

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Rincon	Existing Tx/Rx	34.37286	-119.42106	ANT850Y10-WR / SE414-SWBP2LDF(D00)	800 MHz Simulcast	20 / 35
San Antonio	Proposed New Tx/Rx	34.84197	-120.49917	ANT850Y10-WR / ANT850Y10-WR	800 MHz Simulcast	70 / 70
Santa Ynez	Existing Tx/Rx	34.52663	-119.97845	DB583-XC / DB586XT	800 MHz Simulcast	70 / 90
Sudden	Existing Tx/Rx	34.56625	-120.50006	Telewave ANT850F6 / Telewave ANT850F6	800 MHz Simulcast	120 / 120
Tepusquet	Existing Tx/Rx	34.91507	-120.18269	Telewave ANT850F6 / Telewave ANT850F6	800 MHz Simulcast	42 / 42

2.1.5.2 Coverage Maps

Figures 5 and 6 show the predicted coverage for LG 800 MHz digital P25 conventional simulcast system.

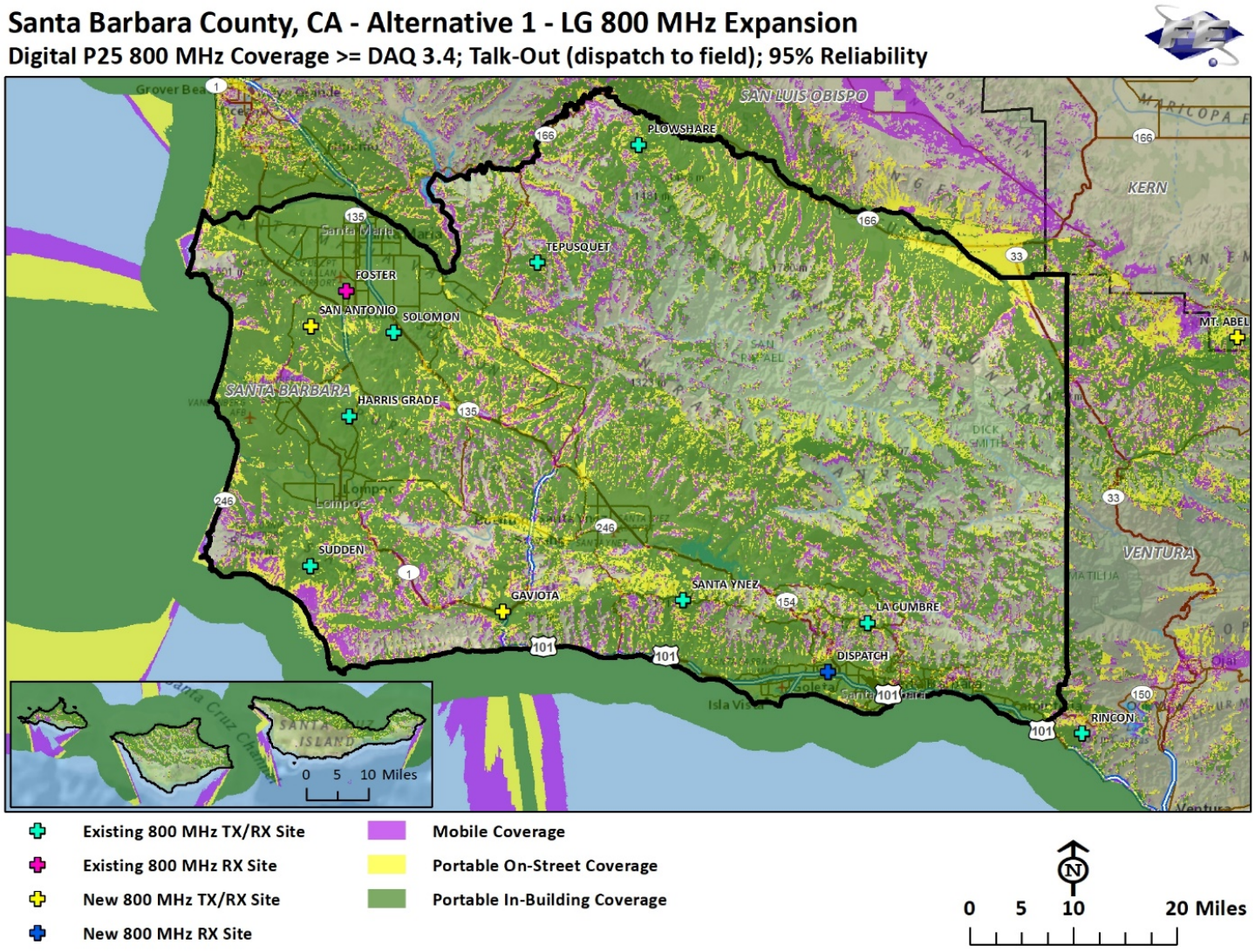

Figure 5 – LG 800 MHz P25 Conventional Simulcast – Talk-Out

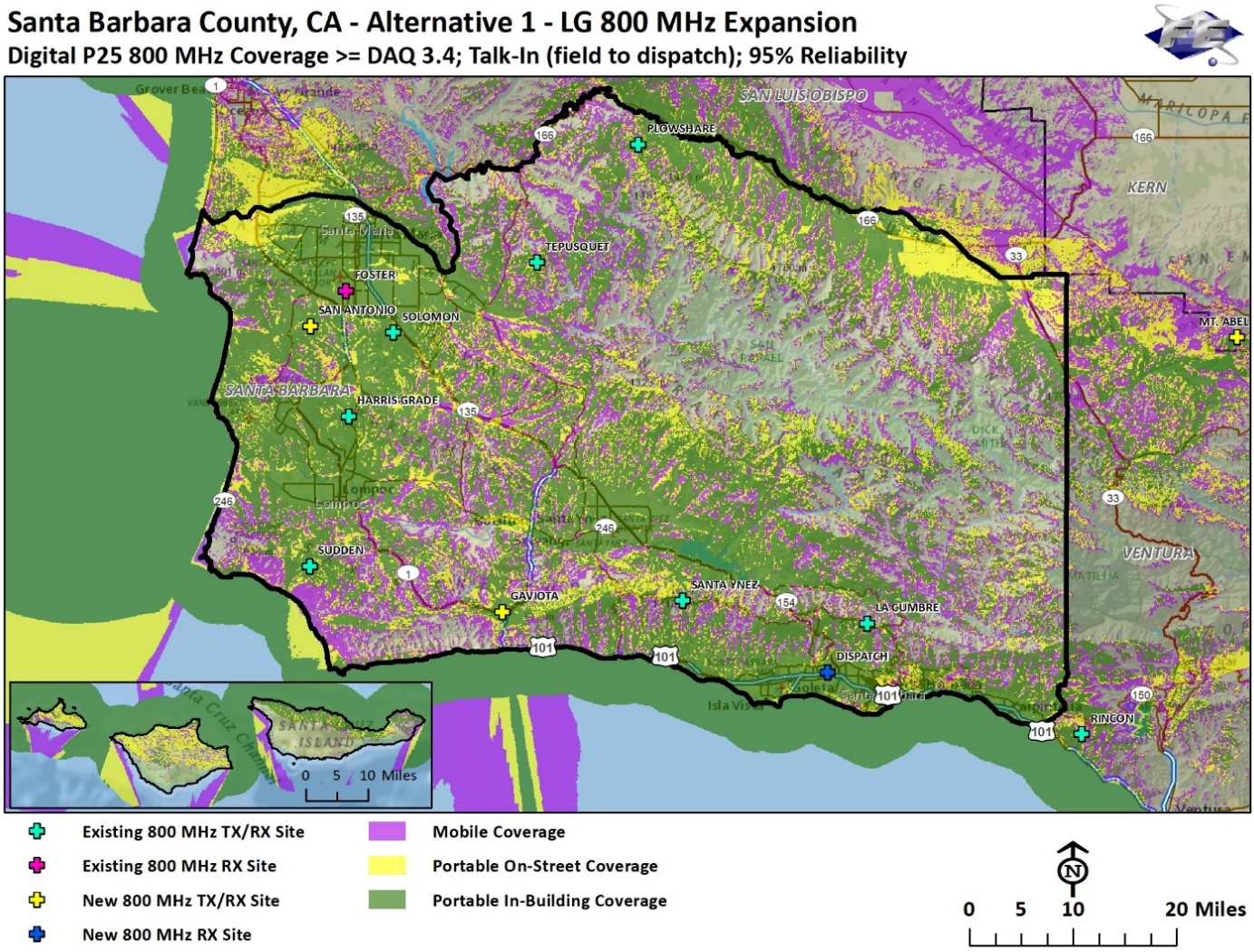

Figure 6 – LG 800 MHz P25 Conventional Simulcast – Talk-In

2.1.5.3 Simulcast Cells and Interference

The coverage maps and percentages presented in this section account for the possibility of TDI within the simulcast cells. Thus, ***FE*** believes that the specified radio sites can provide the displayed coverage, provided the awarded vendor practices sound engineering to mitigate the possibility of TDI within the simulcast environment.

2.2 Channel Capacity Analysis

2.2.1 Fire VHF

FE believes that the six existing Fire channels would be sufficient for the Fire system upgrade in Alternative 1, based on input received from Fire during the stakeholder interviews. Fire would continue to use Fire 1 as the main dispatch channel for paging out units and station alerts and Fire 6 for administrative traffic. Fire would use Fire 2 through 5 as spare command channels, assigned by dispatch as needed.

2.2.2 Sheriff UHF

FE includes the use of four channels for the Sheriff system upgrade for Alternative 1, two more than the existing system, based on input received from the Sheriff during the stakeholder interviews. Following is the intended use of each channel:

- North County operations
- South County operations
- Countywide Administrative (including Probation)
- Countywide backup

2.2.3 LG 800 MHz

FE believes that the two existing channels would be sufficient for the LG system upgrade for Alternative 1, based on input received from LG system users during the stakeholder interviews.

2.3 LMR System Conceptual Design

Based on the results from the coverage and capacity analyses, this section provides a description of ***FE's*** LMR system conceptual design, including major system components and features.

2.3.1 Design Criteria

FE used the following criteria for the Alternative 1 LMR system design:

- Refresh and expand the existing:

  - 6-channel Fire VHF analog conventional simulcast system with a new VHF analog conventional simulcast equipment
  - 2-channel Sheriff UHF analog conventional simulcast system to a 4-channel UHF digital P25 conventional simulcast system
  - 2-channel LG 800 MHz analog conventional simulcast system to a 2-channel 800 MHz digital P25 conventional simulcast system

- Establish two geographically diverse simulcast control/receiver voting sites for redundancy and increased system reliability for the Fire, Sheriff and LG systems
- Leverage existing sites to greatest extent possible; only adding new sites, including towers and shelters, as needed to provide the required radio coverage
- Provide radio coverage equivalent to the existing County systems, plus improved mobile and portable on-street coverage in areas where inadequate coverage currently exists
- Discontinue the use of the Comm Center site due to lack of space for system expansion and water intrusion issues
- Replace the following equipment for the existing Fire, Sheriff and LG simulcast systems:
  - Simulcast control and voting equipment
  - Radios and antenna systems (i.e. antennas, transmission lines, transmitter combiners and receiver multicouplers)
  - DC power systems
  - Grounding and lightning protection systems
- Install the following equipment for new sites on the Fire, Sheriff and LG systems:
  - Simulcast control and voting equipment
  - Radios and antenna systems (i.e. antennas, transmission lines, transmitter combiners and receiver multicouplers)
  - DC power systems

- Grounding and lightning protection systems

- Utilize existing County licensed Fire VHF, Sheriff UHF and LG 800 MHz radio channels

- Replace the following equipment associated with the existing EMS Med 5, Med 6, Med 7 and Med 8 channels:
  - Radios and antenna systems (i.e. antennas, transmission lines, transmitter combiners and receiver multicouplers)
  - DC power systems
  - Grounding and lightning protection systems

2.3.2 LMR System Architecture

Figure 7 is a high-level block diagram of the Alternative 1 conceptual design. The Backhaul Network which is shown multiple times in Figure 7 is a single network and is shown in detail in Figure 8, the microwave radio system logical architecture diagram.

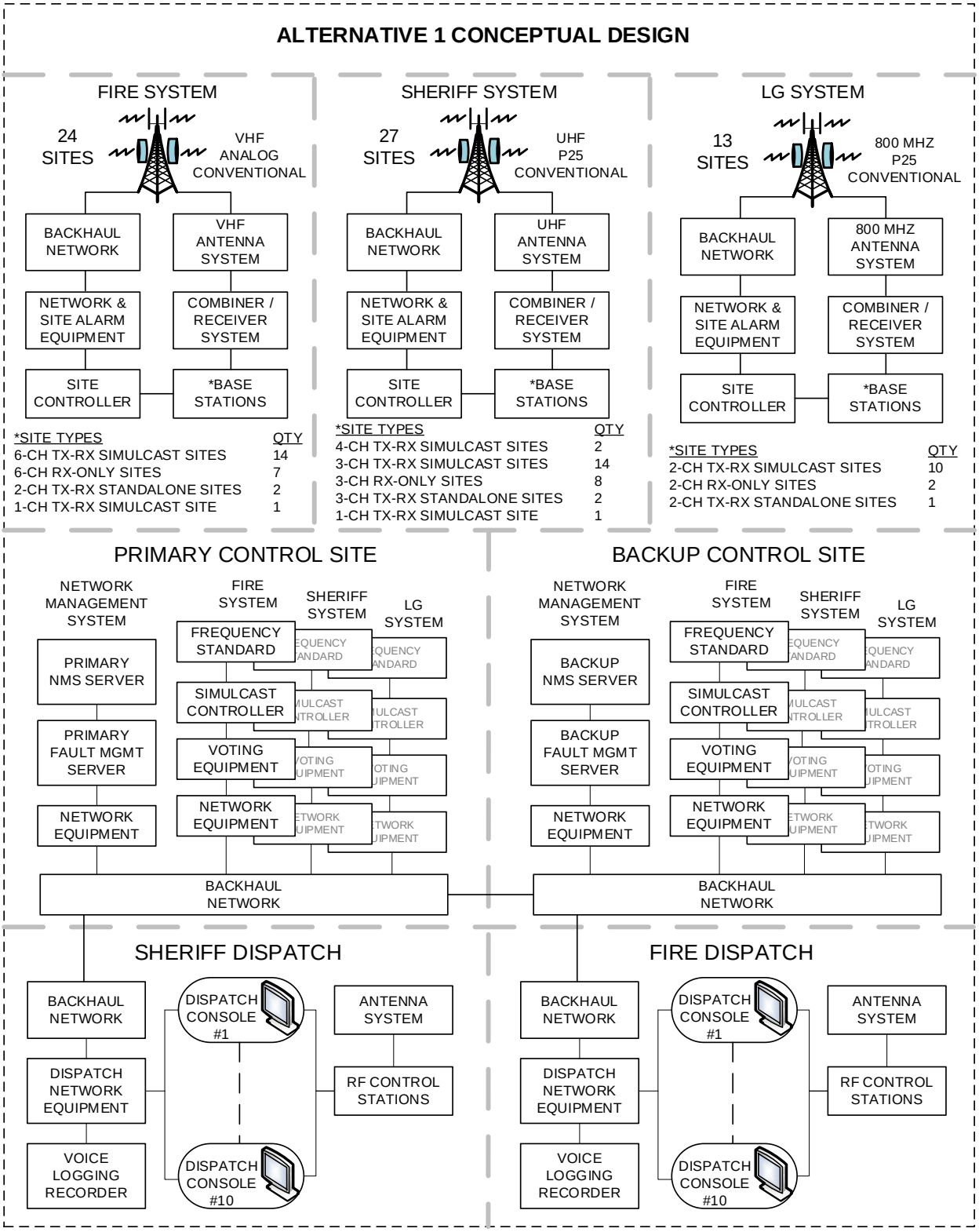

Figure 7 – Alternative 1 Conceptual Design

2.3.3 Simulcast Control and Voting Equipment

Simulcast control and voting equipment at the Primary and Backup Control sites maintain, monitor and control multi-site simulcast configurations. The Fire, Sheriff and LG systems would have separate simulcast control and voting equipment for their respective simulcast cells. The simulcast equipment maintains frequency, phase and amplitude stability of the radio equipment to minimize audio distortion for mobile and portable radios in areas where the transmit signals from multiple simulcast sites overlap. In accordance with County coverage requirements and accounting for simulcast distortion, the systems would provide a minimum audio quality of DAQ 3.4 for portable and mobile radios in the field.

Receiver voting systems would support conventional operation in a single-cell simulcast configuration by selecting the most intelligible audio from one or more radio frequency (RF) sites and routing the selected audio to the simulcast control equipment, dispatch consoles, and radio sites. The system routes dispatcher audio from the dispatch consoles to the simulcast control equipment for broadcast and allows dispatch audio to have priority over portable and mobile radio traffic. The system also directs radio traffic originating from portables and mobiles to the simulcast control equipment for broadcast on all RF simulcast sites. The backhaul system (microwave and T1 leased lines) transports audio between RF sites, simulcast control/voter sites and the dispatch centers.

The simulcast control and voting equipment would include the following components per simulcast cell:

- Simulcast controller
- Global Positioning System (GPS) receivers with high stability oscillators
- Voting equipment (number of channels vary per system)
- Networking equipment

The conceptual design includes primary and secondary control and voting equipment, which can reside at any system core and/or radio site (locations to be determined). The design also assumes that the primary and secondary simulcast control/voting sites would host the simulcast and voting equipment for all three systems. Redundant control sites provide a recovery mode that is not available on the existing systems.

2.3.4 RF Site Equipment

Tables 4 through 6 in Section 2.1, Radio Coverage, include a list of proposed RF sites for the Fire, Sheriff and LG systems, respectively, and identify whether the sites are existing County sites or new sites, and how each site would be used in the new system (i.e. simulcast Tx/Rx, simulcast Rx-only or standalone repeater). The following RF site equipment would support the Fire VHF analog conventional simulcast, and Sheriff UHF and LG 800 MHz digital P25 conventional simulcast operation:

- LMR base stations and antenna systems
- Microwave radios and antenna systems
- T1 channel banks (sites not on the microwave backhaul system)
- Network equipment
- Site alarm equipment

Although the Fire equipment would operate in analog conventional mode, it would be software upgradeable to digital P25 operation. All equipment would have IP standards-compliant interfaces for easy integration with other systems and components. All equipment would be suitable for fixed site installations, including such features as:

- Shielded and suitable for use in a heavily congested RF environment
- Rack mountable utilizing standard 19” racks
- Dual or alternate power sources, including 120 VAC (with or without internal battery backup) and -48 VDC
- Capable of a 100% duty cycle

Frequency band, number of channels, and configuration of base stations (repeaters and/or receivers) vary per system as follows:

- Fire VHF – Six analog conventional channels, requiring six base stations per site (except for GATR which is a single-channel site)
- Sheriff UHF– Four digital P25 conventional channels, requiring four base stations per site

- LG 800 MHz – Two digital P25 conventional channels, requiring two base stations per site

All RF sites for the Fire, Sheriff and LG systems are simulcast, except Mt. Abel and Valley Peak, which would be new standalone repeater sites used to supplement existing radio coverage. Located outside the existing simulcast coverage footprint, Mt. Abel and Valley Peak exceed the typically accepted distance for site separation in a simulcast configuration. Attempting to include them in the simulcast cell may lead to potential interference when roaming between sites. ***FE*** suggests that the County include a requirement in the Request for Proposals (RFP) that vendors evaluate whether Mt. Abel and Valley Peak can be simulcast sites, with standalone repeater operation being the fallback if vendor cannot resolve potential interference issues. Each standalone site can operate independent of the simulcast systems, but Dispatch can patch a standalone repeater to the simulcast system, as needed.

Several proposed RF sites (i.e. Los Olivos, Tanglewood and San Antonio) have limited tower and/or shelter space for new equipment, however, ***FE*** included these sites in the conceptual design for their ability to provide needed radio coverage. Los Olivos and Tanglewood are Rx-only sites, so tower and shelter space requirements are minimal. San Antonio is a simulcast Tx/Rx site connected to the microwave backhaul via a spur route. The size footprint of new radios would be significantly less than the existing County radio equipment and the vendor would have other options available for minimizing the tower and shelter space requirements at these sites, such as the use of:

- Transmit combiners and/or receive multicouplers to share a single antenna between all channels
- A split-mount or all-outdoor microwave radio
- An outdoor, air-conditioned cabinet

2.3.5 LMR Antenna Systems

The Fire, Sheriff and LG systems would have separate receive and transmit antenna systems designed its specific frequency band. This conceptual design does not include specific antenna gain, pattern and/or downtilt. The RFP would require the vendor to select these parameters on a per-system and per-site basis to meet the specified coverage requirements. The antenna systems would include the following components:

- Master receive antenna

- Tower top amplifier (TTA), where applicable
- Receiver multicouplers - each County system would use a receiver multicoupler to allow all receivers to use the same antenna and to provide out-of-band RF filtering, isolation and protection between site receivers and transmitters
- Master transmit antenna(s)
- Transmitter combiner – each County system would use a transmit combiner to allow all transmitters to share the same antenna(s) and to provide out-of-band filtering, isolation and protection between transmitters
- Lightning surge suppressors
- Transmission lines and connectors

Sites with higher channel counts may include additional transmit and receiver antennas, transmission lines, and higher-port multicouplers and/or combiners. Receive-only sites do not require a transmit combiner, therefore reducing the required antenna hardware.

The antenna system design uses antennas and related hardware with the mechanical strength to survive the wind, ice, and earthquake requirements for urban and suburban areas as specified in the TIA-222 standard, *Structural Standard for Antenna Supporting Structures and Antennas*. The antenna system should achieve an optimal balance between meeting the radio coverage requirements and operating an efficient and economical system. The result of this balance must be an interference free environment from the other channels and subsystems sharing the same site.

2.3.6 System Features

The new LMR systems would retain the existing system features that the Fire, Sheriff, and LG systems have today. The Fire system would continue to operate in analog conventional mode with no additional features. However, the Sheriff and LG systems would have additional features by moving from analog to digital P25[5] operation.

The Sheriff and LG systems would operate in P25 digital conventional mode, which employs the Frequency Division Multiple Access (FDMA) protocol and 12.5 kHz channels for data and voice communications. The P25 Common Air Interface (CAI) allows

[5] P25 is a suite of standards developed by the Telecommunications Industry Association (TIA) to describe aspects such as the radio air interface, trunking functionality and open system interfaces to allow multi-vendor systems.

equipment from different manufacturers to operate on the same system with the same basic functionality. The standard defines conventional and trunked infrastructure access methods, replacing vendor-specific solutions.

2.4 Dispatch Conceptual Design

2.4.1 Design Criteria

FE used the following criteria for the Alternative 1 dispatch center design:

- Sheriff Dispatch Center
  - Replace the consoles at Dispatch with 10 new mission-critical, IP-based dispatch consoles
  - Install one new backup control station for each dispatch console position, along with a new antenna system
  - Install a new multi-band control station for interoperability with other regional and state systems
- New Fire Dispatch Center
  - Establish a new Fire Dispatch Center at a location to be determined
  - Install the same new equipment as described above for the Sheriff Dispatch

2.4.2 System Architecture

The conceptual design includes the replacement of the 10 existing dispatch consoles at the existing Sheriff Dispatch. Because the County requires a highly reliable dispatch network with no single point of failure, the design includes redundant networking equipment and backup RF control stations. The new console system would replace the existing backroom equipment with compact servers, routers, switches and computers. Each console position would have all existing functionality, including, but not limited to:

- Radio system channel control (talkgroups for the trunked systems in Alternatives 2 and 3)
- Paging
- Fire station alerting

- Emergency alarms and calls
- Patching between talkgroups and conventional stations (Alternatives 2 and 3)
- Retaining any existing functionality

Each console position would have a backup control station for use in the event of a console or microwave link failure to the core. These control stations would be multi-band units to allow for operation on analog or P25 digital systems on VHF, UHF and/or 700/800 MHz channels.

A new logging recorder would capture all radio traffic, 9-1-1 calls and administrative telephone traffic. The logging recorder would include redundant power supplies and redundant hard drives for a fault-tolerant recording solution. Multiple search parameters such as time and date, user ID#, talkgroup ID and more would be available at personnel computers located on the network and containing the appropriate software license and login credentials.

The conceptual design includes a new Fire Dispatch with the same complement of consoles, control stations, interoperability gateways, and logging recorder as the Sheriff Dispatch. The Sheriff and Fire dispatch centers will serve as a backup for each other.

2.5 Subscriber Equipment

The County would need to replace existing (end-of-life) subscriber units with mid-tier, single-band radios. Table 7 provides the subscriber unit equipment inventory by County department, adjusted to exclude radios that were recently purchased or will be purchased by Sheriff and Fire prior to the implementation of the new LMR systems.

Table 7 – Existing Subscriber Equipment Inventory

Department	Mobiles	Portables	Control Stations
CEO	6	5	2
Courts	0	36	0
District Attorney	13	13	0
Fire*	150	0	22
General Services	13	34	0
Parks	9	32	2
Probation	16	142	0
Public Health - Animal Control	12	18	0
Public Health - EMS	5	21	1
Public Works - Flood Control	41	10	3

Department	Mobiles	Portables	Control Stations
Public Works - Resource Recovery	47	66	0
Public Works - Roads	85	23	3
Public Works (Miscellaneous)	0	3	0
Sheriff**	261	333	11
TOTAL	**658**	**736**	**44**
*Quantity of 20 Fire portables removed per County request			
**Quantity of 305 Sheriff portables removed per County request			

The conceptual design assumes replacement of existing radios with single-band, mid-tier models with software to operate in conventional mode. The Sheriff and LG system radios would also include features like Advanced Encryption Standard (AES) encryption, OTAR, and OTAP. The use of mid-tier models provides a good average for budgetary purposes. Some departments may only purchase low-tier models, while others may purchase high-tier radios with added features. As part of the RFP, the County can specify the quantity and tier requirements for each department, which would allow the vendors to provide a more accurate cost proposal.

2.6 Microwave Backhaul Conceptual Design

FE evaluated alternatives for the upgrade of the County's Public Safety Microwave Radio System to provide connectivity between Dispatch and key LMR sites and to increase system reliability by providing additional path redundancy. The Phase 1 Report, *Santa Barbara County Existing System Assessment and Needs Analysis,* includes a description of the existing Public Safety Microwave Radio System.

2.6.1 Design Criteria

FE used the following criteria to develop the conceptual design for the upgrade of the Public Safety Microwave Radio System:

- Develop a new architecture to provide connectivity between proposed LMR sites and the Sheriff and Fire dispatch centers
- Utilize new paths to key LMR sites for additional redundancy
- Utilize existing licensed County microwave paths to the greatest extent possible
- Replace all microwave radios and antenna systems (i.e. antennas, waveguide and dehydrators) and DC power systems and existing microwave radio sites, and install new network equipment (i.e. switches and MPLS routers)

- Install new microwave radios, antenna systems, DC power systems and network equipment at all new microwave radio sites

2.6.2 System Architecture

FE developed a preliminary system architecture, maximizing the use of existing County microwave radio paths to limit the number of new paths requiring an FCC license. ***FE*** reviewed the preliminary architecture with the County project team and based on their feedback, ***FE*** developed the proposed architecture described below. Figure 8 is a logical diagram showing the connectivity between key LMR sites, with sites appearing on multiple rings shown in purple. Existing paths are identified with an E and proposed new paths are identified with an N.

Although the County has decided to establish a separate Fire Dispatch, the locations for the Sheriff and Fire dispatch centers are currently unknown. Based on this, ***FE*** developed the microwave system architecture with the assumption that one of the two dispatch centers will be located where the existing Sheriff Dispatch is, with the second location to be determined. Because the location and type of backhaul connection for the second dispatch center is unknown, ***FE*** did not include it in the microwave system conceptual design. Modification to the microwave conceptual design may be needed when the County identifies the location and the backhaul connection type.

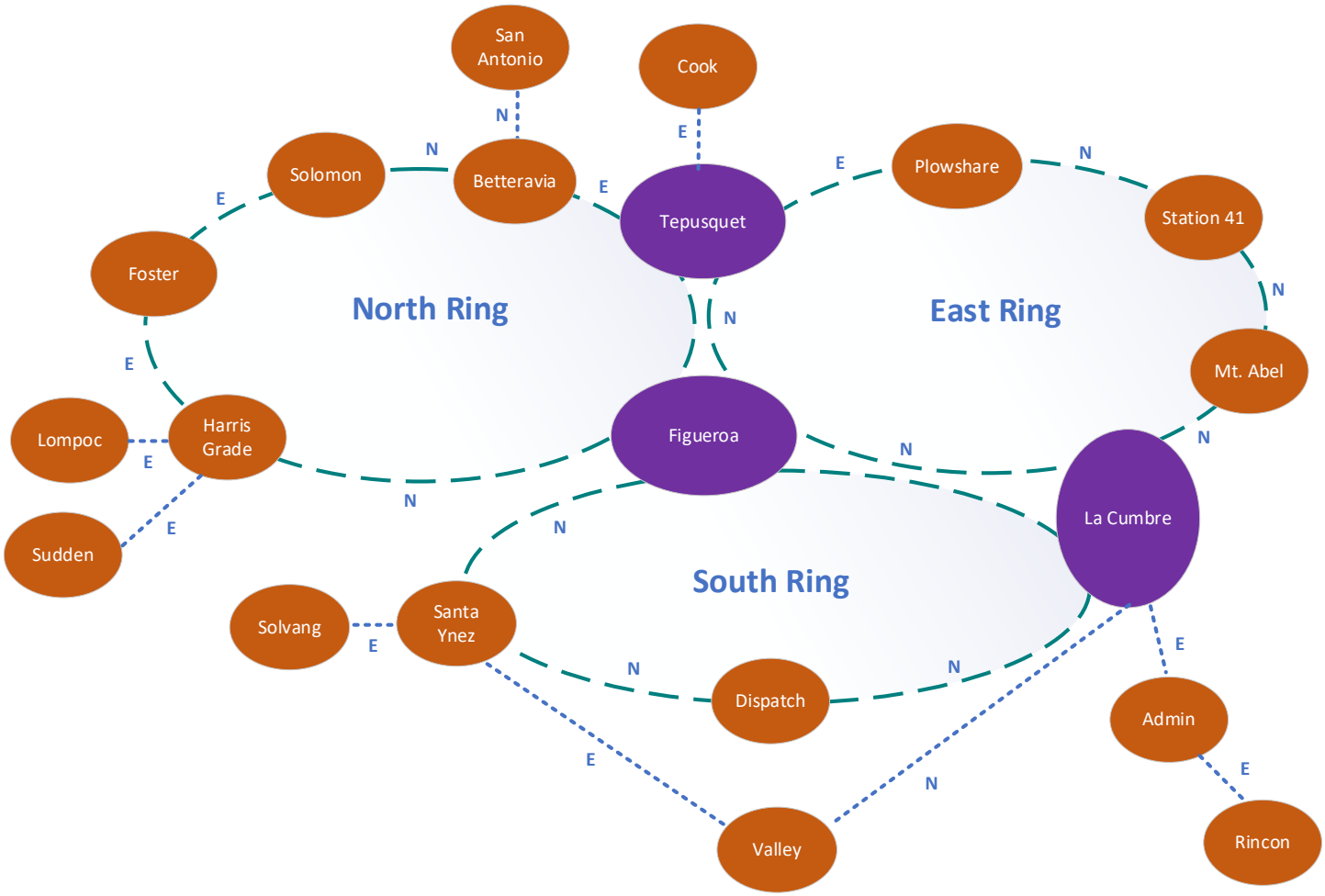

Figure 8. Microwave Backhaul Logical Diagram

The proposed system architecture is composed of three interconnected rings, North, East and South, to provide alternate paths between key LMR sites. Connecting adjacent rings at two sites eliminates single-points-of-failure. LMR sites with lower capacity requirements (i.e. receive-only and smaller transmit/receive sites) connect to one of the three rings via a microwave radio spur. Based on input from the County, the sites listed in Table 8 will be connected to a microwave radio site using leased T1 lines or two-wire radio circuits. Table 8 includes sites for all three LMR upgrade alternatives. Refer to the radio coverage section for each alternative for the specific sites for that alternative. Proposed new sites are highlighted in the table.

Table 8 - LMR Sites Connected Via Leased T1 Lines or Two-Wire Radio Circuits

LMR Site	Site Type	Backhaul Circuit Type
Buellton	Rx Only	Two-wire radio circuit
Chumash Casino	Tx/Rx	Leased T1
Proposed New Fire Station 24	Tx/Rx	Leased T1
Proposed New GATR	Tx/Rx	Leased T1
Gaviota	Tx/Rx	Leased T1
Proposed New Highway 246 Tank	Tx/Rx	Leased T1
Proposed New IV Foot Patrol	Tx/Rx	Two-wire radio circuit
Los Alamos	Rx Only	Leased T1
Los Olivos	Rx Only	Two-wire radio circuit
Tanglewood	Rx Only	Two-wire radio circuit
Vic Trace	Tx/Rx	Leased T1
White Hills	Tx/Rx	Leased T1

Figure 9 shows all proposed microwave paths and Figures 10 through 12 show the radio paths on each ring, along with spur paths off each ring. Green paths are on the North Ring, orange paths are on the East Ring and blue paths are on the South Ring. The Tepusquet to Figueroa path appears on the North and East Rings and the Figueroa to La Cumbre path appears on the East and South rings. Paths shown in red are spurs.

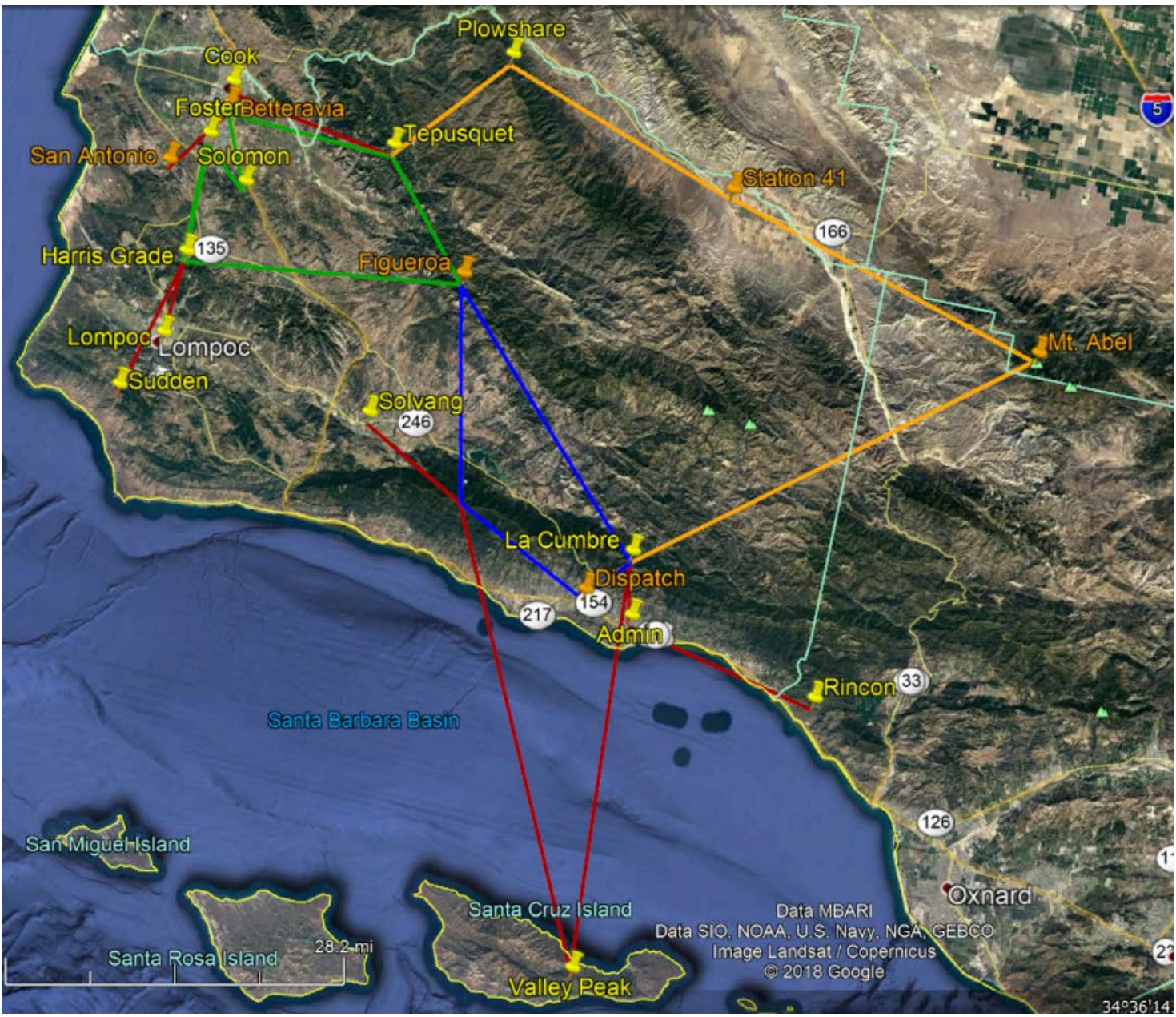

Figure 9 - Microwave Backhaul – All Radio Paths

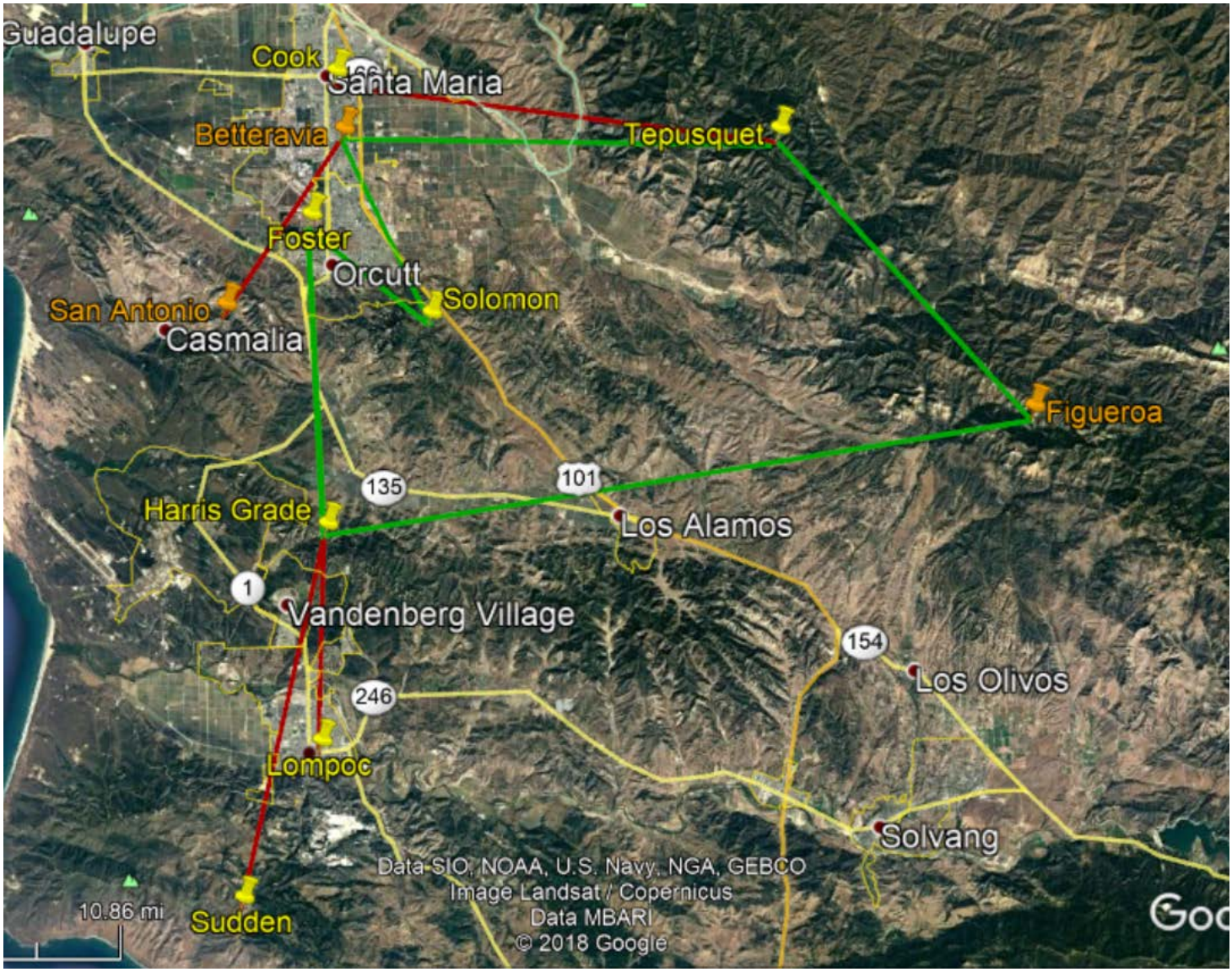

Figure 10 - Microwave Backhaul – North Ring Radio Paths

Figure 11 - Microwave Backhaul – East Ring Radio Paths

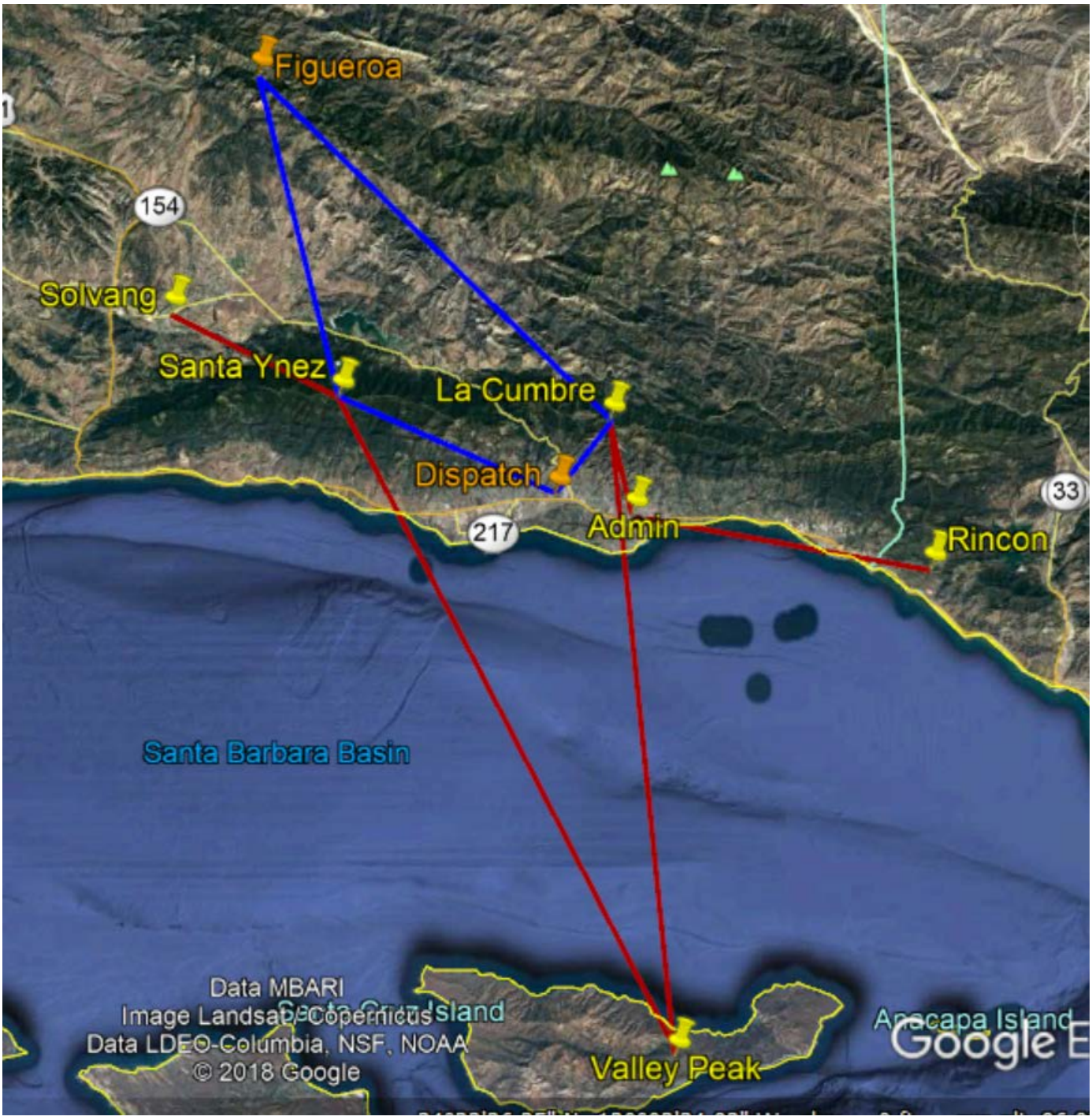

Figure 12 - Microwave Backhaul – South Ring Radio Paths

2.6.3 Microwave Radio Path Analysis

FE analyzed each microwave radio link using Pathloss microwave radio path analysis software, and site information obtained during the site surveys (i.e., site coordinates, tower heights and available antenna space), to assess adequate clearance above terrain and obstructions and calculate the predicted path availability. However, ***FE*** did not perform physical radio path surveys to identify the exact location and height of potential obstructions. The RFP for the procurement and installation of the new microwave radio system should require the awarded vendor to perform final path and system design, including physical path surveys. ***FE*** made the following assumptions to produce the path profiles and path calculations:

- Used the same frequency band for all existing paths
- Used 6 GHz for all proposed paths 10 miles or more and 11 GHz for proposed paths less than 10 miles
- Path availability goal of 99.999% (i.e. five 9's)
- Used standard power transmitters to allow multiple vendors to submit compliant bids
- Assumed 30 MHz channels for both 6 and 11 GHz bands

FE modeled each path using single antennas and standard transmit power at both ends of each path, which resulted in large diameter antennas for some of the paths. However, as noted in the tables below, smaller space diversity antennas and/or high power or extra high-power transmitters could be used to reduce antenna size. The RFP will require the awarded vendor to produce the final path analyses and system design, to consider all options and choose the one that produces the best results.

Tables 9 through 11 show the results of the analysis, broken down by ring. Appendix B includes the radio path profiles and path calculations.

Table 9 - North Ring - Microwave Radio Path Analysis Summary

Site A	Site A Antenna Height (ft)	Site B	Site B Antenna Height (ft)	Band	Path Length (miles)	Availability (%)	Comments / Issues
Betteravia	50	Tepusquet	30	6 GHz	14.0	99.9997	Path should be good with single 6’ antennas at both ends, the Betteravia antenna at rooftop and a fairly low antenna height at Tepusquet.
Foster	25	Solomon	30	11 GHz	5.0	99.9997	There are some trees close to the sides of this path near Foster, but it appears to be clear directly along the path. Single 4’ antennas at both ends should be sufficient.
Solomon	30	Betteravia	50	11 GHz	6.5	99.9993	Path should be good with Betteravia antenna at rooftop, a low antenna height at Solomon and single 4’ antennas at both ends.
Betteravia	50	San Antonio	40	11 GHz	6.8	99.9998	Path should be good with single 4’ antennas at both ends, the Betteravia antenna at rooftop and a fairly low antenna height at San Antonio, as long as the antenna at San Antonio is higher than the trees immediately surrounding the site (35' according to site survey).
Tepusquet	30	Cook	33	6 GHz	14.4	99.9996	Path should be good with single 6’ antennas at both ends, a rooftop antenna at Cook and a fairly low antenna height at Tepusquet.
Sudden	30	Harris Grade	60	6 GHz	12.3	99.9998	Sudden is clear at low antenna heights. Antenna at Harris Grade may need to 60' or higher to overcome a nearby tree directly in the path. Used single 6’ antennas at both ends.
Harris Grade	33	Figueroa	80	6 GHz	26.2	99.9966	Trees near Figueroa necessitates a minimum antenna height of 60-feet, however, due to the path length, an 80-foot antenna height was required to achieve 99.9966% reliability with 8’ antennas on both ends. A high-power transmitter (standard power was used for the calculation) is an option to achieve five 9’s.

Site A	Site A Antenna Height (ft)	Site B	Site B Antenna Height (ft)	Band	Path Length (miles)	Availability (%)	Comments / Issues
Harris Grade	80	Foster	70	6 GHz	9.9	99.9999	Overcoming nearby elevation rise and trees near Harris Grade probably requires an 80' or higher antenna. At Foster, a 70' antenna should clear some trees a few blocks from the site. Six 9's was achieved using single 6' antennas at both ends.
Harris Grade	60	Lompoc	45	6 GHz	6.9	99.9999	Harris Grade has a tree nearby which may impede the path. As a result, the antenna should be 60' or higher. At Lompoc, an antenna height of 45' is needed to clear some trees directly across the street. Used single 6' antennas at each end to achieve better than six 9's.
Figueroa	60	Tepusquet	60	6 GHz	16.3	99.9995	Should be able to clear nearby trees at Figueroa with a 60' antenna. An antenna higher than 60' may be needed at Tepusquet because the path runs along a road of similar elevation to the tower and there may be trees along the road that could impede the path. Measurement of tree height along the path is needed to determine if 60' would be sufficient. Single 6' antennas were used at both ends to achieve five 9's.

Table 10 - East Ring - Microwave Radio Path Analysis Summary

Site A	Site A Antenna Height (ft)	Site B	Site B Antenna Height (ft)	Band	Path Length (miles)	Availability (%)	Comments / Issues
Tepusquet	40	Plowshare	20	6 GHz	12.3	99.9999	Path should be good if it can clear the surrounding trees at Plowshare. May want to go 40' or higher to be sure. Single 6' antennas were used at both ends to achieve five 9's.
Plowshare	40	Station 41	40	6 GHz	21.6	99.9992	Probably want 40' minimum at Plowshare to overcome potential tree obstructions near the site. FS 41 should have clearance over the nearby clutter at 60' antenna height. Modeled 12' antennas and standard power transmitters on both ends to achieve five 9's. However, space diversity and/or high power or extra high-power transmitters are options to reduce antenna size.
Mt. Abel	40	La Cumbre	15	6 GHz	37.2	99.9971	Should be able to clear nearby trees at Mt. Abel with a 40' antenna height. La Cumbre should have good clearance, even at low antenna heights. Modeled 12' antennas and standard power transmitters on both ends to achieve 99.9971. However, space diversity and/or high power or extra high-power transmitters are options to reduce antenna size and/or achieve five 9's..
La Cumbre	30	Figueroa	60	6 GHz	22.5	99.9997	While clearance looks good, may want to mount this on La Cumbre at 30' to ensure a good link. At Figueroa, 60' or higher would probably clear the nearest tree line by the site. Modeled 12' antennas and standard power transmitters on both ends to achieve five 9's. However, space diversity and/or high power or extra high power transmitters are options to reduce antenna size.

Site A	Site A Antenna Height (ft)	Site B	Site B Antenna Height (ft)	Band	Path Length (miles)	Availability (%)	Comments / Issues
Figueroa	60	Tepusquet	60	6 GHz	16.3	99.9995	Should be able to clear nearby trees at Figueroa with a 60' antenna. An antenna higher than 60' may be needed at Tepusquet because the path runs along a road of similar elevation to the tower and there may be trees along the road that could impede the path. Measurement of tree height along the path is needed to determine if 60' would be sufficient. Single 6' antennas were used at both ends to achieve five 9's.
Station 41	45	Mt. Abel	100	6 GHz	28.3	99.9988	A minimum 90' antenna height is needed at Mt. Abel to clear a nearby hill and trees. Because of this, a new 100-foot tower has been included for this site. ***FE*** estimates a minimum antenna height of 90 feet is required at Fire Station 41 to provide adequate clearance above a nearby tree, however the County's current plan is to install a 50-foot tower. Therefore, careful planning will be needed to choose a tower location where the tree is not in the radio path. Modeled 12' antennas and standard power transmitters on both ends to achieve five 9's. However, space diversity and/or high power or extra high-power transmitters are options to reduce antenna size.

Table 11 - South Ring - Microwave Radio Path Analysis Summary

Site A	Site A Antenna Height (ft)	Site B	Site B Antenna Height (ft)	Band	Path Length (miles)	Availability (%)	Comments / Issues
La Cumbre	30	Figueroa	60	6 GHz	22.5	99.99966	While clearance looks good, may want to mount this on La Cumbre at 30' to ensure a good link. At Figueroa, 60' or higher would probably clear the nearest tree line by the site. Modeled 12' antennas and standard power transmitters on both ends to achieve five 9's. However, space diversity and/or high power or extra high-power transmitters are options to reduce antenna size.
La Cumbre	70	Admin	68	11 GHz	5.3	99.99994	Need as much height as possible at La Cumbre to get clearance over some hills that are in the path within a few miles of the site. On the Admin side, a rooftop antenna should clear nearby clutter. With this, five 9's can be achieved with single 4' antennas at both ends.
Santa Ynez	50	Dispatch	40	6 GHz	12.9	99.9998	The roofline at Dispatch can be cleared with an antenna height around 35'. Clearance should be good the rest of the way, although some elevation rise along the path may be cleared more with a few more feet at Dispatch. At Santa Ynez, the nearby trees should be cleared easily, but a hill a few thousand feet down the path could present some tree problems so a 50' or higher antenna should be used. Used single 6' antennas at both ends to achieve five 9's.
Dispatch	40	La Cumbre	30	11 GHz	5.0	99.9999	The La Cumbre antenna should be minimum 30'. A 40' antenna at Dispatch would probably clear the nearby trees, however, some additional height would provide a buffer for potential tree growth. Used single 4' antennas at each end to achieve six 9's.
Santa Ynez	60	Solvang	40	6 GHz	10.1	99.9999	This path may prove difficult. An antenna at Solvang would need to be 60' or higher to clear trees a few blocks from the site, and an antenna at Santa Ynez may shoot directly into another tower at the site. The height of that tower is unknown, but the

Site A	Site A Antenna Height (ft)	Site B	Site B Antenna Height (ft)	Band	Path Length (miles)	Availability (%)	Comments / Issues
							shadows on satellite imagery appear to show it's taller than the County tower. That being said, there is an existing link between the sites now, so perhaps there is some workaround for these obstacles. Assuming the path is not impacted by the adjacent tower, six 9's can be achieved with single 6' antennas at both ends.
Santa Ynez	30	Figueroa	60	6 GHz	14.9	99.9991	An antenna at Santa Ynez should have good clearance at low mounting heights, however because there is a short tree near Figueroa, the antenna would need to be 60' or higher. Single 8' antennas were used at both ends to achieve five 9's.
Admin	68	Rincon	40	11 GHz	16.5	Lower than 99.9965	Based on ***FE's*** analysis, a minimum antenna height of 76' is needed to clear a nearby building and achieve 99.9965% reliability. However, due to local restrictions, the maximum antenna height at Admin is 68' (roof level), which will result in a path reliability lower than 99.9965%. Several options are available to increase path availability, including the use of space diversity and/or a high power or extra high-power transmitter, or going to 6 GHz.
Valley Peak	30	Santa Ynez	30	6 GHz	40.2	99.99412	Clearance should be sufficient for both ends with regards to trees, however the tower to the immediate SSE of the Santa Ynez tower is very close to the path which could be a problem. Since the tower is so close to the site, the Fresnel Zone may not be impacted. Modeled 12' antennas and standard power transmitters on both ends to achieve 99.9941%. However, space diversity and/or high power or extra high-power transmitters are options to reduce antenna size and/or increase path availability.
Valley Peak	28	La Cumbre	58	6 GHz	34.6	99.9809	Diversity 8-foot antennas are required at both ends to achieve 99.9809% reliability. Space diversity and/or a high power or extra high-power transmitter are options to increase the availability.

2.7 Network Management System

Alternative 1 includes a new Network Management System (NMS) to:

- Remotely monitor LMR and microwave radio system and site performance and alarms (i.e. rectifier failure, elevated temperature and intrusion)
- Troubleshoot system outages
- Administer and manage system security, functionality and software licenses
- Page or send emails to report system alarms or outages to staff required to respond
- Remotely manage subscriber radios, allowing for over-the-air programming changes or software license updates

The NMS software interface would identify the current operating status of the equipment and sites and would flag 'out of tolerance' conditions via an audio/visual indication. The indication would return to a normal indication after correction of the out of tolerance condition. The NMS would archive system data and would maintain a history of alarm events in a searchable database for a minimum of 180 days. Storage of alarm events enables root cause analysis on infrequent recurring events. Following are some of the events and functions that the NMS would monitor and manage:

- Transmitter low power output
- Antenna system high Voltage Standing Wave Ratio (VSWR)
- Transmitter power amplifier (PA) failure
- Base station power supply failure
- Tower top amplifier failure
- GPS frequency standard failure
- Router/switch failure
- Controller/gateway/server failure
- External interference detection
- Telephone interconnect subsystem failure
- Critical site path re-route alert
- IP network intrusion and security
- Configuration database changes

The NMS includes geographically separate NMS servers replicate each other so that if one server fails the other server would have the most up-to-date configuration data and can provide monitoring and diagnostic capabilities for the entire microwave network.

2.8 Interoperability

2.8.1 Interoperability Continuum

Interoperability is the ability for County departments and/or outside agencies to communicate during incidents that require the response of multiple departments or agencies. ***FE*** analyzed the radio interoperability capabilities of each LMR system upgrade alternative using the Department of Homeland Security Office of Emergency Communications (DHS-OEC) Interoperability Continuum. Figure 13 illustrates the "five lanes" of interoperability.

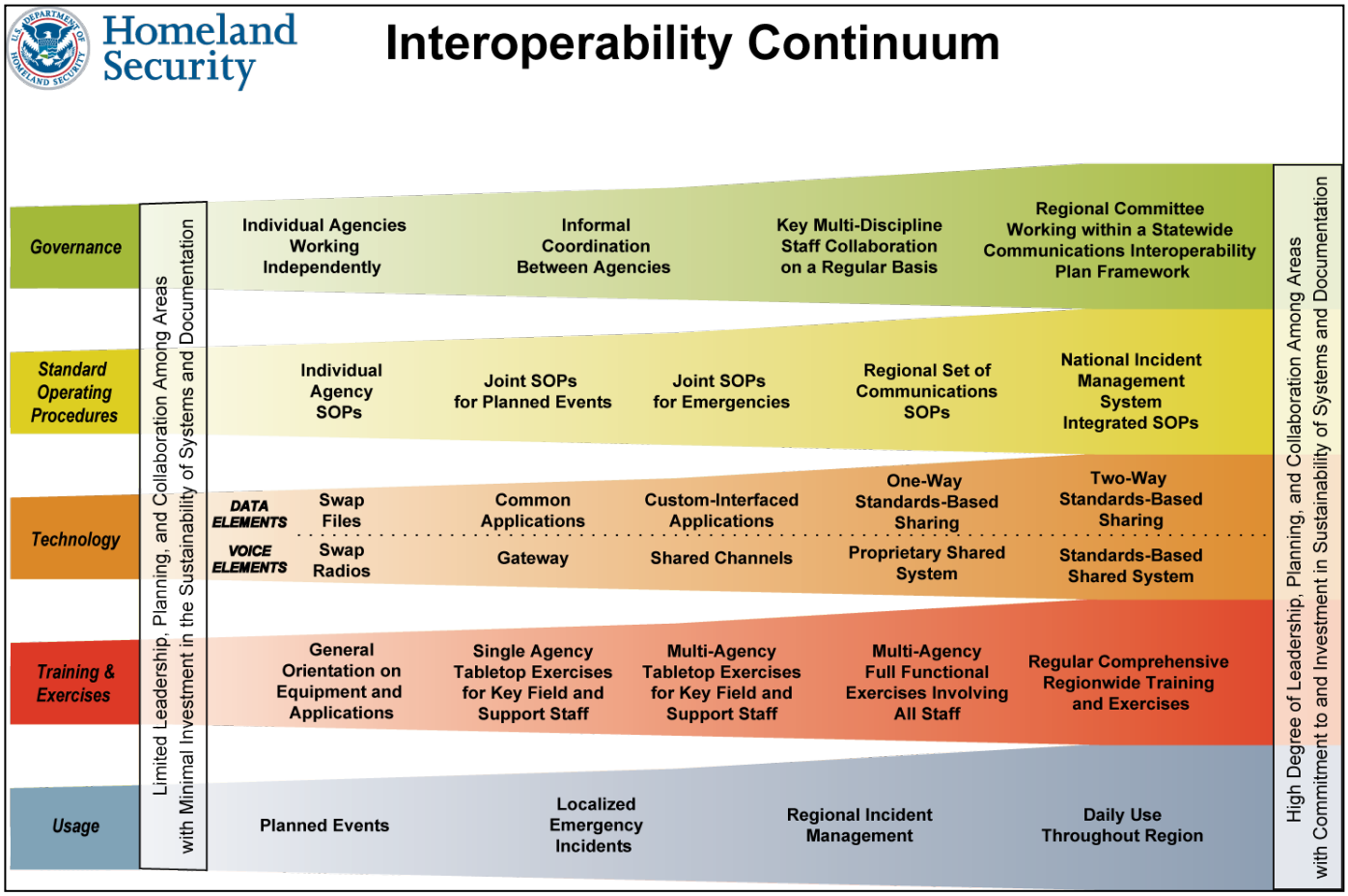

Figure 13 – DHS-OEC Interoperability Continuum

FE focused on the Voice Elements section of the Technology lane. Moving from left to right, the methods become more advanced and effective in their ability to address interoperability requirements, and rely more on technology to increase the ease of interoperability, as follows:

- **Swap Radios**. The most basic solution for interoperability is for one agency to lend some of their radios to another agency. This requires one agency to become familiar with the other agencies system and radio operation and requires one agency to maintain a cache of radios for interoperability

- **Gateway**. A gateway interconnects the channels from different systems and rebroadcasts transmissions received on one of the channels on all interconnected channels. This method is inefficient in that it uses the channels of all agencies involved.

- **Shared Channels**. An agency programs the channels used by another agency into their radios so that they can switch their radios to the other agencies channel for direct communications. This method is efficient in that it requires the use of only one channel. However, it requires that the systems for each agency are in the same frequency band or the use of multi-band portable and/or mobile radios. This is the method currently used by the County.

- **Dispatch Console Patch**. Although not listed in the Interoperability Continuum diagram above, a dispatcher can create a “patch” between the channels used by different agencies so that transmissions on either channel are heard on both channels. Dispatchers typically create console patches for short durations and for specific events, but it can lead to operational confusion because of infrequent use. Console patching is also inefficient in that is uses the channels of all involved agencies involved.

- **Proprietary Shared Trunked System.** In a proprietary shared trunked radio system talkgroups allow users from different departments or agencies to communicate with each other. Gateways and console patches provide connectivity between a trunked radio system and a conventional system. The system can also include conventional channels for mutual aid. When the interoperability continuum was first developed, proprietary trunked systems were more prevalent, but today most public-safety agencies are using standards-based P25 systems.

- **Standards-based Shared Trunked System**. In addition to the features described above for the proprietary shared trunked system, a P25 standards-based system provides the following additional features for interoperability:

- The P25 Common Air Interface (CAI) enables over-the-air interoperability between P25 radios regardless of manufacturer. If another agency in the County had a P25 radio system, the County could program their P25 mobile and portable radios with talkgroups on the other P25 system, and vice versa.

- The P25 Inter-RF Subsystem Interface (ISSI) interconnects different P25 cores, regardless of frequency band or manufacturer, to allow roaming of user radios between networks. ISSI supports many common P25 features, including Caller ID, group calls, encryption and emergency calls. A user roaming into a foreign system must have radios which are on the same frequency or multi-band compatible with the foreign host.

2.8.2 Interoperability Analysis

Looking at the DHS Interoperability Continuum, most County departments are meeting their interoperability needs through the sharing of radio channels with the other departments or agencies they interoperate with (i.e. they program the other agencies channels in their radios and vice versa). This works well for Fire because nearly all the fire agencies they need to interoperate with are also on the VHF Band. However, for Sheriff and EMS that are on UHF, and LG system users that are on 800 MHz, meeting their interoperability needs is more difficult. Table 12 shows how County departments currently interoperate with other departments or agencies in the County and how the Alternative 1 system upgrade would impact their ability to interoperate.

Table 12 – Radio Interoperability Comparison – Current vs. Alternative 1

County Department	Current Method	Alternative 1
Fire	1. All other agencies that Fire interoperates with also have VHF radio systems, so Fire programs the other agencies channels into their radios and vice versa. 2. Fire has some VHF/UHF dual-band portable radios, which they can use to communicate with the Sheriff. 3. Fire cannot interoperate with Santa Maria because they moved to a 700 MHz trunked radio system	1. Fire would continue to be able to talk to other fire agencies in the County. 2. Fire would not be able to interoperate with the Sheriff unless they purchase multi-band P25-compatible subscriber units. 3. Fire would not be able to interoperate with Santa Maria Fire unless they purchase multi-band P25 compatible subscriber units.
EMS	1. EMS has UHF radios on their system and VHF radios to talk to County Fire and other fire agencies in the County. 2. EMS cannot communicate with Santa Maria Fire Department since they went to a 700 MHz trunked radio system.	1. EMS is moving their operations to the County Fire 1 channel, which would improve their ability to interoperate with Fire and other fire agencies.

County Department	Current Method	Alternative 1
	3. Ambulances communicate with County base hospitals using standalone repeaters on Med 5, 6, 7 and 8 channels.	2. EMS still would not be able to communicate with Santa Maria Fire unless they purchase multi-band P25-compatible subscriber units. 3. Ambulances would continue to communicate to the hospitals on the Med 5, 6, 7 and 8 channels.
Sheriff	1. Sheriff currently interoperates with Santa Barbara police department (PD), Lompoc PD and San Luis Obispo Sheriff who also have UHF radio systems, by programming the other agencies channels in their radios and vice versa. 2. Sheriff can't interoperate with Santa Maria PD because they moved to a 700 MHz trunked system.	1. Sheriff would continue to be able to talk to other law enforcement agencies in the County on the UHF band. 2. Sheriff is buying multi-band subscriber units that would allow them to talk to Santa Maria PD on their 700 MHz system.
Floods	1. Floods currently interoperates with Roads on the LG radio system. 2. Floods expressed interest in being able to interoperate with Sheriff and Fire, but, can't because they are on different frequency bands.	1. Floods would continue to be able to interoperate with Roads on the LG system. 2. Floods still would not be able to communicate with Sheriff and Fire.
Parks	1. Parks would like to be able to interoperate with Fish and Wildlife and USFS but cannot because they are on a different frequency band. 2. Parks currently uses cell phones to talk to these agencies.	1. Parks still would not be able to communicate with Fish and Wildlife or USFS. 2. Parks would still need to use cell phones for interoperability.
Roads	1. Roads currently uses cell phones to talk to Caltrans. 2. Roads would like to be able to communicate with Floods.	1. Roads would still need to use cell phones to talk to Caltrans. 2. Roads would need to program the LG 1 channel in their radios to be able to talk to Floods.
Public Health, Animal Services	1. Animal Services calls Dispatch to request that they monitor the LG 1 channel for after hours or emergency support. 2. Animal Services would like to be able to interoperate with CHP after hours but can't because CHP is on VHF Low Band.	1. Animal Services would still need to contact Dispatch for support. 2. Animal Services would still not be able to interoperate with CHP.
District Attorney	1. The District Attorney (DA) uses cell phone or landline for most communications needs; they use the Sheriff system for operations with Sheriff deputies, for surveillance activities, and for mass casualties or disasters. 2. The DA needs radio interoperability with Santa Maria PD.	1. DA may choose to use the Sheriff system with the improved coverage of the new system. 2. DA would need dual-band radios to communicate with both the Sheriff (UHF) and Santa Maria PD (700 MHz).

County Department	Current Method	Alternative 1
Probation	1. Probation uses the Sheriff radio system for primary operations and coordinate operations with Dispatch. 2. Probation needs to interoperate with Santa Maria PD but can't since Santa Maria PD moved to a 700 MHz trunked radio system. 3. Probation mostly uses cell phones but have radios for officer safety.	1. Probation would still need to coordinate operations with Dispatch. 2. Probation is purchasing radios to interoperate with Santa Maria PD. Could also purchase dual-band radios to allow communications on with Sheriff and (Santa Maria PD. 3. The need for cell phones may lessen with the improved coverage of the new system.

2.9 Cost Analysis

Using our in-house cost analysis tool, ***FE*** prepared high-level budgetary cost estimates for the LMR systems, microwave system, NMS, dispatch centers, subscriber equipment, implementation services, and site improvements. These estimates reflect results from previous project activities, our knowledge of the County systems, our experience designing radio systems comparable to this project, and publicly available industry information. This cost analysis takes advantage of our team's knowledge base and should prove to be invaluable during the development of budgets and the completion of procurement activities with system vendors. Actual system costs are highly dependent on final system design choices as well as conditions in the LMR and microwave radio markets during the system procurement phase.

FE's budgetary estimates are conservative so that the vendor proposal pricing does not exceed the estimates. The cost estimates prepared for the conceptual design reflect non-discounted (list) pricing. The cost estimates also include a Sales Tax of 8.75% on equipment (hardware and software), and a 10% contingency, as requested by the County. Frequently, system vendors provide additional discounts for system and subscriber unit purchases of this size. System discounts of 20% to 25% are common (and mirror many state contracts), but ***FE*** has seen them higher. However, it is not possible to forecast the level of discount a vendor will offer at the time of proposal submission.

2.9.1 Cost Assumptions

2.9.1.1 LMR Systems

Table 13 outlines the system- and services-related assumptions developed by ***FE*** for Alternative 1 systems. While the conceptual design has Mt. Abel and Valley Peak as standalone sites for technical reasons (refer to Section 2.10.2), the cost estimates include

them as simulcast sites to account for the possibility that the awarded vendor determines that they can be included as simulcast sites.

Table 13 – Alternative 1 LMR System Cost Assumptions

Alternative 1 Assumptions	QTY	Notes
Fire VHF System		
Number of Simulcast Control Sites	2	Redundant / geographically separated
6-channel (CH) Transmit/Receive (Tx/Rx) Simulcast Sites	16	Chumash Casino (Parking Garage), Gaviota, Harris Grade, La Cumbre Peak, Mount Solomon, Plowshare, Rincon, San Antonio, Santa Ynez, Sudden, Tepusquet, Figueroa, Hwy 246 Tank, Fire Station 24, Mt. Abel and Valley Peak
6-CH Receive (Rx)-Only Sites	7	Chumash Casino (Hotel), Dispatch, Foster, Los Alamos, Solvang, White Hills, Vic Trace
1-CH Tx/Rx Simulcast Sites	1	GATR (serves Jalama Beach area)
6-CH VHF Tx/Rx Antenna System	16	All new transmission lines, combiners, multicouplers, and antennas
1-CH VHF Tx/Rx Antenna System	1	All new transmission lines, combiners, multicouplers, and antennas
6-CH VHF Rx-only Antenna System	7	All new transmission lines, combiners, multicouplers, and antennas
Site Networking Equipment	24	Routing and switching at each radio site
FCC licensing and coordination	31	Simulcast frequency pairs needed for expansion
Sheriff UHF System		
Number of Simulcast Control Sites	2	Redundant / geographically separated
4-CH Tx/Rx Simulcast Sites	2	North/South County: La Cumbre, Santa Ynez
3-CH Tx/Rx Simulcast Sites	16	North County: Chumash Casino (PG), Foster, Harris Grade, Solomon, Plowshare, San Antonio, Tepusquet, White Hills, Figueroa, Hwy 246 Tank, FS24, Mt. Abel South County: Gaviota, Rincon, Sudden, Valley Peak
3-CH Rx-Only Sites	8	North County: Buellton Sheriff, Los Alamos, Los Olivos, Purisima, Solvang, Tanglewood South County: Dispatch, Vic Trace
1-CH Tx/Rx Simulcast Sites	1	South County: GATR
UHF Tx/Rx Antenna System	19	All new transmission lines, combiners, multicouplers, and antennas
UHF Rx-only Antenna System	8	All new transmission lines, combiners, multicouplers, and antennas
Site Networking Equipment	27	Routing and switching at each radio site
FCC licensing and coordination	25	Simulcast frequency pairs needed for expansion
LG 800 MHz System		

Alternative 1 Assumptions	QTY	Notes
Number of Simulcast Control Sites	2	Redundant / geographically separated
2-CH Tx/Rx Simulcast Sites	11	Gaviota, Harris Grade, La Cumbre Peak, Mount Solomon, Plowshare, Rincon, San Antonio, Santa Ynez, Sudden, Tepusquet, Mt. Abel
2-CH Rx-Only Sites	2	Dispatch and Foster
800 MHz Tx/Rx Antenna System	11	All new transmission lines, combiners, multicouplers, and antennas
800 MHz Rx-only Antenna System	2	All new transmission lines, combiners, multicouplers, and antennas
Site Networking Equipment	13	Routing and switching at each radio site
FCC licensing and coordination	6	Simulcast frequency pairs needed for expansion
EMS UHF System		
MED10 UHF Channel	N/A	EMS moves to Fire 1 VHF channel
MED5 UHF Repeater	1	New analog conventional repeater
MED6 UHF Repeater	1	New analog conventional repeater
MED7 UHF Repeater	1	New analog conventional repeater
MED8 UHF Repeater	1	New analog conventional repeater
UHF Antenna System	4	All new transmission lines, duplexers, and antennas
Site Improvements		
Tower Structural Analysis	9	Quantity based site survey results and County feedback
Existing Site Renovations	9	Quantity based site survey results and County feedback
New Self-Supported Tower	12	Quantity based site survey results and County feedback
New Prefabricated Shelter	10	Quantity based site survey results and County feedback
Generator/Transfer switch/fuel tank	12	Quantity based site survey results and County feedback
Uninterruptible Power Supply (UPS)	11	Quantity based site survey results and County feedback
A&E, Environmental Compliance	12	Per Industry Best Practices, new structure
Site Acquisition Cost		
Fire Dispatch	1	County provided estimate of $500,000. Site location currently unknown, so could be new site purchase, existing site renovation or site lease
Figueroa	1	County provided estimate of $1,200,000 for new radio site (i.e. establish AC power and site preparation)
Mt. Abel	1	County provided estimate of $500,000 to purchase site
Sheriff Dispatch		
Logging Recorder System	1	New IP-based P25 compatible recorder
Dispatch Console Position	10	Replace existing consoles with new ones
Backup RF Control Station	10	One per operator position for backup
Interoperability Control Station	4	Multiband, analog and P25 Phase 2
Control Station Antenna System	2	New combiners, coax, and antennas
Conventional Channel Gateway	10	Interface for non-trunked channels
Networking Equipment	1	Redundant routing / switching equipment
Fire Dispatch	1	Same equipment as Sheriff Dispatch

Alternative 1 Assumptions	QTY	Notes
Network Management System		
Network Management Server	1	Primary (location to be determined)
Network Management Terminal	2	Can reside anywhere on network
Fault Management Server	1	Primary (location to be determined)
Fault Management Equipment	25	For site alarms at LMR & MW sites
Backup NMS Server	1	Backup (location to be determined)
Backup Fault Mgmt. Server	1	Backup (location to be determined)
Subscriber Equipment		
Mobile Radios	658	Replace existing with new single-band P25 Phase 1, mid-tier model
Portable Radios	736	20 Fire and 305 Sheriff portables removed per County request Replace all other existing radios with new single-band P25 Phase 1, mid-tier model
Control Stations	44	Replace existing with new single-band P25 Phase 1, mid-tier model
Implementation Services		
Spare / Test Equipment	5%	Based on total of all system components
Santa Barbara Sales Tax	8.75%	Based on total of all system components
Project Management	10%	Based on total of all system components
Installation	10%	Based on total of all system components
Engineering	10%	Based on total of all system components
Removal of Existing Equipment	2%	Based on total of all system components
Training	1%	Based on total of all system components
Staging	5%	Based on total of all system components
Acceptance/Coverage Testing	1%	Based on total of all system components
Documentation	1%	Based on total of all system components
Contingency	10%	Based on total of all system components
Operational Expenditures (OPEX)		
System OPEX Period (years)	15	System lifecycle costs in 5-year increments
Manufacturer's Warranty (years)	3	Out-of-warranty supports begins in Year 4
Subscriber Lifecycle (years)	7	Replace on 7th year after warranty expires
Annual Subscriber Growth	2%	Based on ***FE*** historical / industry data
Annual Subscriber Attrition	1%	Based on ***FE*** historical / industry data
Annual Inflation Rate	3%	Based on ***FE*** historical / industry data
Annual System Technical Support	1%	Based on ***FE*** historical / industry data
Annual System Software Upgrades	2%	Based on ***FE*** historical / industry data

2.9.1.2 Microwave Radio System

In addition to the LMR specific assumptions above, ***FE*** made the following assumptions specific to the microwave system:

- Existing antennas, waveguide, dehydrators and DC power systems will be replaced
- All microwave radios will be all-indoor
- All links will be MHSB
- Assume 310 Mbps capacity for links between Figueroa, La Cumbre and Tepusquet because the paths occur on multiple rings
- Minimum of 155 Mbps capacity required on all other links
- T1 multiplexers not required for legacy traffic. Existing multiplexers will be used during the migration period
- Microwave equipment pricing is based on National Association of Procurement Officials (NASPO) contract. Vendors typically offer discounts beyond that pricing
- Leased T1 lines will be used for Buellton, Chumash Casino, Gaviota, Los Alamos, Los Olivos, Tanglewood, White Hills, Hwy 246 Tank, Fire Station 24, GATR, IV Foot Patrol, Vic Trace and Purisima
- Spare equipment: 10% of total equipment cost
- Test equipment: 2% of total equipment cost

2.9.1.3 Site Development

The conceptual design leverages existing sites to the greatest extent possible. Site modifications recommended below are based on the site visits conducted by ***FE*** and input from the County. Except for the Comm Center, ***FE*** identified no major issues that would prevent the re-use of those sites for the new systems. Because some sites are of older construction, the costs for each alternative may include the following items, based on site survey results and County feedback:

- Grounding/electrical improvements for shelters and/or towers

- Potential upgrades to backup generator and/or UPS, and replacement of all DC power systems
- Structural analysis by a California Registered Professional Engineer for all existing towers
- Vendor-provided project management, engineering and installation

Based on site survey results and County feedback, ***FE*** included cost estimates for a new tower and/or shelter at sites identified as requiring one or both of the structures:

- A new tower, including site work, concrete, steel and electrical
- A new pre-fabricated shelter, including site work, concrete, and electrical
- Vendor-provided project/construction management, engineering and installation

FE included FCC licensing and coordination fees for new LMR and microwave licenses required at sites not on the existing systems.

Table 14 is a summary of site-related assumptions for all three LMR system upgrade alternatives.

Table 14 – Site Improvement Assumptions

Site	Name	Tower Analysis	Site Renovations	New Tower	New Shelter	New Generator and Fuel Tank	New Uninterruptible Power Supply	Architecture and Engineering	Backhaul Requirement	Site Acquisition Cost
1	Primary Core									
2	Secondary Core									
3	Buellton Sheriff	X	X	X	X	X	X	X	X	
4	Chumash Casino (PG)								X	
5	Chumash Casino (Hotel)								X	
6	Sheriff Dispatch			X				X		
7	Fire Dispatch	X	X	X	X	X	X	X	X	X
8	Foster	X	X							
9	Gaviota			X	X	X	X	X	X	
10	Harris Grade	X	X							
11	La Cumbre Peak			X	X	X		X		
12	Los Alamos									
13	Los Olivos (No growth potential)									

Site	Name	Tower Analysis	Site Renovations	New Tower	New Shelter	New Generator and Fuel Tank	New Uninterruptible Power Supply	Architecture and Engineering	Backhaul Requirement	Site Acquisition Cost
14	Mount Solomon									
15	Plowshare									
16	Rincon									
17	San Antonio	X	X	X				X	X	
18	Santa Ynez			X	X	X	X	X	X	
19	Solvang									
20	Sudden								X	
21	Tanglewood (No growth potential)									
22	Tepusquet	X				X	X		X	
23	White Hills	X							X	
24	Valley Peak			X	X	X	X	X	X	
25	Mt. Abel	X	X	X		X	X	X	X	X
26	Figueroa		X	X	X	X	X	X	X	X
27	Hwy 246 Tank			X	X	X	X	X	X	
28	Fire Station 24		X	X	X	X	X	X	X	
29	GATR								X	
30	Courthouse	X	X					X	X	
31	Betteravia Building		X					X	X	
32	Lompoc Civic Center		X						X	
33	IV Foot Patrol			X	X	X	X	X	X	
34	Vic Trace									
35	Purisima								X	

The cost estimates include architecture and engineering (A&E) and environmental compliance for any site that requires installation of new towers and/or shelters. The cost estimates also include $2,200,000 for site acquisition costs, based the list of sites and estimated cost provided by the County.

The location of the primary and secondary core have not been chosen yet, but based on input from the County, ***FE*** assumed that the primary and backup control/core equipment will be installed at one of the other sites listed in Table 14, Sheriff Dispatch will remain in its existing location and Fire Dispatch will require a new facility.

2.9.2 Fire System

Table 15 summarizes the estimated costs for the Fire radio system equipment and services.

Table 15 – Fire System Cost Estimate

Alternative 1 Fire System Cost Estimate			
Primary Control Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	6	$16,000	$96,000
Networking Equipment	1	$37,000	$37,000
Subtotal			**$239,000**
Backup Control Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	6	$16,000	$96,000
Networking Equipment	1	$37,000	$37,000
Subtotal			**$239,000**
Remote RF Site Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
6-CH Tx/Rx Simulcast Equipment	16	$107,000	$1,712,000
6-CH Receive-Only Equipment	7	$38,000	$266,000
1-CH Tx/Rx Simulcast Equipment	1	$18,000	$18,000
6-CH VHF Tx/Rx Antenna System	16	$30,000	$480,000
1-CH VHF Tx/Rx Antenna System	1	$22,000	$22,000
VHF RX-only Antenna System	7	$14,000	$98,000
Site Networking Equipment	24	$13,000	$312,000
Subtotal			**$2,908,000**
Equipment Subtotal			**$3,386,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	31		$6,000
LMR Frequency Coordination Fees	31		$11,000
LMR Engineering Services Fees	31		$6,000
Subtotal			**$23,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$170,000
Santa Barbara Sales Tax	8.75%		$297,000
Project Management	10%		$339,000
Installation	10%		$339,000
Engineering	10%		$339,000
Removal of Existing Equipment	2%		$68,000
Training	1%		$34,000

Alternative 1 Fire System Cost Estimate			
Staging	5%		$170,000
Acceptance Testing	1%		$34,000
Documentation	1%		$34,000
Contingency	10%		$339,000
Subtotal			**$2,163,000**
Services Total			**$2,186,000**
Equipment and Services Total			**$5,572,000**

2.9.3 Sheriff System

Table 16 summarizes the estimated costs for the Sheriff UHF equipment and implementation services.

Table 16 – Sheriff System Cost Estimate

Alternative 1 Sheriff System Cost Estimate			
Primary Control Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	2	$32,000	$64,000
Networking Equipment	1	$37,000	$37,000
Subtotal			**$207,000**
Backup Control Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	2	$32,000	$64,000
Networking Equipment	1	$37,000	$37,000
Subtotal			**$207,000**
Remote RF Site Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
4-CH Tx/Rx Simulcast Equipment	2	$133,000	$266,000
3-CH Tx/Rx Simulcast Equipment	16	$114,000	$1,824,000
3-CH Receive-Only Equipment	8	$26,000	$208,000
1-CH Tx/Rx Simulcast Equipment	1	$46,000	$46,000
UHF Tx/Rx Antenna System	19	$11,000	$209,000
UHF Rx-only Antenna System	8	$7,000	$56,000
Site Networking Equipment	27	$13,000	$351,000
Subtotal			**$2,960,000**
Equipment Subtotal			**$3,374,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	25		$19,000

Alternative 1 Sheriff System Cost Estimate			
LMR Frequency Coordination Fees	25		$19,000
LMR Engineering Services Fees	25		$19,000
Subtotal			**$57,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$169,000
Santa Barbara Sales Tax	8.75%		$296,000
Project Management	10%		$338,000
Installation	10%		$338,000
Engineering	10%		$338,000
Removal of Existing Equipment	2%		$68,000
Training	1%		$34,000
Staging	5%		$169,000
Acceptance Testing	1%		$34,000
Documentation	1%		$34,000
Contingency	10%		$338,000
Subtotal			**$2,156,000**
Services Total			**$2,213,000**
Equipment and Services Total			**$5,587,000**

2.9.4 LG System

Table 17 summarizes the estimated costs for the LG radio system equipment and services.

Table 17 – LG System Cost Estimate

Alternative 1 LG System Cost Estimate			
Primary Control Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	1	$32,000	$32,000
Networking Equipment	1	$37,000	$37,000
Subtotal			**$175,000**
Backup Control Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	1	$32,000	$32,000
Networking Equipment	1	$37,000	$37,000
Subtotal			**$175,000**
Remote RF Site Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
2-CH Tx/Rx Simulcast Equipment	11	$83,000	$913,000

Alternative 1 LG System Cost Estimate			
2-CH Receive-Only Equipment	2	$18,000	$36,000
800 MHz Tx/Rx Antenna System	11	$22,000	$242,000
800 MHz Rx-only Antenna System	2	$17,000	$34,000
Site Networking Equipment	13	$13,000	$169,000
Subtotal			**$1,394,000**
Equipment Subtotal			**$1,744,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	6		$3,000
LMR Frequency Coordination Fees	6		$3,000
LMR Engineering Services Fees	6		$3,000
Subtotal			**$9,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$88,000
Santa Barbara Sales Tax	8.75%		$153,000
Project Management	10%		$175,000
Installation	10%		$175,000
Engineering	10%		$175,000
Removal of Existing Equipment	2%		$35,000
Training	1%		$18,000
Staging	5%		$88,000
Acceptance Testing	1%		$18,000
Documentation	1%		$18,000
Contingency	10%		$175,000
Subtotal			**$943,000**
Services Total			**$952,000**
Equipment and Services Total			**$2,696,000**

2.9.5 EMS System

Table 18 summarizes the estimated costs for the EMS system equipment and services.

Table 18 – Alternative 1 EMS Cost Estimate

EMS UHF Radio System Cost Estimate			
Remote RF Site Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
MED5 UHF Repeater	1	$46,000	$46,000
MED6 UHF Repeater	1	$46,000	$46,000
MED7 UHF Repeater	1	$46,000	$46,000
MED8 UHF Repeater	1	$46,000	$46,000
UHF Antenna System	4	$7,000	$28,000

EMS UHF Radio System Cost Estimate			
Subtotal			**$212,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$11,000
Santa Barbara Sales Tax	8.75%		$19,000
Project Management	10%		$22,000
Installation	10%		$22,000
Engineering	10%		$22,000
Removal of Existing Equipment	2%		$5,000
Training	1%		$3,000
Staging	5%		$11,000
Acceptance Testing	1%		$3,000
Documentation	1%		$3,000
Contingency	10%		$22,000
Services Total			**$143,000**
Equipment and Services Total			**$355,000**

2.9.6 Microwave System

Table 19 provides the estimated costs for the microwave system equipment and services.

Table 19 – Alternative 1 Microwave Cost Estimate

Microwave System Cost Estimate			
Microwave Equipment	*Qty*	*Unit Cost*	*Extended Cost*
Radios			
6 GHz Hot Standby Radio	36	$30,000	$1,080,000
11 GHz Hot Standby Radio	12	$30,000	$360,000
Subtotal - Radios	**48**		**$1,440,000**
Antennas			
6 GHz - 6' Dual-Polarization	32	$9,500	$304,000
11 GHz - 4' Dual-Polarization	14	$4,500	$63,000
Subtotal - Antennas	**46**		**$367,000**
Coaxial Cable, Waveguide and Accessories			
Waveguide and Accessories	46	$5,000	$230,000
Subtotal - Coax/Waveguide	**46**		**$230,000**
DC Plant			
Large	3	$20,000	$60,000
Medium	3	$10,000	$30,000
Small	13	$7,000	$91,000
Subtotal - DC Plant	**19**		**$181,000**

Microwave System Cost Estimate			
Equipment Rack and Accessories			
Large	3	$10,000	$30,000
Medium	3	$7,500	$22,500
Small	13	$5,000	$65,000
Subtotal - Equipment Rack	**19**		**$117,500**
T1 Multiplexers			
Large	2	$12,000	$24,000
Small	6	$8,000	$48,000
Subtotal - T1 Multiplexers	**8**		**$72,000**
MPLS Router			
Large	3	$30,000	$90,000
Medium	3	$25,000	$75,000
Small	13	$20,000	$260,000
Subtotal - MPLS Router	**19**		**$425,000**
Timing System	1	$ 15,000	**$15,000**
Dehydrator	19	$3,500	**$66,500**
Total - Microwave Equipment			**$2,914,000**
Spares	10%		**$292,000**
Test Equipment	2%		**$59,000**
Services			
FCC Licensing			
FCC License Coordination	24	$1,700	$40,800
FCC License	48	$1,200	$57,600
Sales Tax	8.75%		$255,000
Training	1%		$30,000
Project Management	10%		$292,000
Installation	10%		$292,000
Engineering	10%		$292,000
Removal of Old Equipment	2%		$59,000
Staging	5%		$146,000
Acceptance Testing	1%		$30,000
Documentation	1%		$30,000
Contingency	10%		$292,000
Subtotal - Services			**$1,817,000**
TOTAL			**$5,082,000**

FE developed the microwave radio system conceptual design based on computer-based radio path profiles and calculations. ***FE*** did not perform physical radio path surveys. The RFP will include a requirement for the vendor to perform physical path surveys and final system design, which could impact the cost of the microwave radio system upgrade.

2.9.7 Network Management System

Table 20 summarizes the estimated costs for the NMS equipment and services.

Table 20 – NMS Cost Estimate

Network Management System Cost Estimate			
Primary NMS Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Network Management Server	1	$201,000	$201,000
Network Management Terminal	2	$24,000	$48,000
Fault Management Server	1	$60,000	$60,000
Fault Management Site	25	$10,000	$250,000
Subtotal			**$559,000**
Backup NMS Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Network Management Server	1	$201,000	$201,000
Fault Management Server	1	$60,000	$60,000
Subtotal			**$261,000**
Equipment Subtotal			**$820,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$41,000
Santa Barbara Sales Tax	8.75%		$72,000
Project Management	10%		$82,000
Installation	10%		$82,000
Engineering	10%		$82,000
Removal of Existing Equipment	2%		$17,000
Training	1%		$9,000
Staging	5%		$41,000
Acceptance Testing	1%		$9,000
Documentation	1%		$9,000
Contingency	10%		$82,000
Services Total			**$526,000**
Equipment and Services Total			**$1,346,000**

2.9.8 Site Improvements

Table 21 summarizes the estimated costs for site improvements and services.

Table 21 – Site Improvements Cost Estimate

Alternative 1 Site Improvements Cost Estimate			
Site Improvements	*Quantity*	*Unit Cost*	*Extended Cost*
Tower Structural Analysis	9	$5,000	$45,000
Existing Site Renovations	9	$15,000	$135,000
New Self-Supported Tower	12	$283,000	$3,396,000
New Prefabricated Shelter	10	$109,000	$1,090,000
Generator/Transfer switch/fuel tank	12	$30,000	$360,000
UPS (20 KVA 208V 2-hour runtime)	11	$30,000	$330,000
A&E, Environmental Compliance	12	$14,000	$168,000
Subtotal			**$5,524,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$277,000
Santa Barbara Sales Tax	8.75%		$484,000
Project Management	10%		$553,000
Installation	10%		$553,000
Engineering	10%		$553,000
Removal of Existing Equipment	2%		$111,000
Training	1%		$56,000
Staging	5%		$277,000
Acceptance Testing	1%		$56,000
Documentation	1%		$56,000
Contingency	10%		$553,000
Subtotal			**$3,529,000**
Site Acquisition Cost	3		$2,200,000
Equipment and Services Total			**$11,253,000**

2.9.9 Dispatch System

Table 22 summarizes the estimated costs for the dispatch system equipment and services.

Table 22 – Dispatch System Cost Estimate

Dispatch System Cost Estimate			
Sheriff Dispatch	*Quantity*	*Unit Cost*	*Extended Cost*
Logging Recorder System	1	$175,000	$175,000
Dispatch Console Position	10	$48,000	$480,000
Backup RF Control Station	10	$6,000	$60,000
Interoperability Control Station	4	$8,000	$32,000
Control Station Antenna System	2	$18,000	$36,000
Conventional Channel Gateway	10	$7,000	$70,000
Networking Equipment	1	$13,000	$13,000
Subtotal			**$866,000**
Equipment Subtotal			**$866,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$44,000
Santa Barbara Sales Tax	8.75%		$76,000
Project Management	10%		$87,000
Installation	10%		$87,000
Engineering	10%		$87,000
Removal of Existing Equipment	2%		$18,000
Training	1%		$9,000
Staging	5%		$44,000
Acceptance Testing	1%		$9,000
Documentation	1%		$9,000
Contingency	10%		$87,000
Services Total			**$557,000**
Sheriff Dispatch Total			**$1,423,000**
Fire Dispatch	*Quantity*	*Unit Cost*	*Extended Cost*
Dispatch Equipment (Same as Sheriff)	1	$866,000	$866,000
Implementation Services (Same as Sheriff)	1	$557,000	$557,000
Subtotal			**$1,423,000**
Sheriff and Fire Dispatch Total			**$2,846,000**

2.9.10 Subscriber Equipment

Table 23 summarizes the estimated costs for subscriber equipment and services.

Table 23 – Alternative 1 Subscriber Equipment Cost Estimate

Alternative 1 Subscriber Equipment Cost Estimate			
Subscriber Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	658	$4,000	$2,632,000
Portable Radios	736	$3,500	$2,576,000
Control Stations	44	$5,500	$242,000
Subtotal (Rounded)			**$5,450,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Radio Programming	1438	$100	$143,800
Radio Installation	702	$200	$140,400
Subtotal (Rounded)			**$285,000**
Equipment and Services Total			**$5,735,000**
Contingency	10%		$574,000
Total (with Contingency)			**$6,309,000**

Appendix A includes a detailed breakdown of each departments subscriber unit costs.

2.9.11 Cost Summary

Table 24 summarizes the total cost for Alternative 1, including LMR, microwave, NMS, dispatch, subscribers, and site improvements.

Table 24 – Alternative 1 Total Cost Estimate

Alternative 1 Total Cost Estimate			
Item	*Equipment*	*Services*	*Total Cost*
Fire VHF Radio System	$3,386,000	$2,186,000	$5,572,000
Sheriff UHF Radio System	$3,374,000	$2,213,000	$5,587,000
LG 800 MHz Radio System	$1,744,000	$952,000	$2,696,000
EMS UHF Radio System	$212,000	$143,000	$355,000
Digital Microwave System	$3,265,000	$1,817,000	$5,082,000
Network Management System	$820,000	$526,000	$1,346,000
Site Civils / Improvements	$5,524,000	$3,529,000	$9,053,000
Site Acquisition Cost	$0	$2,200,000	$2,200,000
Sheriff Dispatch	$866,000	$557,000	$1,423,000
Fire Dispatch	$866,000	$557,000	$1,423,000
Subscriber Equipment	$5,450,000	$859,000	$6,309,000
Total	**$25,507,000**	**$15,539,000**	**$41,046,000**

2.9.12 Operational Costs

Table 25 summarizes the 15-year operational cost estimate for Alternative 1. It is important to note that the estimate does not include any current operational expenses such as LMR and microwave system maintenance contracts, site maintenance, site leases, staff salaries, or other recurring expenditures. The cost estimate includes only the new LMR, microwave, NMS, dispatch center, and subscriber equipment that are part of each alternative.

Table 25 – Alternative 1 15-Year Operational Cost Estimate

Alternative 1 Operating Costs Estimate					
Operating Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Technical Support	$0	$0	$0	$377,000	$389,000
Software/Hardware Upgrades	$0	$0	$0	$754,000	$777,000
Subscriber Growth	$0	$133,000	$135,000	$139,000	$141,000
Subscriber Attrition	$0	$68,000	$68,000	$68,000	$70,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$0**	**$201,000**	**$203,000**	**$1,338,000**	**$1,377,000**
Operating Costs	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Technical Support	$401,000	$414,000	$427,000	$440,000	$454,000
Software/Hardware Upgrades	$801,000	$826,000	$851,000	$877,000	$904,000
Subscriber Growth	$144,000	$148,000	$150,000	$153,000	$156,000
Subscriber Attrition	$70,000	$71,000	$71,000	$72,000	$73,000
Subscriber Refresh	$0	$0	$0	$0	$6,309,000
Estimated Annual Cost	**$1,416,000**	**$1,459,000**	**$1,499,000**	**$1,542,000**	**$7,896,000**
Operating Costs	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
Technical Support	$468,000	$483,000	$498,000	$513,000	$529,000
Software/Hardware Upgrades	$932,000	$960,000	$989,000	$1,019,000	$1,050,000
Subscriber Growth	$158,000	$162,000	$166,000	$169,000	$173,000
Subscriber Attrition	$73,000	$75,000	$75,000	$75,000	$76,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$1,631,000**	**$1,680,000**	**$1,728,000**	**$1,776,000**	**$1,828,000**

2.10 Migration Strategy

2.10.1 General

LMR and microwave radio systems the size and complexity of the County's require a migration plan that minimizes cost and disruption to operations during the migration of radios and consoles. System migration and cutover from existing to new system(s) is even more challenging when the frequencies from the existing systems are reused in the new systems. In addition, migration plans vary by vendor due to design, technology, and

experience. The County should ensure that the awarded vendor develop and follow a thorough migration plan that is logical and considers every facet of the existing and new systems.

The migration plan is one of the most critical components of the overall project. As such, the plan should outline the appropriate steps to avoid or minimize downtime during migration. The plan should include major tasks, dependencies, and appropriate duration for each task. Tasks include detailed design, installation, optimization, training, cutover and burn-in, and decommissioning of legacy systems. The vendor should develop their proposed migration plan with the following objectives in mind:

- Maintaining reliable and stable mission critical communications
- Timely deployment of a complete, functional LMR and backhaul network
- Identification of physical and technical constraints that must be considered for successful implementation planning such as site ownership, shelter space, tower loading and availability, and electrical load limitations
- Successful integration with existing systems, including a smooth transition from existing operations
- Minimize operational impact for users during migration of sites, microwave interconnection, dispatch operations, and user radio equipment
- Clearly defined roles and responsibilities between the vendor and County
- Development of fleet maps and communicating to the County the impact of new technology to current operations such as talkgroups and other digital system features
- Training for all field users, dispatch operators, and system administrators and service personnel

The County should review the awarded vendor's migration plan, provide feedback, and approve a final version during or following the detailed design phase. The plan should adhere to parameters that address and mitigate issues discovered during due diligence and design planning while preserving enough flexibility to allow for creativity. The plan should demonstrate that it meets the following requirements:

- Supports the operational requirements of the County departments, including but not limited to:

  - Administrative use
  - Day-to-day operations
  - Emergency response
  - Catastrophic incidents
  - Special events

- Ensures system users and technical staff are prepared for the migration to the new system(s)
- Includes risk mitigation, including but not limited to back-up, fallback, and other outage avoidance techniques
- Places responsibility for obtaining any additional frequencies, equipment, or facilities required to support the migration on the awarded vendor
- Provides for the maintenance or replacement of current gateways or other interfaces (as applicable) to prevent loss of interoperability during migration
- Requires that the vendor carefully orchestrate user radio reprogramming to minimize operational disruption and unnecessary expense of overtime due to the difficulty of scheduling the availability of users

Some public safety agencies may encounter issues that are unique to their frequency band or operating procedures. However, most issues would be common for all public safety agencies, such as scheduling, coordination, space limitations, changes in operations, training, and defining roles and responsibilities. It is important to note that the above guidelines are simply a framework for what the potential vendors are to provide with their proposed designs. The County and ***FE*** can develop more detailed RFP migration requirements, specifying what the vendor shall adhere to during implementation and migration to the new systems.

2.10.2 Fire VHF Migration

The Fire VHF system migration would require Fire to shift traffic on the Fire 1 channel to the Fire 2 channel while the new equipment is installed on the Fire 1 channel. Traffic would be moved back to the Fire 1 channel when the new equipment is installed and tested. The migration of the Fire 6 channel would follow the same procedure. Fire 2 through 5 channels would be unavailable while the new equipment is installed and tested, however, the impact to operations would be minimal because these channels are used

on an as-needed basis. These channels could be migrated one at a time to minimize the number of unavailable channels.

As part of the VHF system expansion, the conceptual design includes the following six new sites:

- Mt. Abel: standalone, 2 VHF channels
- Valley Peak: standalone, 2 VHF channels
- GATR: simulcast, 1 VHF channel
- Figueroa: simulcast, 6 VHF channels
- Highway 246 Tank: simulcast, 6 VHF channels
- Fire Station 24: simulcast, 6 VHF channels

The new sites would operate in analog conventional mode; four would be simulcast and two would be standalone sites as noted. Located outside of the existing simulcast coverage footprint, Mt. Abel and Valley Peak exceed the typically accepted distance for site separation in a simulcast configuration. Attempting to include them in the simulcast cell may lead to potential interference when roaming between sites. ***FE*** suggests that the County include a requirement in the RFP that vendors evaluate the ability to establish Mt. Abel and Valley Peak as simulcast sites, with standalone being the fallback if potential interference issues cannot be resolved.

FE conducted a search of the FCC database and identified only two VHF channels that the County could potentially license for these standalone sites. The sites would be configured with new frequency pair(s), requiring FCC licensing and coordination. When entering the footprint of these sites, the users would need to manually switch to the new channels on their portable and/or mobile radios. Given the large distance and terrain between the sites, frequencies at Mt. Abel could potentially be re-used at Valley Peak. At either of these sites, Dispatch could patch the channels to the simulcast cell or the channels could be operated locally, independent of the simulcast channels.

GATR was added specifically to cover the Jalama Beach area and would require only a single simulcast channel.

Licensing the six simulcast VHF channels at Figueroa, Highway 246 Tank and Fire Station 24 should not be an issue due to exclusive use of currently licensed frequencies within the existing simulcast footprint. FCC licensing and coordination for all other existing Fire VHF sites would not be necessary given they would remain analog conventional with no added capacity. Based on the conceptual design, migration to the new Fire VHF

system would require the following major tasks, with the first four tasks common for all County radio systems:

- Replace the Comm Center as a primary control site, with implementation of a geo-redundant backup control site (both locations to be determined)
- Site readiness, including but not limited to improvements to site grounding, backup generator(s), shelter/equipment rooms, and towers (in compliance with TIA-222, latest revision)
- Procuring and deploying infrastructure equipment to replace the existing dispatch equipment, including logging recorder, dispatch consoles, RF control stations, and implementation of a backup dispatch center (location to be determined)
- Procuring and deploying infrastructure equipment to replace and expand the existing network management system
- FCC licensing and coordination for additional VHF channels proposed at new simulcast and standalone sites
- Procuring and deploying infrastructure equipment to replace and expand the existing Fire VHF system
- Procuring and deploying replacement subscriber radios for Fire and any other agency that may use the Fire VHF system
- Complete coverage testing per requirements to be specified in the RFP
- Complete technical and operator training, with the latter being as close to cutover as possible
- Preliminary acceptance and functional testing of the new Fire VHF system and subscriber equipment
- Migration and cutover of VHF radio users, by user groups, from the existing Fire VHF system to the new expanded system
- Final testing and acceptance of new Fire VHF system
- Finalize system and project documentation
- Decommissioning of the existing Fire VHF system

- Punch list resolution and project closeout

It is important to note that other Fire agencies and interoperability partners would need to re-program their radios to include the new simulcast and standalone sites on the Fire VHF system.

2.10.3 Sheriff UHF Migration

The UHF migration is somewhat unique in that two additional channels would be added to the existing 2-channel system, one for the North County service area and one for the South County service area. While the system may be viewed as a “4-channel system”, most sites would be equipped with three UHF channels (sites on the border between the North and South service areas would have both the North and South channels). Although limited UHF frequency availability exists, finding and licensing additional UHF channels may be less challenging than with the VHF system.

The addition of a new channel in the North and South County can make the UHF migration smoother. The awarded vendor can install and move traffic to the new North and South County channels, replace the existing Ops 1 and Ops 2 channels, and move traffic back to Ops1 and Ops 2 channels once installed. The UHF migration plan would depend on the awarded vendor design, technology and experience. The County should be cognizant of the potential for temporary removal of UHF channel(s) from service during the migration of the existing system to the new system. This can cause increased loading on the existing system until all subscriber units can be migrated to the new system.

As part of the UHF coverage and channel capacity expansion, the conceptual design includes the following new sites:

- Mt. Abel: standalone, 3 UHF channels
- Valley Peak: standalone, 3 UHF channels
- GATR: simulcast, 1 UHF channel
- Figueroa: simulcast, 3 UHF channels
- Highway 246 Tank: simulcast, 3 UHF channels
- Fire Station 24: simulcast, 3 UHF channels

Four of the new sites would be simulcast, and two would be standalone sites as noted. Located outside of the existing simulcast footprint, Mt. Abel and Valley Peak exceed the typically accepted distance for site separation in a simulcast configuration. Therefore, these two sites would be standalone as attempting to include them in the simulcast cell may lead to potential interference when roaming between sites. As with the Fire VHF

system, ***FE*** suggests that the County include a requirement in the RFP that the vendor evaluate the ability to establish Mt. Abel and Valley Peak as simulcast sites, with standalone being the fallback if potential interference issues cannot be resolved.

Although limited channel availability exists, licensing new UHF channels should not be an issue. The standalone sites would be configured with new frequency pairs, requiring FCC licensing and coordination and possibility letters of concurrence with other agencies.

Unlike the Fire VHF system, the Sheriff UHF system would transition from analog to P25 Phase 1 digital operation. The system would still operate in conventional mode, requiring a RF channel for each voice transmission. Roaming in and out of the simulcast and standalone coverage footprints would require users to manually switch channels on their portable and/or mobile radios. Given the large distance and terrain between the sites, UHF frequencies at Mt. Abel can potentially be re-used at Valley Peak. At either of these sites, Dispatch can patch the standalone UHF channels to the simulcast cell or the standalone channels can operate locally, independent of the simulcast channels.

GATR was added specifically to cover the Jalama Beach area and would require only a single simulcast channel.

Licensing the three simulcast UHF channels at Figueroa, Highway 246 Tank and Fire Station 24 should not be an issue, given two are currently licensed frequencies within the existing simulcast footprint. However, FCC licensing and coordination would be necessary to add the new UHF channel and change the emission designator at all proposed sites. Based on the conceptual design, migration to the new Sheriff UHF system would require the following major tasks, with the first four tasks common for all County radio systems:

- Replace the Comm Center as a primary control site, with implementation of a geo-redundant backup control site (both sites to be determined)
- Site readiness, including but not limited to improvements to site grounding, backup generator(s), shelter/equipment rooms, and towers (in compliance with TIA-222, latest revision)
- Procuring and deploying infrastructure equipment to replace the existing dispatch equipment, including logging recorder, dispatch consoles, RF control stations, and implementation of a backup dispatch center (location to be determined)
- Procuring and deploying infrastructure equipment to replace and expand the existing network management system

- FCC licensing and coordination for an additional UHF frequency pair at existing sites and three new frequency pairs at proposed new sites; sites on the border between the North and South service areas (i.e. Santa Ynez and La Cumbre) would require both new channels
- Procuring and deploying infrastructure equipment to replace and expand the existing Sheriff UHF system
- Procuring and deploying the remaining radios for Sheriff and any other agency that may use the Sheriff UHF system
- Complete coverage testing per requirements to be specified in the RFP
- Complete technical and operator training, with the latter being as close to cutover as possible
- Preliminary acceptance and functional testing of the new Sheriff UHF system and subscriber equipment
- Migration and cutover of UHF radio users, by user groups, from the existing system to the new Sheriff UHF system
- Final testing and acceptance of new Sheriff UHF system
- Finalize system and project documentation
- Decommissioning of the existing Sheriff UHF system
- Punch list resolution and project closeout

There has been some discussion on the potential for using the Med 10 channel as an additional UHF channel on the Sheriff UHF system. However, this channel is currently a State channel that would need to be vacated by EMS and licensed by the County.

2.10.4 LG 800 MHz Migration

The LG 800 MHz system migration includes transitioning the users from an analog conventional simulcast system to a P25 Phase 1 digital conventional simulcast system. While the conceptual design does not include added capacity, new sites are included to address coverage deficiencies reported by the users. Based on 800 MHz frequency availability, finding and licensing 800 MHz channels at the new sites should not be as difficult as VHF.

There are a couple options that the County and awarded vendor have regarding the LG system migration. Finding and licensing temporary frequency pair(s) would make the migration smoother. The awarded vendor could install and move traffic to the temporary channel(s), replace the existing channels, and move traffic back to the County channel(s) once installed. Alternatively, the vendor can move all traffic to one of the LG channels and replace the other LG channel equipment. The vendor would then move all traffic to the new LG channel equipment (operating in analog mode) and replace the other old LG channel equipment. Once replacement of both channels is complete, the vendor and County could cutover users to digital operation. Like the Sheriff UHF system, the LG system would be transitioned from analog to P25 Phase 1 digital operation. Because the system would still operate in conventional mode, there would be no added capacity with this transition. Therefore, the latter option may not be desirable as it would have a significant (but temporary) impact on channel congestion.

As with the other systems, the LG migration plan would depend on the awarded vendor design, technology and experience. The County should be cognizant of the potential for temporary removal of existing 800 MHz channel(s) from service during the migration of the existing system to the new system. This can cause temporary increased loading on the existing system, until all subscriber units can migrate to the new system. As part of the 800 MHz coverage expansion, the conceptual design includes the following new sites:

- Mt. Abel: standalone, two 800 MHz channels
- Gaviota: simulcast, two 800 MHz channels
- San Antonio: simulcast, two 800 MHz channels

Two of the new sites would be simulcast, and one would be standalone as noted. Located outside of the existing simulcast footprint, Mt. Abel exceeds the typically accepted distance for site separation in a simulcast configuration. Therefore, this site would be standalone to avoid potential interference when roaming to and from the simulcast cell. As with the Fire and Sheriff systems, ***FE*** suggests that the County include a requirement in the RFP that the vendor evaluate the ability to establish Mt. Abel as simulcast site, with standalone being the fallback if potential interference issues cannot be resolved.

The County would have to coordinate with the Southern California 800 MHz Regional Planning Committee for Region 5 for additional frequencies (channels). The standalone site would be configured with new frequency pairs, requiring FCC licensing and coordination. Adding Gaviota and San Antonio, as well as changing emission designators, would require FCC licensing and coordination.

As with the UHF digital system, roaming between the simulcast and standalone coverage footprints does require that users manually switch to the new channels on their portable and/or mobile radios. As with the VHF and UHF standalone configurations, Dispatch can patch the standalone channel at Mt. Abel to the simulcast cell or operate the channel locally, independent of the simulcast channels. Based on the conceptual design, migration to the new LG 800 MHz system would require the following major tasks, with the first four tasks common for all County radio systems:

- Replace the Comm Center as a primary control site, with implementation of a geo-redundant backup control site (both sites to be determined)
- Site readiness, including but not limited to improvements to site grounding, backup generator(s), shelter/equipment rooms, and towers (in compliance with TIA-222, latest revision)
- Procuring and deploying infrastructure equipment to replace the existing dispatch equipment, including logging recorder, dispatch consoles, RF control stations, and implementation of a backup dispatch center (location to be determined)
- Procuring and deploying infrastructure equipment to replace and expand the existing network management system
- FCC licensing and coordination for two new 800 MHz channels at proposed new sites
- Procuring and deploying infrastructure equipment to replace and expand the existing LG 800 MHz system
- Procuring and deploying new radios for agencies that use the LG 800 MHz system
- Complete coverage testing per requirements to be specified in the RFP
- Complete technical and operator training, with the latter being as close to cutover as possible
- Preliminary acceptance and functional testing of the new LG 800 MHz system and subscriber equipment
- Migration and cutover of 800 MHz radio users, by user groups, from the existing system to the new LG system

- Final testing and acceptance of new LG 800 MHz system
- Finalize system and project documentation
- Decommissioning of the existing LG 800 MHz system
- Punch list resolution and project closeout

2.10.5 Microwave Backhaul Migration

The County will be upgrading the existing Public Safety Microwave Radio System from a Time Division Multiplex (TDM)-based system to an Internet Protocol (IP)/Multiprotocol Label Switching (MPLS) system to support the LMR system upgrade. The awarded LMR vendor and their microwave radio subcontractor will need to manage the migration of the Public Safety Microwave Radio System in conjunction with the LMR system migration while minimizing existing system downtime. The vendors migration approach must support existing TDM-based traffic and new IP/MPLS traffic during the migration period.

The new microwave backhaul design utilizes existing County microwave paths to the greatest extent possible, while adding paths for path redundancy and increased system reliability. All new paths and existing paths with channel bandwidths less than 30 MHz will require FCC licensing and coordination. The new paths can be migrated at any time during the implementation period, but the migration of the existing paths must be done in conjunction with turn up of LMR sites.

Based on the conceptual design, migration to the new IP/MPLS microwave radio system will require the following major tasks:

- Site readiness, including but not limited to improvements to site grounding, site AC power (i.e. generators), shelter/equipment rooms, and towers (in compliance with TIA-222, latest revision)
- Procuring and deploying RF infrastructure equipment to replace and expand the existing backhaul system
- FCC licensing and coordination for 6 and 11 GHz channels for proposed new paths and to upgrade existing path licenses to 30 MHz channels, as needed
- Complete technical and operator training, with the latter being as close to cutover as possible

- Preliminary acceptance and functional testing of the new IP/MPLS microwave radio system
- Cutover of existing TDM-based circuits to support the existing LMR systems during the migration to the new systems(s)
- Final testing and acceptance
- Finalize system documentation
- Decommission existing paths, as needed
- Punch list resolution and project closeout

2.11 Project Implementation Schedule

Following is the implementation schedule for the upgrade of the County's LMR and Public Safety Microwave Radio System, showing the projected sequence and duration of tasks and the dependencies between the tasks, following the migration strategy in Section 2.10.

2.11.1 Overall Project Implementation Schedule

Project implementation follows the delivery of this report, the *County of Santa Barbara Land Mobile and Microwave Radio Conceptual Design*. Figure 14 is the overall schedule, showing major project phases and timeframes, including the development of the RFP, system procurement and system implementation.

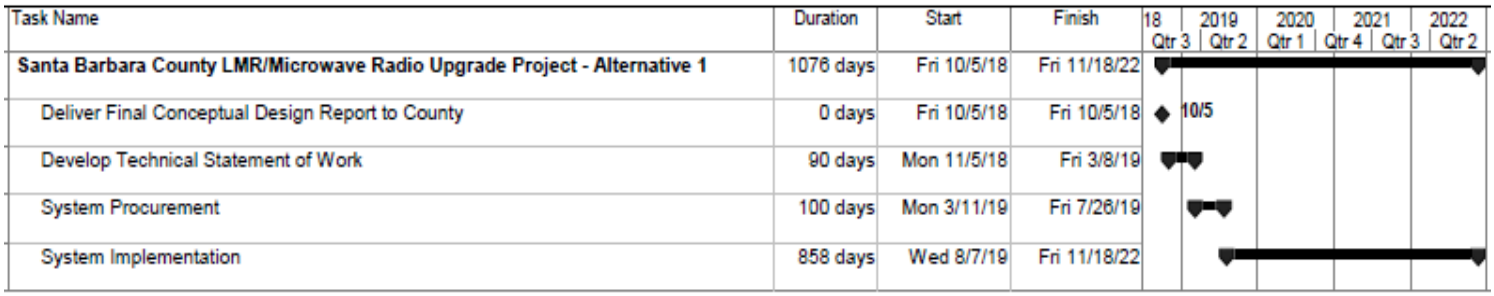

Figure 14 – Overall Implementation Schedule – Alternative 1

2.11.2 RFP Development Schedule

Figure 15 is a breakdown of the tasks required to produce the RFP, beginning with the development of the technical statement of work (SOW) and ending with the inclusion of the SOW into the County's RFP.

Task Name	Duration	Start	Finish
Santa Barbara County LMR/Microwave Radio Upgrade Project - Alternative 1	1076 days	Fri 10/5/18	Fri 11/18/22
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	90 days	Mon 11/5/18	Fri 3/8/19
Develop Draft Technical Specs	40 days	Mon 11/5/18	Fri 12/28/18
QC Review	5 days	Mon 12/31/18	Fri 1/4/19
Deliver Draft SOW to County	0 days	Fri 1/4/19	Fri 1/4/19
County Review of Draft SOW	10 days	Mon 1/7/19	Fri 1/18/19
Review Workshop with County	1 day	Wed 1/23/19	Wed 1/23/19
Develop Final SOW	17 days	Thu 1/24/19	Fri 2/15/19
Develop Vendor Scoresheet	17 days	Thu 1/24/19	Fri 2/15/19
Deliver Final SOW and Vendor Scoresheet	0 days	Fri 2/15/19	Fri 2/15/19
County Incorporates SOW into RFP	10 days	Mon 2/18/19	Fri 3/1/19
County Releases RFP	5 days	Mon 3/4/19	Fri 3/8/19
System Procurement	100 days	Mon 3/11/19	Fri 7/26/19
System Implementation	858 days	Wed 8/7/19	Fri 11/18/22

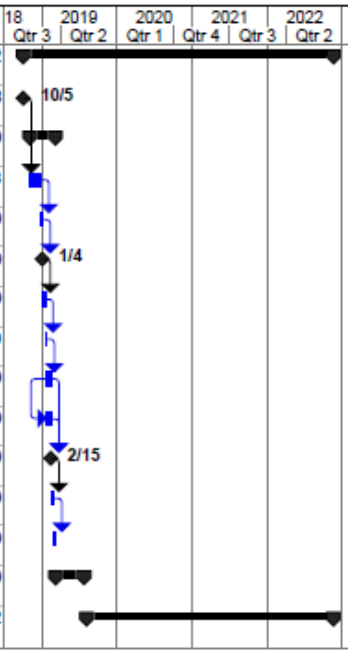

Figure 15 – RFP Development Schedule – Alternative 1

2.11.3 System Procurement Schedule

Figure 16 shows the tasks required to procurement the new LMR and microwave radio backhaul systems, beginning with the release of the RFP by the County and ending with a negotiated contract with the selected vendor.

Task Name	Duration	Start	Finish
Santa Barbara County LMR/Microwave Radio Upgrade Project - Alternative 1	1076 days	Fri 10/5/18	Fri 11/18/22
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	90 days	Mon 11/5/18	Fri 3/8/19
System Procurement	100 days	Mon 3/11/19	Fri 7/26/19
Pre-Bid Meeting/Site Visits	4 days	Tue 3/12/19	Fri 3/15/19
Respond to Bidder Questions	25 days	Mon 3/11/19	Fri 4/12/19
Bidder Proposal Development	40 days	Mon 3/11/19	Fri 5/3/19
Bidder Proposals Due	0 days	Fri 5/3/19	Fri 5/3/19
Vendor Proposal Review	20 days	Mon 5/6/19	Fri 5/31/19
Vendor Presentations	2 days	Wed 6/5/19	Thu 6/6/19
Evaluation Meeting	1 day	Fri 6/7/19	Fri 6/7/19
Vendor Selection	5 days	Mon 6/10/19	Fri 6/14/19
Vendor Contract Negotiation	30 days	Mon 6/17/19	Fri 7/26/19
Vendor Contract Execution	0 days	Fri 7/26/19	Fri 7/26/19
System Implementation	858 days	Wed 8/7/19	Fri 11/18/22

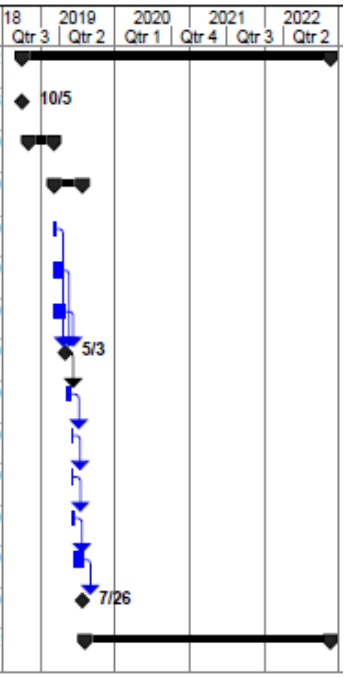

Figure 16 – System Procurement Schedule – Alternative 1

2.11.4 System Implementation Schedule

Figure 17 shows the tasks to be completed by the vendor, including detailed system design, equipment installation, final testing and system acceptance.

Task Name	Duration	Start	Finish
Santa Barbara County LMR/Microwave Radio Upgrade Project - Alternative 1	1076 days	Fri 10/5/18	Fri 11/18/22
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	90 days	Mon 11/5/18	Fri 3/8/19
System Procurement	100 days	Mon 3/11/19	Fri 7/26/19
System Implementation	858 days	Wed 8/7/19	Fri 11/18/22
Implementation Kickoff Meeting with Vendor	1 day	Wed 8/7/19	Wed 8/7/19
Detailed Design	185 days	Mon 8/19/19	Fri 5/1/20
Site Acquisition/Lease Agreements	120 days	Thu 8/8/19	Wed 1/22/20
Equipment Manufacture and Factory Staging	60 days	Mon 5/4/20	Fri 7/24/20
Factory Acceptance Testing	10 days	Mon 7/27/20	Fri 8/7/20
Package and Ship Equipment	10 days	Mon 8/10/20	Fri 8/21/20
Equipment Installation, Testing and Cutover	725 days	Mon 2/10/20	Fri 11/18/22
LMR and Microwave RF Site Improvements	190 days	Mon 2/10/20	Fri 10/30/20
Microwave System	100 days	Mon 11/2/20	Fri 3/19/21
Dispatch Centers	**25 days**	**Mon 8/24/20**	**Fri 9/25/20**
Fire VHF System	80 days	Mon 3/22/21	Fri 7/9/21
Sheriff UHF System	**175 days**	**Mon 7/12/21**	**Fri 3/11/22**
LG 800 MHz System	145 days	Mon 3/14/22	Fri 9/30/22
Coverage Testing	30 days	Mon 10/3/22	Fri 11/11/22
Final LG System Acceptance Test	5 days	Mon 11/14/22	Fri 11/18/22
LG System Accepted	0 days	Fri 11/18/22	Fri 11/18/22

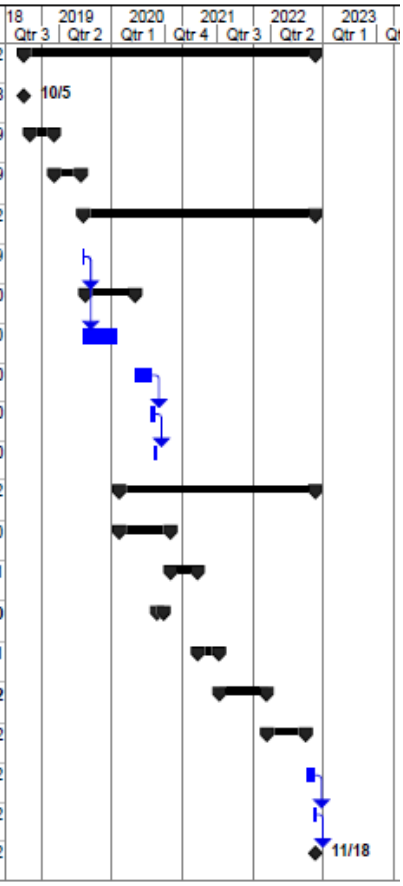

Figure 17 – System Implementation Schedule – Alternative 1

3. LMR Alternative 2 – UHF P25 Trunked Radio System

Alternative 2 includes the replacement of all existing equipment and the addition of radio sites and equipment to provide the required radio coverage for all current Fire, Sheriff, EMS and LG LMR systems users, as follows:

- Replace the existing two-channel Sheriff UHF system with a new four-channel UHF P25 digital trunked radio system for primary use by the Sheriff and all existing County LG system users (Fire and EMS would use it for interoperability communications, as needed) and for interoperability communications with other fire, law and emergency medical agencies in the County. Radio talkgroups would replace dedicated radio channels for intra-department, inter-department and interoperability communications needs using a common radio system, but still allowing each department to be autonomous, while improving the ability to interoperate, as needed

- Replace the existing six-channel Fire VHF conventional analog simulcast system with a new conventional analog simulcast system for primary use by Fire and EMS (EMS is moving operations to the Fire 1 channel) and for interoperability with other Local, County, State and Federal fire and EMS agencies. EMS communications with the hospitals will shift to the UHF trunked system

3.1 Radio Coverage Analysis

FE performed a computer-based radio coverage assessment to identify the specific sites and equipment required to meet the County's coverage requirements.

3.1.1 Required Coverage

Refer to Section 2.1.1 for a description of the required coverage area.

3.1.2 Methodology

Refer to Section 2.1.2 for a description of the methodology ***FE*** used to conduct the radio coverage analysis.

3.1.3 Radio Coverage Analysis Results – VHF Fire

The new Fire VHF system Alternative 2 is the same as Alternative 1. Refer to Section 2.2.1 for the coverage analysis results.

3.1.4 Coverage Analysis Results – Shared UHF Trunked System

FE modeled the UHF trunked system radio coverage assuming a digital P25 trunked simulcast system, with 12.5 kHz channel bandwidth and 12 dB building loss for in-inbuilding portable radio coverage (consistent with light-office/residential building loss at UHF).

3.1.4.1 Selected Radio Sites

Based on the results of the coverage study and input received from the County at the coverage workshop, ***FE*** developed the final list of sites needed to meet the County's coverage and design targets. When selecting sites, ***FE*** prioritized existing County, existing non-County and greenfield (i.e., brand new) sites, in order of preference.

Table 26 includes information for the sites selected for the UHF P25 trunked system and defines their simulcast configuration. Sites identified as "proposed new" in the Site Status column are sites which are currently not being used for any of the County LMR systems, but ***FE*** has included in the conceptual design for radio coverage improvement. Proposed new sites are highlighted in the table.

Table 26 – Sites for UHF P25 Trunked System

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Buellton Sheriff	Proposed New Rx	34.61373	-120.19594	None / ANT450D3 (25)	UHF Rx Only	NA / 15
Chumash	Existing Tx/Rx	34.60802	-120.08757	ANT450D / ANT450D (25)	UHF Simulcast	37 / 48
Dispatch	Proposed New Rx	34.44409	-119.77607	None / ANT450D6 (50)	UHF Rx Only	NA / 40
Figueroa	Proposed New Tx/Rx	34.74340	-119.98496	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	40 / 40
Fire Station 24	Proposed New Tx/Rx	34.74523	-120.27980	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	80 / 100
Foster	Existing Tx/Rx	34.88231	-120.44933	ANT450D (25) / ANT450D (25)	UHF Simulcast	39 / 39
GATR	Proposed New Tx/Rx	34.55206	-120.50238	ANT450D6 (25) / ANT450D6 (25)	UHF Stand-Alone	25 / 25
Gaviota	Existing Tx/Rx	34.51368	-120.23116	ANT450D9 (25) / ANT450F2	UHF Simulcast	86 / 110
Harris Grade	Existing Tx/Rx	34.73856	-120.44578	None / Laird FG4500	UHF Rx Only	NA / 32
Hwy 246 Tank	Proposed New Tx/Rx	34.62864	-120.26819	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	30 / 30
La Cumbre Peak	Existing Tx/Rx	34.50030	-119.72112	ANT450D (25) / ANT450D (25)	UHF Simulcast	27 / 27

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Los Alamos	Existing Rx	34.77225	-120.32797	None / ANT450D (25)	UHF Rx Only	NA / 12
Los Olivos	Existing Rx	34.66494	-120.11125	None / ANT450F2	UHF Rx Only	NA / 26
Mount Solomon	Existing Tx/Rx	34.83475	-120.38319	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	60 / 85
Mt. Abel	Proposed New Tx/Rx	34.82907	-119.20385	ANT450D6 (25) / ANT450D6 (25)	UHF Stand-Alone	40 / 40
Plowshare	Existing Tx/Rx	35.05006	-120.04102	ANT450D (25) / ANT450D6 (25)	UHF Simulcast	42 / 88
Rincon	Existing Tx/Rx	34.37286	-119.42106	ANT450D6 (25) / ANT450D6 (25)	UHF Simulcast	60 / 60
San Antonio	Existing Tx/Rx	34.84197	-120.49917	ANT450F2 / ANT450F2	UHF Simulcast	69 / 69
Santa Ynez	Existing Tx/Rx	34.52663	-119.97845	ANT450D (25) / ANT450D3 (25)	UHF Simulcast	60 / 80
Solvang	Existing Rx	34.59658	-120.13550	None / ANT450D9 (25)	UHF Rx Only	NA / 51
Sudden	Existing Tx/Rx	34.56625	-120.50006	ANT450D3 (25) / ANT450D3 (25)	UHF Simulcast	60 / 60
Tanglewood	Existing RX	34.89553	-120.48359	None / ANT450D3 (25)	UHF Rx Only	NA / 31
Tepusquet	Existing Tx/Rx	34.91507	-120.18269	ANT450D (25) / ANT450D (25)	UHF Simulcast	96 / 128
Valley Peak	Existing Tx/Rx	33.99893	-119.68361	ANT450D6 (25) / ANT450D6 (25)	UHF Stand-Alone	40 / 60
White Hills	Existing Tx/Rx	34.57022	-120.35450	ANT450D (25) / ANT450F2	UHF Simulcast	44 / 60

3.1.4.2 Coverage Maps

Figures 18 and 19 are maps showing the predicted coverage for UHF P25 trunked system.

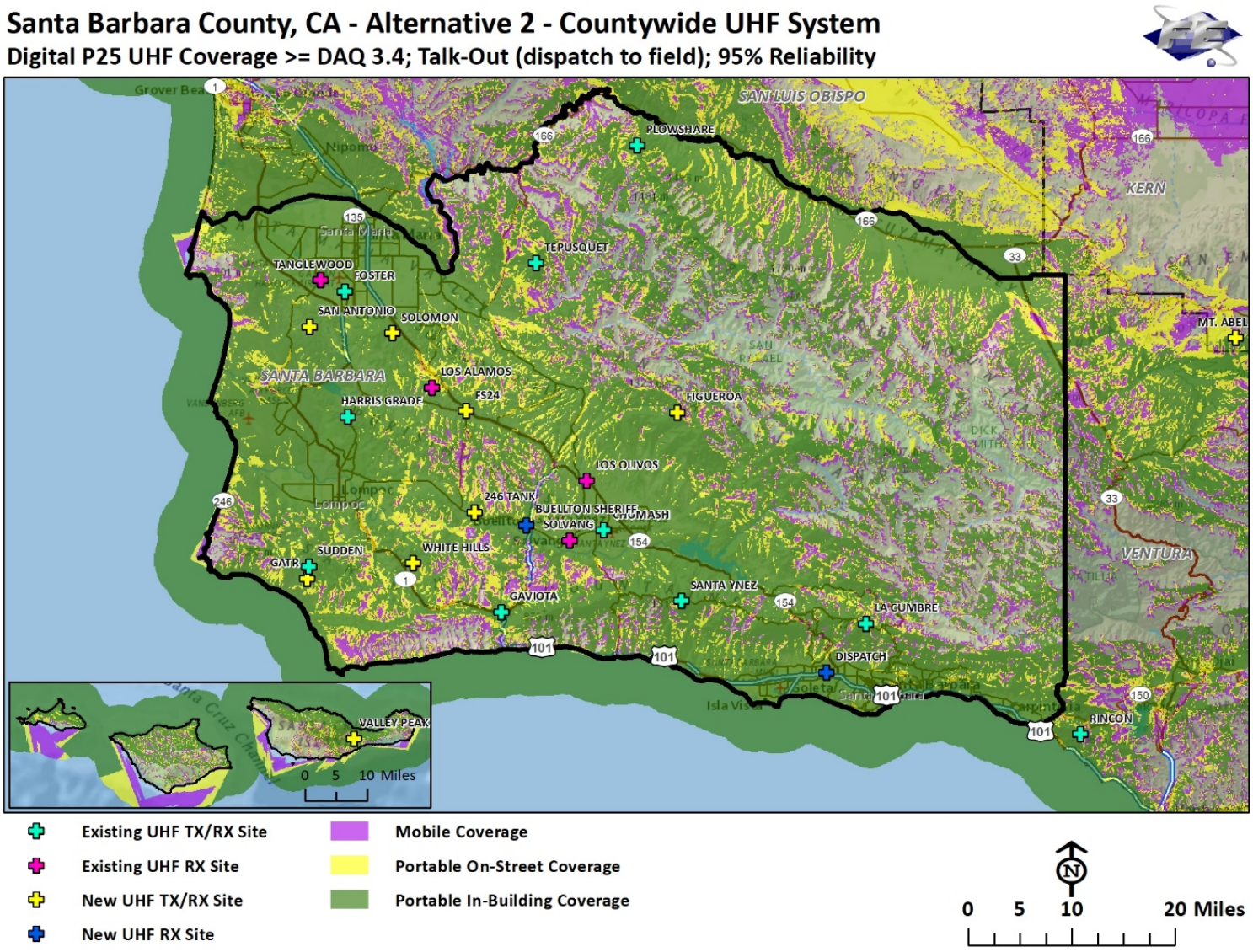

Figure 18 – UHF P25 Trunked System – Talk-Out

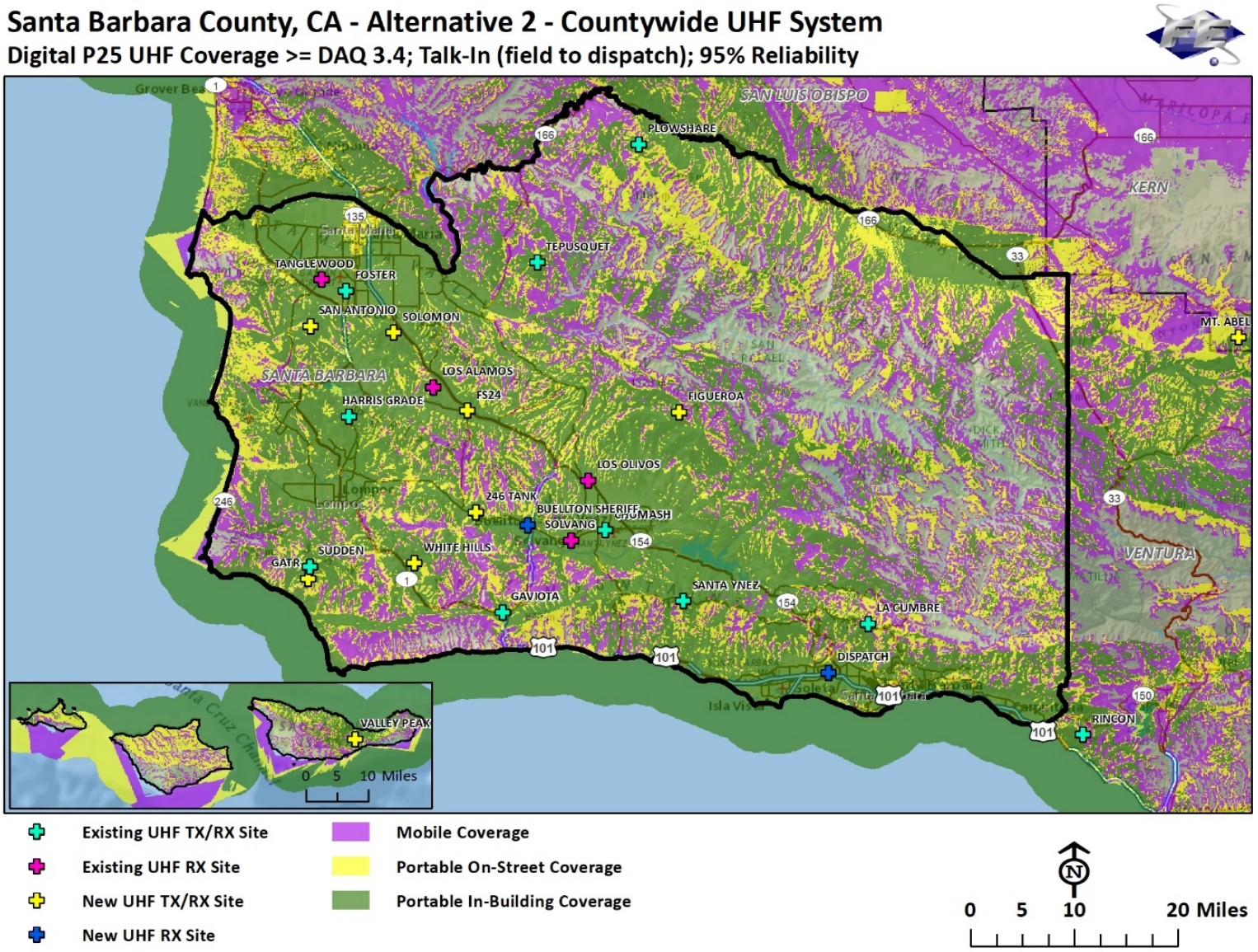

Figure 19 – UHF P25 Trunked System – Talk-In

3.1.4.3 Simulcast Cells and Interference

The coverage maps and percentages presented in this section account for the possibility of TDI within the simulcast cells. Thus, ***FE*** believes that the system design presented here can be constructed, and the displayed coverage can be provided by the specified radio sites, provided the system manufacturer practices sound engineering to mitigate the possibility of TDI within the simulcast environment.

3.2 Channel Capacity Analysis

3.2.1 Methodology

FE used existing and projected subscriber unit quantities to perform an Erlang-C trunked system loading analysis, which determines the required number of channels at each site to meet the County system capacity needs. ***FE*** used the following design targets for the capacity analysis:

- The system would have a public-safety Grade of Service (GoS) less than or equal to 1%, meaning that less than 1% of all attempted calls would be queued or blocked
- The system would support a subscriber unit growth factor of 2% per year for 10 years

FE made the following assumptions regarding the capacity analysis for the P25 trunked radio systems:

- P25 Phase 2 would provide two voice paths per radio licensed frequency pair using time division multiple access (TDMA) technology
- Due to a lack of existing traffic data, ***FE*** assumed projected push-to-talk (PTT) duration and PTTs per hour based on our extensive experience analyzing public safety radio system traffic data
- The number of talk paths (i.e. two per P25 Phase 2 channel) would support projected traffic in the Average Non-Busy Hour, as well as Busy Hour traffic scenarios

FE derived an Average Non-Busy Hour user traffic profile for the County by examining public safety traffic data obtained from other similar public safety radio projects. Based on evaluations by the Public Safety Wireless Advisory Committee (PSWAC)[6], Busy Hour traffic is assumed to be 4 times the Average Non-Busy Hour traffic. ***FE*** used the Busy Hour traffic scenario as the minimum requirement for the channel capacity throughout the P25 system.

[6] Final Report of the Public Safety Wireless Advisory Committee to the Federal Communications Commission. September 11, 1996. https://www.apcointl.org/doc/spectrum-management/173-public-safety-wireless-pdf/file.html

3.2.2 Results

Based on the results of the Erlang-C analysis, a four-channel P25 Phase 2 system would meet the GoS requirement for a countywide UHF trunked system during Busy Hour traffic scenarios. A four-channel P25 Phase 2 system provides six talk paths (i.e. six distinct simultaneous conversations can occur amongst P25 Phase 2 talkgroups). Providing this amount of capacity at all sites within the simulcast cell should meet the County's current capacity needs as well as provide room for growth for the next ten years.

3.3 LMR System Conceptual Design

Based on the results from the coverage and capacity analyses, this section provides a description of ***FE's*** conceptual design, including major system components and cost estimates for Alternative 2.

3.3.1 Design Criteria

FE used the following criteria for the Alternative 2 LMR system design:

- Refresh and expand the existing Fire VHF system as described in Alternative 1
- Replace and expand the existing 2-channel Sheriff UHF analog conventional simulcast system with a 4-channel shared UHF digital P25 Phase 2 trunked simulcast system. Install the following new equipment:
  - Simulcast control and voting equipment
  - Site equipment (P25 Phase 2 repeaters and/or receivers)
  - Antenna systems (i.e. antennas, transmission lines, transmitter combiners and receiver multicouplers)
  - DC power systems
  - Grounding and lightning protection systems
- Establish geographically diverse P25 core and simulcast control/receiver voting sites for redundancy and increased system reliability for the Fire VHF and Shared UHF trunked radio systems
- Leverage existing sites to greatest extent possible; only adding new sites, including towers and shelters, as needed to provide the required radio coverage

- Provide radio coverage equivalent to the existing County systems, plus improved mobile and portable on-street coverage in areas where inadequate coverage currently exists
- Discontinue the use of the Comm Center site due to lack of space for system expansion and water intrusion issues
- Utilize existing County licensed Fire VHF and Sheriff UHF radio channels

3.3.2 System Architecture

Figure 20 provides a high-level block diagram showing the architecture of the P25 UHF trunked system. The Backhaul Network blocks shown in multiple areas of Figure 20 is a single network and is shown in detail in Figure 8, the microwave radio system logical architecture diagram.

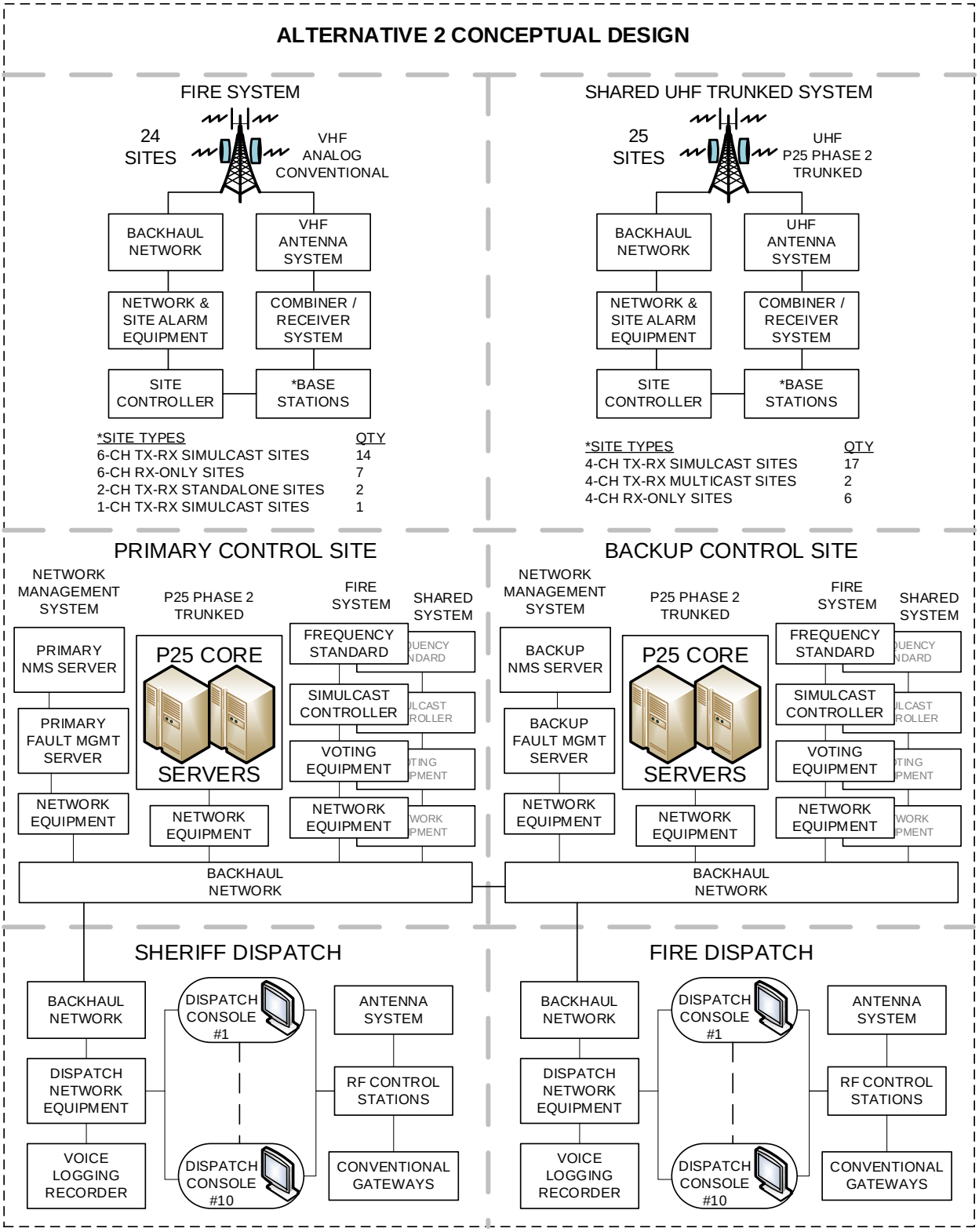

Figure 20 – Alternative 2 Conceptual Design

3.3.3 System Control Equipment

System core equipment at the Primary and Backup Control sites includes management, administration and networking components utilized for control of the shared UHF trunked system. Major functions of the core are voice call processing, mobility management, and system management. Voice call processing manages all aspects of call setup, queuing, and tear down. Mobility management refers to the system's ability to track users as they move from site to site. System management includes management of aliases and unit permissions as well as system fault monitoring. The conceptual design includes geographically separate primary and backup simulcast controllers to maintain system availability in the event of a controller failure or loss of the primary control facility.

Depending on manufacturer and customer requirements, system architecture designs can be centralized or distributed. The RFP will be written to allow both approaches, but for the conceptual design, ***FE*** assumed a centralized core architecture with primary and secondary core sites.

The primary and secondary cores can be located anywhere within the network, provided adequate physical space, supporting infrastructure, and backhaul capacity exist. Although the primary and backup core locations have not been selected yet, the County will need to do so for inclusion in the RFP. Dispatch and radio sites will need network access to the secondary core as they would to the primary core. If the primary core fails, the secondary core assumes voice and data traffic control thereby maintaining normal system communications.

As mentioned, a distributed architecture is offered by some system manufacturers. Each communications site in a distributed architecture has the capacity and capability to take on a central core function for the entire LMR system operations. Site equipment distributes call control, mobility management and traffic management across the system and is able to handle radio traffic for the entire system independently, so no centralized core equipment is needed.

3.3.4 Simulcast and Voting Equipment

The only difference between Alternative 2 and Alternative 1 is that Alternative 2 has only two simulcast systems, as follows:

- 6-channel Fire VHF analog conventional simulcast
- 4-channel Shared UHF P25 Phase 2 simulcast

Refer to Section 2.3.3 for a description of the simulcast and voting equipment in Alternative 1. Alternative 2 also includes redundant simulcast control and voting equipment at the Primary and Backup Control sites for each of the above simulcast cells.

3.3.5 Radio Site Equipment

Refer to Section 2.3.4 for a description of the radio site equipment in Alternative 1. The difference with Alternative 2 is that users of the existing LG system would move to the new Shared UHF P25 Trunked System. For Alternative 2, the frequency band, number of channels, and base station configuration vary per system as follows:

- Fire System – Six VHF analog conventional channels, requiring six base stations per site
- Shared System – Four UHF P25 Phase 2 trunking channels, requiring four base stations per site

Note that the Med 10 is currently a State channel and would require licensing by the County for use as an additional UHF channel on the Sheriff trunked radio system.

3.3.6 Antenna Systems

Refer to Section 2.3.5 for a description of the antenna systems in Alternative 1. The difference with Alternative 2 is that only two systems require equipment as follows:

- Fire System – VHF antenna systems at 17 transmit and receive sites and 7 receive-only sites
- Shared System – UHF antenna systems at 19 transmit and receive sites and 6 receive-only sites

3.3.7 System Features

The system features for the Fire VHF system would be the same as Alternative 1, as described in Section 2.3.6. However, the new standards-based, UHF P25 trunked system would offer the following additional features and capabilities.

3.3.7.1 Improved Coverage and Less Noise

Existing County LMR systems use frequency modulation (FM) technology. While FM is relatively resistant to noise in areas with a moderately strong signal, in areas of low signal

strength, radio users would hear the desired signal and noise. As the noise level increases, radio users must consciously separate the audio from the noise. A digital P25 radio system can provide relatively noise-free communications by leveraging vocoders and forward error correction (FEC).

P25 vocoders (voice coders) encode sounds related to understandable speech while providing some protection from transmission of non-voice sounds and converts the analog voice signal to a digital signal. After the signal is digitized (turned into a string of digital bits), FEC is applied to help the receiving radio correct errors that occur during transmission, due to weak signal levels or external interference. The result of these two processes is that the received signal quality is relatively consistent over much of the coverage area, which allows radio users to listen without the extra effort needed to separate audio from noise.

3.3.7.2 Encryption and Improved Encrypted Voice Quality

While many legacy radio systems have had encryption options, prior to P25 there was no standardized encryption system for LMR systems. P25 brings to the user a thorough set of encryption standards that go beyond the basis of the encryption protocol and include key distribution and key management.

Over the Air Rekeying (OTAR) can be implemented with the new system. This feature facilitates key system/subscriber management without the need to touch each radio physically. The digital encryption standard uses the same Vocoder and modulation as P25 non-encrypted voice; therefore, the use of encryption does not reduce either range or voice clarity.

3.3.7.3 Increased Voice Channel Efficiency

P25 Phase 2 trunked systems use a 2-slot Time Division Multiple Access (TDMA) channel format that allows two voice conversations on a single radio channel, effectively doubling the voice capacity of the system. This is important on a shared system where more user groups need to work within the same number of channels.

The capacity of the new Shared P25 trunked radio system, including the individual capacity of each simulcast cell and multicast site, would be less than or equal to 1% Grade of Service. This means that less than one percent of all attempted calls (i.e., push-to-talks) would be either queued or blocked. This reflects a public-safety grade of service.

3.3.7.4 Open Data Interfaces

P25 provides an open standardized data interface at both the network and subscriber levels of the system which simplifies development of third party data applications and prevents the sunk cost of application development from becoming a barrier to the use of new subscriber products. The applications to which this applies vary widely from simple messaging to location and over the air programming.

3.3.7.5 Competitive Procurement

P25 standards have created a marketplace where multiple radio system manufacturers produce systems compatible with subscriber radios from multiple manufacturers. Most major radio system manufacturers supply P25 radio systems or subscriber units and some supply both. In addition, several specialty manufacturers supply standards-based equipment for specialized uses such as aircraft, surveillance, data and receive-only applications. The radio system products include trunked networks, conventional stations, and transportable systems. This range of suppliers fosters a truly competitive procurement process and makes it easy to acquire comparable pricing sources from the multiple public contracts available.

3.3.7.6 Other System Features

The new Shared UHF P25 Trunked Radio System would retain all features of the existing County analog systems and would provide other features and capabilities that may be beneficial to County departments/radio users. P25 systems support most of the following system features, while some vendors support additional features by using underlying standardized services.

- **Group Calls** – allows multiple radios to operate as a talkgroup, effectively creating their own channel
- **Emergency Calls** – allow a radio user or dispatcher to declare an emergency for their group with a single button press. This feature informs all users on that talkgroup of the emergency, and that talkgroup receives highest priority on the system so critical communications is not blocked
- **Emergency Alarm** – a subscriber unit may declare an emergency with a single button press. This feature assures that all users on the channel are informed of the emergency that may or may not need to be followed with voice traffic

- **User Authentication** – ensures that only properly authorized subscriber radios may communicate on the system, preventing unauthorized (and potentially disruptive or fraudulent) access to the system

- **Radio Inhibit / Uninhibit** – the system manager may temporarily or permanently disable a lost, stolen or misused radio

- **Global Positioning System (GPS)** – GPS and Automatic Vehicle Location (AVL) systems typically use the standardized GPS protocol within the P25 standard. In some cases, vendors have created higher efficiency proprietary protocols to improve system operation. The hope is that these extensions will become standardized in the future

- **Call alert** – standardized feature that allows a dispatcher or subscriber unit to send a page-like call to another subscriber unit

- **Announcement group call** – standardized feature that is much like a talkgroup call; however, it is usually used to make announcements to larger groups made up of two or more talkgroups

- **Status query** – standardized feature that allows a user to set a status on his/her radio that can be displayed to a dispatcher or used by a Computer Aided Dispatch (CAD) system in directing calls

- **Voice encryption** with **over-the-air rekeying (OTAR)** – standardized feature that would no longer bring along the range and voice quality deficit of previous generation encryption systems

- **Private calls** – standardized feature allows a radio user to talk directly to a dispatcher or to another radio user, in relative privacy. While not encrypted, it does assure that other users on the system are not included in the conversation

- **Short Messaging Service (SMS)** – allows transmission of short text messages between radio units or between a dispatch position and a radio unit. This message system while not currently incorporated into the standard uses the standardized data services to transport the message

- **Dynamic Regrouping** – allows units to be regrouped, or for multiple groups to be brought together for short-term activities. Often comprehensive talk-group planning minimizes the need for this feature

While the new trunked radio system may support all of the above features, it is important to note that specific hardware options and/or software licenses may be required on the system core and/or subscriber units for features to function properly.

3.4 Dispatch

Refer to Section 2.4 for the dispatch conceptual design.

3.5 Subscriber Equipment

Sheriff and departments using the existing LG system would need to replace existing (end-of-life) subscriber units with mid-tier, single-band radios with P25 Phase 2 trunking enabled. Fire would need to replace existing (end-of-life) subscriber units with mid-tier, single-band radios.

Subscriber replacement quantities provided in Alternative 1 are the same for Alternative 2 and have been adjusted to exclude radios that were recently purchased or will be purchased by Sheriff and Fire prior to the implementation of the new LMR systems. However, the budgetary estimates will increase for Alternative 2 subscriber units due to additional software and licensing required for the Shared UHF P25 Trunked System, which would include AES encryption, OTAR, and OTAP features. Using mid-tier radios provides a good average for budgetary purposes. Some agencies may only purchase low-tier models, while other may purchase high-tier radios with added features. As part of the RFP, the County can specify the quantity and tier requirements per department, which would allow the vendors to provide a more accurate cost proposal.

3.6 Microwave Backhaul Conceptual Design

Refer to Section 2.6 for the microwave backhaul conceptual design.

3.7 Network Management

Refer to Section 2.7 for the Network Management conceptual design.

3.8 Interoperability

3.8.1 Interoperability Continuum

Refer to Section 2.8.1 for a description of the Department of Homeland Security's Interoperability Continuum.

3.8.2 Interoperability Analysis

Looking at the DHS Interoperability Continuum, most County departments are meeting their interoperability needs through the sharing of radio channels with the other departments or agencies they interoperate with (i.e. they program the other agencies channels in their radios and vice versa). This works well for Fire because nearly all the fire agencies they need to interoperate with are also on the VHF Band. However, for Sheriff and EMS that are on UHF, and LG system users that are on 800 MHz, meeting their interoperability needs is more difficult. Table 27 shows how County departments currently interoperate with other departments or agencies in the County and how the Alternative 2 system upgrade would impact their ability to interoperate.

With P25 digital trunked radio systems, as proposed for Alternative 2, the use of talkgroups allows users from different departments to communicate with each other. Although not included in the conceptual design, P25 digital trunked radio systems provide the following additional capabilities which can be implemented in the future:

- P25 digital trunked radio systems allow connection to other P25 trunked radio systems (i.e. Santa Maria), allowing users on different systems to communicate with each other, regardless of frequency band, and if the two systems are on the same frequency band users could roam on the other system, as needed

- Gateways and console patches provide connectivity between a trunked P25 system and a conventional system

Table 27 – Radio Interoperability Comparison – Current vs. Alternative 2

County Department	Current Method	Alternative 2
Fire	1. All other agencies that Fire interoperates with also have VHF radio systems, so Fire programs the other agencies channels into their radios and vice versa. 2. Fire has some VHF/UHF dual-band portable radios, which they use to interoperate with the Sheriff. 3. Fire cannot interoperate with Santa Maria Fire because they moved to a 700 MHz trunked radio system	1. Fire would continue to be able to talk to other fire agencies in the County. 2. Fire would not be able to interoperate with the Sheriff unless they purchase multi-band P25-compatible subscriber units. 3. Fire would still not be able to interoperate with Santa Maria Fire.
EMS	1. EMS has UHF radios on their system and VHF radios to talk to County Fire and other fire agencies in the County.	1. EMS is moving their operations to the County Fire 1 channel, which would improve their ability to interoperate with Fire and other fire agencies.

County Department	Current Method	Alternative 2
	2. EMS cannot communicate with Santa Maria Fire Department since they went to a 700 MHz trunked radio system. 3. Ambulances communicate with County base hospitals using standalone repeaters on Med 5, 6, 7 and 8 channels.	2. EMS still would not be able to communicate with Santa Maria Fire. 3. Ambulance communications with the hospitals would move to the new UHF trunked system. EMS would need to purchase new subscriber units that can operate on the new trunked radio system.
Sheriff	1. Sheriff currently interoperates with Santa Barbara police department (PD), Lompoc PD and San Luis Obispo Sheriff who also have UHF radio systems, by programming the other agencies channels in their radios and vice versa. 2. Sheriff can't interoperate with Santa Maria PD because they moved to a 700 MHz trunked system.	1. Sheriff would continue to be able to talk to other law enforcement agencies in the County on the UHF band. 2. Sheriff is buying multi-band subscriber units that would allow them to talk to Santa Maria PD on their 700 MHz system.
Floods	1. Floods currently interoperates with Roads on the LG radio system. 2. Floods expressed interest in being able to interoperate with Sheriff and Fire, but, can't because they are on different frequency bands.	1. Floods would continue to be able to interoperate with Roads on the new UHF P25 trunked system. 2. Floods would be able to interoperate with Sheriff on the new P25 trunked system, and new multi-band radios would allow them to talk to Fire.
Parks	1. Parks would like to be able to interoperate with Fish and Wildlife and USFS but cannot because they are on a different frequency band; they currently use cell phones to talk to these agencies.	1. Parks would require multi-band subscriber units to talk to USFS and Fish and Wildlife.
Roads	1. Roads currently uses cell phones to talk to Caltrans. 2. Roads would like to be able to communicate with Floods.	1. If Roads purchases multi-band subscriber units, they would be able to interoperate with Caltrans on their VHF High Band or 800 MHz systems. 2. Roads would be able to interoperate with Floods on the new UHF P25 trunked system.
Public Health, Animal Services	1. Animal Services calls Dispatch to request that they monitor the LG 1 channel for after hours or emergency support. 2. Animal Services would like to be able to interoperate with CHP after hours but can't because CHP is on VHF Low Band.	1. Animal Services would be able to interoperate with Sheriff on the new UHF P25 trunked system. 2. Animal Services would still not be able to interoperate with CHP, who are on VHF Low Band.

County Department	Current Method	Alternative 2
District Attorney	1. The District Attorney (DA) uses cell phone or landline for most communications needs; they use the Sheriff system for operations with Sheriff deputies, for surveillance activities, and for mass casualties or disasters. 2. The DA needs radio interoperability with Santa Maria PD.	1. DA would be able to fully interoperate with the Sheriff on the new UHF P25 trunked system. 2. DA would be able to interoperate with Santa Maria PD if they purchase multi-band radios for operation on the new UHF P25 trunked system.
Probation	1. Probation uses the Sheriff radio system for primary operations and coordinate operations with Dispatch. 2. Probation needs to interoperate with Santa Maria PD but can't since Santa Maria PD moved to a 700 MHz trunked radio system. 3. Probation mostly uses cell phones but have radios for officer safety.	1. Probation would be able to interoperate with Sheriff on the new UHF P25 trunked system. 2. Probation would be able to interoperate with Santa Maria PD if they purchase multi-band radios for operation on the new UHF P25 trunked system. 3. Probation may choose to expand their radio use with the improved coverage and interoperability provided by the new UHF P25 trunked system.

3.9 Cost Analysis

FE developed cost assumptions and budgetary estimates for the Alternative 2 conceptual design using the same methodology used for Alternative 1 (refer to Section 2.9). The cost estimates prepared for the conceptual design reflect non-discounted (list) pricing, an 8.75% Sales Tax on equipment hardware and software, and 10% contingency on all system and subscriber equipment.

3.9.1 Cost Assumptions

Table 28 includes the cost assumptions used by ***FE*** for Alternative 2. While the conceptual design has Mt. Abel and Valley Peak as standalone sites for technical reasons (refer to Section 2.10.2), the cost estimates include them as simulcast sites to account for the possibility that the awarded vendor determines that they can be included as simulcast sites.

Table 28 – Alternative 2 System Assumptions

Alternative 2 Assumptions	QTY	Notes
General Assumptions		
Fire VHF System	1	Same as Alternative 1
LG 800 MHz System	N/A	LG migrates to Shared UHF Trunked System
EMS UHF System	N/A	EMS MED10 operation migrates to the Fire 1 channel. EMS operations on MED5, MED6, MED7 and MED8 migrates to the Shared UHF Trunked System
Microwave System	1	Same as Alternative 1
Network Management System	1	Same as Alternative 1
Sheriff/Fire Dispatch Center	1	Same as Alternative 1
Subscriber Equipment	1	Quantities same as Alternative 1, add P25 Phase 2 capability
Implementation Services	1	Same as Alternative 1
OPEX Assumptions	1	Same as Alternative 1
Shared UHF Trunked System		
P25 Phase 2 Core Network Sites	2	Redundant / geographically separated with redundant networking equipment
Over the Air Rekeying Server	2	Redundant hardware, software and licensing
Over the Air Programming Server	2	Redundant hardware, software and licensing
GPS Application Interface	2	Redundant hardware, software and licensing
Number of Simulcast Control Sites	2	Redundant / geographically separated
UHF 4-CH Tx/Rx Simulcast Sites	19	Chumash Casino (PG), Foster, Gaviota, Harris Grade, La Cumbre Peak, Mount Solomon, Plowshare, Rincon, San Antonio, Santa Ynez, Sudden, Tepusquet, White Hills, Figueroa, Hwy 246 Tank, Fire Station 24, Mt. Abel, Valley Peak, GATR
UHF 4-CH Rx-Only Sites	6	Buellton Sheriff, Dispatch, Los Alamos, Los Olivos, Solvang, Tanglewood
UHF Tx/Rx Antenna System	19	All new transmission lines, combiners, multicouplers, and antennas
UHF Rx-only Antenna System	6	All new transmission lines, combiners, multicouplers, and antennas
Site Networking Equipment	25	Routing and switching at each radio site
FCC licensing and coordination	72	Simulcast frequency pairs needed for expansion
ISSI Hardware and Software	1	Optional equipment for one ISSI connection
Site Improvements		
Tower Structural Analysis	9	Quantity based on site survey results and County feedback
Existing Site Renovations	9	Quantity based on site survey results and County feedback
New Self-Supported Tower	12	Quantity based on site survey results and County feedback
New Prefabricated Shelter	10	Quantity based on site survey results and County feedback
Generator/Transfer switch/fuel tank	12	Quantity based on site survey results and County feedback
Uninterruptible Power Supply (UPS)	11	Quantity based on site survey results and County feedback
A&E, Environmental Compliance	12	Per Industry Best Practices, new structure
Site Acquisition Cost	3	County provided estimate of $2,200,000

The Alternative 2 microwave system cost assumptions are the same as those described in Section 2.9.1.2 for Alternative 1.

3.9.2 Fire System

The Alternative 2 budgetary estimate for the Fire VHF system equipment and services is the same as Alternative 1, as described in Section 2.9.2.

3.9.3 UHF Shared Trunked System

Table 29 summarizes the estimated costs for the shared UHF trunked system equipment and services.

Table 29 – Alternative 2 - Shared UHF Trunked System Cost Estimate

Alternative 2 Shared UHF Trunked System Cost Estimate			
Primary Core Network	*Quantity*	*Unit Cost*	*Extended Cost*
P25 Phase 2 Core Equipment	1	$766,000	$766,000
Core Networking Equipment	1	$147,000	$147,000
Over the Air Rekeying Server	1	$218,000	$218,000
Over the Air Programming Server	1	$33,000	$33,000
GPS Application Interface	1	$163,000	$163,000
Subtotal			**$1,327,000**
Backup Core Network	*Quantity*	*Unit Cost*	*Extended Cost*
P25 Phase 2 Core Equipment	1	$766,000	$766,000
Core Networking Equipment	1	$147,000	$147,000
Over the Air Rekeying Server	1	$218,000	$218,000
Over the Air Programming Server	1	$33,000	$33,000
GPS Application Interface	1	$163,000	$163,000
Subtotal			**$1,327,000**
Primary Simulcast Control	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	2	$64,000	$128,000
Networking Equipment	1	$73,000	$73,000
Subtotal			**$307,000**
Backup Simulcast Control	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	1	$69,000	$69,000
GPS Frequency Standard	1	$37,000	$37,000
Voting Equipment	2	$64,000	$128,000
Networking Equipment	1	$73,000	$73,000
Subtotal			**$307,000**

Alternative 2 Shared UHF Trunked System Cost Estimate			
Remote RF Site Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
4-CH Tx/Rx Simulcast Equipment	19	$258,000	$4,902,000
4-CH Rx-Only Equipment	6	$90,000	$540,000
UHF Tx/Rx Antenna System	19	$16,000	$304,000
UHF Rx-only Antenna System	6	$11,000	$66,000
Site Networking Equipment	25	$13,000	$325,000
Subtotal			**$6,137,000**
Equipment Subtotal			**$9,405,000**
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	72		$18,000
LMR Frequency Coordination Fees	72		$36,000
LMR Engineering Services Fees	72		$18,000
Subtotal			**$72,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$471,000
Santa Barbara Sales Tax	8.75%		$823,000
Project Management	10%		$941,000
Installation	10%		$941,000
Engineering	10%		$941,000
Removal of Existing Equipment	2%		$189,000
Training	1%		$95,000
Staging	5%		$471,000
Acceptance Testing	1%		$95,000
Documentation	1%		$95,000
Contingency	10%		$941,000
Subtotal			**$6,003,000**
Services Total			**$6,075,000**
Equipment and Services Total			**$15,480,000**

3.9.4 Microwave Radio System

The Alternative 2 budgetary estimate for the microwave system equipment and services is the same as described in Section 2.9.6 for Alternative 1.

3.9.5 Network Management System

The Alternative 2 budgetary estimate for the NMS equipment and services is the same as described in Section 2.9.7 for Alternative 1.

3.9.6 Site Improvements

Table 30 summarizes the estimated costs for the Alternative 2 site improvements. Refer to Table 14 for detailed breakdown of the required improvements for the sites in Alternative 2.

Table 30 – Alternative 2 Site Improvements Cost Estimate

Alternative 2 Site Improvements Cost Estimate			
Site Improvements	*Quantity*	*Unit Cost*	*Extended Cost*
Tower Structural Analysis	9	$5,000	$45,000
Existing Site Renovations	9	$15,000	$135,000
New Self-Supported Tower	12	$283,000	$3,396,000
New Prefabricated Shelter	10	$109,000	$1,090,000
Generator/Transfer switch/fuel tank	12	$30,000	$360,000
UPS (20 KVA 208V 2 hour runtime)	11	$30,000	$330,000
A&E, Environmental Compliance	12	$14,000	$168,000
Subtotal			**$5,524,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$277,000
Santa Barbara Sales Tax	8.75%		$484,000
Project Management	10%		$553,000
Installation	10%		$553,000
Engineering	10%		$553,000
Removal of Existing Equipment	2%		$111,000
Training	1%		$56,000
Staging	5%		$277,000
Acceptance Testing	1%		$56,000
Documentation	1%		$56,000
Contingency	10%		$553,000
Services Total			**$3,529,000**
Site Acquisition Cost	3		$2,200,000
Equipment and Services Total			**$11,253,000**

3.9.7 Dispatch System

The Alternative 2 budgetary estimate for the dispatch equipment and services is the same as described for Alternative 1 in Section 2.9.9 for Alternative 1.

3.9.8 Subscriber Equipment

Table 31 summarizes the estimated subscriber equipment and services costs. Appendix A provides a detailed breakdown of each departments subscriber unit costs.

Table 31 – Alternative 2 - Subscriber Equipment Cost Estimate

Alternative 2 Subscriber Equipment Cost Estimate			
Subscriber Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	658	$4,500	$2,961,000
Portable Radios	736	$4,000	$2,944,000
Control Stations	44	$6,000	$264,000
Subtotal (Rounded)			**$6,169,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Radio Programming	1438	$100	$143,800
Radio Installation	702	$200	$140,400
Subtotal (Rounded)			**$285,000**
Equipment and Services Total			**$6,454,000**
Contingency	10%		$646,000
Total (with Contingency)			**$7,100,000**

3.9.9 Cost Summary

Table 32 summarizes the total cost for Alternative 2, including LMR, microwave, NMS, dispatch, subscribers and site improvements.

Table 32 – Alternative 2 - Total Cost Estimate

Alternative 2 Total Cost Estimate			
Item	*Equipment*	*Services*	*Total Cost*
Fire VHF Radio System	$3,386,000	$2,186,000	$5,572,000
Shared UHF Trunked System	$9,405,000	$6,075,000	$15,480,000
Digital Microwave System	$3,265,000	$1,817,000	$5,082,000
Network Management System	$820,000	$526,000	$1,346,000
Site Civils / Improvements	$5,524,000	$3,529,000	$9,053,000
Site Acquisition Cost	$0	$2,200,000	$2,200,000
Sheriff Dispatch	$866,000	$557,000	$1,423,000
Fire Dispatch	$866,000	$557,000	$1,423,000
Subscriber Equipment	$6,169,000	$931,000	$7,100,000
Total	**$30,301,000**	**$18,378,000**	**$48,679,000**

3.9.10 Optional Costs

Table 33 summarizes the estimated cost to implement a P25 ISSI connection for interoperability with another P25 radio system.

Table 33 – Optional P25 ISSI Connection Cost Estimate

P25 ISSI Connection Cost Estimate			
Core Network Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
ISSI Hardware and Software	1	$250,000	$250,000
Subtotal			**$250,000**
Equipment Subtotal			**$250,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$13,000
Santa Barbara Sales Tax	8.75%		$22,000
Project Management	10%		$25,000
Installation	10%		$25,000
Engineering	10%		$25,000
Removal of Existing Equipment	2%		$5,000
Training	1%		$3,000
Staging	5%		$13,000
Acceptance Testing	1%		$3,000
Documentation	1%		$3,000
Contingency	10%		$25,000
Services Total			**$162,000**
Equipment and Services Total			**$412,000**

Procuring and integrating ISSI equipment after deployment of the core may have the above additional implementation services.

3.9.11 Operational Costs

Table 34 summarizes the 15-year operational cost estimate for Alternative 2. The estimate does not include the optional equipment nor any current operational expenses such as LMR and microwave system maintenance contracts, site maintenance, site leases, staff salaries, or other recurring expenditures. The estimate includes only the new LMR, microwave, NMS, dispatch center, and subscriber equipment that are part of this alternative.

Table 34 – Alternative 2 15-Year Operational Cost Estimate

Alternative 2 Operating Costs Estimate					
Operating Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Technical Support	$0	$0	$0	$514,000	$530,000
Software/Hardware Upgrades	$0	$0	$0	$1,028,000	$1,059,000
Subscriber Growth	$0	$151,000	$154,000	$157,000	$160,000
Subscriber Attrition	$0	$76,000	$76,000	$78,000	$78,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$0**	**$227,000**	**$230,000**	**$1,777,000**	**$1,827,000**
Operating Costs	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Technical Support	$546,000	$563,000	$580,000	$598,000	$616,000
Software/Hardware Upgrades	$1,091,000	$1,124,000	$1,158,000	$1,193,000	$1,229,000
Subscriber Growth	$163,000	$166,000	$169,000	$174,000	$177,000
Subscriber Attrition	$79,000	$80,000	$81,000	$81,000	$82,000
Subscriber Refresh	$0	$0	$0	$0	$7,100,000
Estimated Annual Cost	**$1,879,000**	**$1,933,000**	**$1,988,000**	**$2,046,000**	**$9,204,000**
Operating Costs	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
Technical Support	$635,000	$655,000	$675,000	$696,000	$717,000
Software/Hardware Upgrades	$1,266,000	$1,304,000	$1,344,000	$1,385,000	$1,427,000
Subscriber Growth	$180,000	$184,000	$187,000	$191,000	$194,000
Subscriber Attrition	$83,000	$83,000	$85,000	$85,000	$87,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$2,164,000**	**$2,226,000**	**$2,291,000**	**$2,357,000**	**$2,425,000**

3.10 Migration Strategy

3.10.1 General

The Alternative 2 general migration strategy is the same as described in Section 2.10.1 for Alternative 1.

3.10.2 Fire VHF Migration

The Alternative 2 migration strategy for the Fire VHF system is the same as described in Section 2.10.2 for Alternative 1.

3.10.3 Shared UHF Trunked System Migration

Alternative 2 includes the migration of all County radio system users (except for Fire and EMS) to a shared 4-channel, UHF P25 Phase 2 trunked simulcast system, utilizing

existing Sheriff UHF system sites and radio channels. Radio coverage improvements required the additional new sites and the addition of other County departments to the system required two additional countywide UHF channels to the two existing Sheriff channels. Unlike Alternative 1 where a channel is added to the Sheriff system for the North and South County service areas, all proposed sites would be equipped with four UHF channels. UHF channel availability is typically limited, however, finding and licensing additional UHF channels for a countywide trunked radio system should be less difficult than for the Fire VHF system.

The trunked system requires one RF channel to serve as a control channel, regardless of simulcast or multicast site configuration. The three other RF channels are available for voice communications. Unlike conventional channels, trunked channels provide more efficient use of spectrum, increased redundancy, and more efficient management of call congestion. A major benefit of P25 Phase 2 trunking is the use of a 2-slot TDMA which allows two separate voice conversations to operate on a single RF channel.

With the proposed TDMA technology, the addition of two new RF channels countywide would make the migration smoother. The awarded vendor can install and move traffic to the new channels while installing new trunking equipment on the existing RF channels. All four RF channels (one control and three voice) would be available for use by all radio users, once new equipment has been installed and tested on the existing and new RF channels.

The TDMA system would provide six UHF voice paths that the County users would share. This is important on a shared system where multiple user groups need to work within the same number of RF channels. The capacity of the new UHF system, including the individual capacity of each simulcast cell and multicast site, would be less than or equal to 1% Grade of Service. This means that less than one percent of all attempted calls (i.e., push-to-talks) would be either queued or blocked. This reflects a public-safety grade of service.

The Shared UHF Trunked System migration plan would depend on the awarded vendors design, technology and experience. However, the County should be aware of potential (but temporary) channel congestion during the migration. Two additional channels would be licensed and used for the migration period. One RF channel would be used as the control channel, and the other would provide two talk paths for voice traffic. This is equivalent to the current capacity the Sheriff UHF system has today. However, the Sheriff and existing LG system users would share these two talk paths during the transition. This increased loading on two channels would be temporary until all channels are operational in P25 Phase 2 trunking mode.

As part of the UHF coverage and capacity expansion, the conceptual design includes the following new sites:

- Mt. Abel: multicast, 4 UHF channels
- Valley Peak: multicast, 4 UHF channels
- GATR: multicast, 4 UHF channels
- Figueroa: simulcast, 4 UHF channels
- Highway 246 Tank: simulcast, 4 UHF channels
- Fire Station 24: simulcast, 4 UHF channels

Three of the new sites would be simulcast, and three would be multicast sites as noted. Because Mt. Abel and Valley Peak exceed the typically accepted distance for site separation in a simulcast configuration, these sites would be multicast. Attempting to include these sites in the simulcast cell could lead to potential interference when roaming between them and the nearest simulcast site. As with the Fire and Sheriff systems in Alternative 1, ***FE*** suggests that the County include a requirement in the RFP that the vendor evaluate the ability to establish Mt. Abel and Valley Peak as simulcast sites, with standalone being the fallback if potential interference issues cannot be resolved.

Although limited channel availability exists, licensing new UHF channels should not be difficult. The multicast sites would be configured with new frequency pairs, requiring FCC licensing and coordination and possibility letters of concurrence with other agencies.

With the new digital trunked system, roaming in and out of the simulcast and multicast footprints does not require the users to manually switch to the new channels on their portable and/or mobile radios. The operation is seamless and transparent when programmed correctly at the core and in the radios. Given the large distance and terrain between the sites, UHF frequencies at Mt. Abel can potentially be re-used at Valley Peak. The GATR site would serve the Jalama Beach area and may require the full complement of UHF channels.

Licensing the four simulcast UHF channels at Figueroa, Highway 246 Tank, and Fire Station 24 should not be an issue, given two are currently licensed channels within the existing simulcast footprint. However, FCC licensing and coordination would be necessary to add the new UHF channels at those sites and change the emission designator at all proposed sites. Based on the conceptual design, migration to the Shared

UHF Trunked System would require the following major tasks, with the first five tasks common for all County radio systems:

- Replace Comm Center as a primary control site, with implementation of a geo-redundant backup control site (both the primary and backup sites to be determined)
- Site readiness, including but not limited to improvements to site grounding, backup generator(s), shelter/equipment rooms, and towers (in compliance with TIA-222, latest revision)
- Procuring and deploying RF infrastructure equipment to replace and expand the existing backhaul system
- Procuring and deploying infrastructure equipment to replace the existing dispatch equipment, including logging recorder, dispatch consoles, RF control stations, and implementation of a backup dispatch center
- Procuring and deploying infrastructure equipment to replace and expand the existing network management system
- FCC licensing and coordination for additional UHF frequency pairs at existing sites and four frequency pairs at proposed new sites
- Procuring and deploying infrastructure equipment to replace the existing Sheriff UHF and LG 800 MHz systems with a shared UHF trunked system
- Procuring and deploying new subscriber radios for Sheriff and LG system users and other agencies that may use the Shared UHF Trunked System
- Complete coverage testing per requirements to be specified in the RFP
- Complete fleetmapping and training (technical and operator), with the latter being as close to cutover as possible
- Preliminary acceptance and functional testing of the new Shared UHF system and subscriber equipment
- Migration and cutover of UHF and 800 MHz radio users, by user group, from the existing systems to the new Shared UHF Trunked System
- Final testing and acceptance of new Shared UHF system

- Finalize system and project documentation
- Decommissioning of the existing Sheriff UHF system and LG 800 MHz system
- Punch list resolution and project closeout

It is important to note that LG and other users that currently use the 800 MHz system would have to procure and deploy new radios that can operate on UHF P25 Phase 2 system.

3.10.4 Microwave System Migration

The Alternative 2 microwave system migration strategy is the same as described in Section 2.10.5 for Alternative 1.

3.11 Project Implementation Schedule

Following is the implementation schedule for the upgrade of the County's LMR and Public Safety Microwave Radio System, showing the projected sequence and duration of tasks and the dependencies between the tasks, following the migration strategy in Section 2.10.

3.11.1 Overall Project Implementation Schedule

Project implementation follows the delivery of this report, the *County of Santa Barbara Land Mobile and Microwave Radio Conceptual Design*. Figure 21 is the overall schedule, showing major project phases and timeframes, including the development of the RFP, system procurement and system implementation.

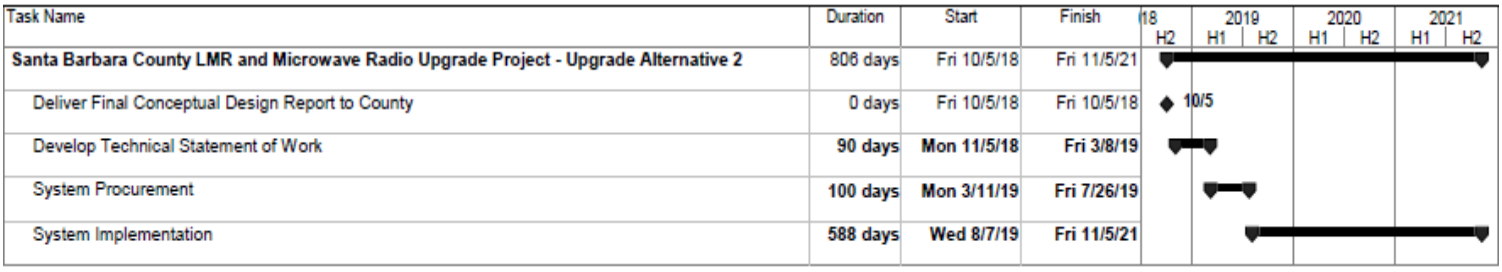

Figure 21 – Overall Implementation Schedule – Alternative 2

3.11.2 RFP Development Schedule

Figure 22 is a breakdown of the tasks required to produce the RFP, beginning with the development of the technical statement of work (SOW) and ending with the inclusion of the SOW into the County's RFP.

Task Name	Duration	Start	Finish
Santa Barbara County LMR and Microwave Radio Upgrade Project - Upgrade Alternative 2	806 days	Fri 10/5/18	Fri 11/5/21
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	**90 days**	**Mon 11/5/18**	**Fri 3/8/19**
Develop Draft Technical Specs	40 days	Mon 11/5/18	Fri 12/28/18
QC Review	5 days	Mon 12/31/18	Fri 1/4/19
Deliver Draft SOW to County	0 days	Fri 1/4/19	Fri 1/4/19
County Review of Draft SOW	10 days	Mon 1/7/19	Fri 1/18/19
Review Workshop with County	1 day	Wed 1/23/19	Wed 1/23/19
Develop Final SOW	17 days	Thu 1/24/19	Fri 2/15/19
Develop Vendor Scoresheet	17 days	Thu 1/24/19	Fri 2/15/19
Deliver Final SOW and Vendor Scoresheet	0 days	Fri 2/15/19	Fri 2/15/19
County Incorporates SOW into RFP	10 days	Mon 2/18/19	Fri 3/1/19
County Releases RFP	5 days	Mon 3/4/19	Fri 3/8/19
System Procurement	**100 days**	**Mon 3/11/19**	**Fri 7/26/19**
System Implementation	**588 days**	**Wed 8/7/19**	**Fri 11/5/21**

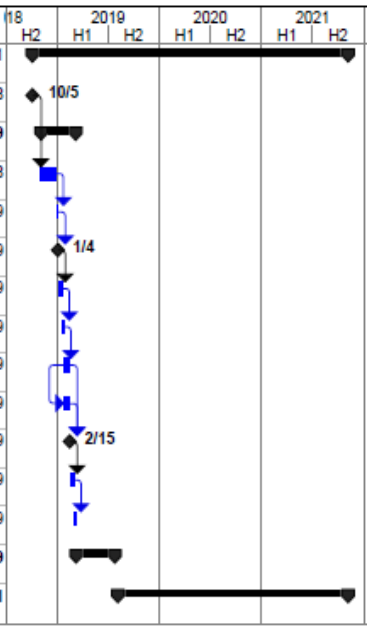

Figure 22 – RFP Development Schedule – Alternative 2

3.11.3 System Procurement Schedule

Figure 23 shows the tasks required to procurement the new LMR and microwave radio backhaul systems, beginning with the release of the RFP by the County and ending with a negotiated contract with the selected vendor.

Task Name	Duration	Start	Finish
Santa Barbara County LMR and Microwave Radio Upgrade Project - Upgrade Alternative 2	806 days	Fri 10/5/18	Fri 11/5/21
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	**90 days**	**Mon 11/5/18**	**Fri 3/8/19**
System Procurement	**100 days**	**Mon 3/11/19**	**Fri 7/26/19**
Pre-Bid Meeting/Site Visits	4 days	Tue 3/12/19	Fri 3/15/19
Respond to Bidder Questions	25 days	Mon 3/11/19	Fri 4/12/19
Bidder Proposal Development	40 days	Mon 3/11/19	Fri 5/3/19
Bidder Proposals Due	0 days	Fri 5/3/19	Fri 5/3/19
Vendor Proposal Review	20 days	Mon 5/6/19	Fri 5/31/19
Vendor Presentations	2 days	Wed 6/5/19	Thu 6/6/19
Evaluation Meeting	1 day	Fri 6/7/19	Fri 6/7/19
Vendor Selection	5 days	Mon 6/10/19	Fri 6/14/19
Vendor Contract Negotiation	30 days	Mon 6/17/19	Fri 7/26/19
Vendor Contract Execution	0 days	Fri 7/26/19	Fri 7/26/19
System Implementation	**588 days**	**Wed 8/7/19**	**Fri 11/5/21**

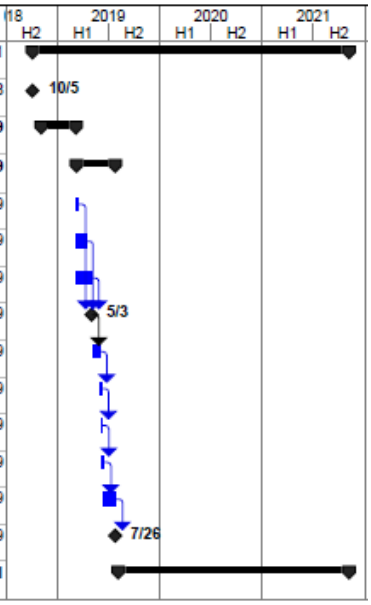

Figure 23 – System Procurement Schedule – Alternative 2

3.11.4 System Implementation Schedule

Figure 24 shows the tasks to be completed by the vendor, detailed system design, equipment installation, final testing and system acceptance.

Task Name	Duration	Start	Finish
Santa Barbara County LMR and Microwave Radio Upgrade Project - Upgrade Alternative 2	806 days	Fri 10/5/18	Fri 11/5/21
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	**90 days**	**Mon 11/5/18**	**Fri 3/8/19**
System Procurement	**100 days**	**Mon 3/11/19**	**Fri 7/26/19**
System Implementation	**588 days**	**Wed 8/7/19**	**Fri 11/5/21**
Implementation Kickoff Meeting with Vendor	1 day	Wed 8/7/19	Wed 8/7/19
Detailed Design	192 days	Thu 8/8/19	Fri 5/1/20
Site Acquisition/Lease Agreements	120 days	Thu 8/8/19	Wed 1/22/20
Equipment Manufacture and Factory Staging	60 days	Mon 5/4/20	Fri 7/24/20
Factory Acceptance Testing	10 days	Mon 7/27/20	Fri 8/7/20
Package and Ship Equipment	10 days	Mon 8/10/20	Fri 8/21/20
Equipment Installation, Testing and Cutover	422 days	Thu 1/23/20	Fri 9/3/21
LMR and Microwave RF Site Improvements	190 days	Mon 2/10/20	Fri 10/30/20
Microwave System	100 days	Mon 11/2/20	Fri 3/19/21
Dispatch Centers	**30 days**	**Mon 8/24/20**	**Fri 10/2/20**
Fire System	45 days	Mon 3/22/21	Fri 5/21/21
Shared UHF Trunked System	**422 days**	**Thu 1/23/20**	**Fri 9/3/21**
Coverage Testing	30 days	Mon 9/6/21	Fri 10/15/21
Final System Acceptance Test	15 days	Mon 10/18/21	Fri 11/5/21
LMR and MW Systems Accepted	0 days	Fri 11/5/21	Fri 11/5/21

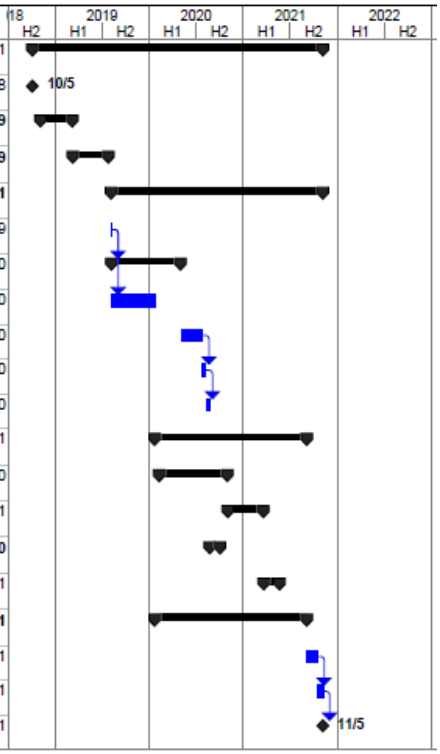

Figure 24 – System Implementation Schedule – Alternative 2

4. Alternative 3 – Dual-Band P25 Trunked Radio System

Alternative 3 includes the replacement of all existing equipment and the addition of radio sites and equipment to provide the required radio coverage for the Fire, Sheriff and LG LMR systems, as follows:

- Replace the existing two-channel Sheriff UHF system with a new four-channel UHF P25 digital trunked radio system for primary use by the Sheriff and all existing County LG system users (Fire and EMS would use it for interoperability communications, as needed) and for interoperability communications with other fire, law and emergency medical agencies in the County. Radio talkgroups would replace dedicated radio channels for intra-department, inter-department and interoperability communications needs using a common radio system, but still allowing each department to be autonomous, while improving the ability to interoperate, as needed

- Install new 700/800 MHz radio sites on the shared UHF trunked system to provide improved in-building coverage in urban areas (i.e. Lompoc area, and the Santa Barbara, Santa Ynez and Santa Maria valleys)

- Replace the existing six-channel Fire VHF conventional analog simulcast system with a new conventional analog simulcast system for primary use by Fire and EMS (EMS operations is moving to the Fire 1 channel) and for interoperability with other Local, County, State and Federal fire and EMS agencies. EMS communications with the hospitals would shift to the dual-band trunked system

4.1 Radio Coverage Analysis

FE performed a computer-based radio coverage assessment to identify the specific sites and equipment required to meet the County's coverage requirements.

4.1.1 Required Coverage

Refer to Section 2.1.1 for a description of the required coverage area.

4.1.2 Methodology

Refer to Section 2.1.2 for a description of the methodology ***FE*** used to conduct the radio coverage analysis.

4.1.3 Coverage Analysis Results – VHF Fire

The new Fire VHF system is the same for Alternative 3 as it is for Alternative 1. Refer to Section 2.1.3 for the coverage analysis results.

4.1.4 Coverage Analysis Results – Dual-Band Shared Trunked System

FE modeled the dual-band trunked system radio coverage assuming a digital P25 trunked simulcast system, with 12.5 kHz channel bandwidth, and building loss for in-inbuilding portable radio coverage, 12 dB for UHF and 10 dB for 700/800 MHz (consistent with light-office/residential building loss).

4.1.4.1 Selected Radio Sites

Based on the results of the coverage study and input received from the County at the coverage workshop, ***FE*** developed the final list of sites needed to meet the County's coverage and design targets. When selecting sites, ***FE*** prioritized existing County, existing non-County and greenfield (i.e., brand new) sites, in order of preference.

The sites selected and radio coverage for the UHF portion of the dual-band trunked system are the same as Alternative 2. Refer to Section 3.1.4.

Table 35 includes information for the 700/800 MHz RF sites selected for the dual-band trunked system and defines their simulcast configuration. Sites identified as "proposed new" in the Site Status column are sites which are currently not being used for any of the County LMR systems, but ***FE*** has included in the conceptual design for radio coverage improvement. Proposed new sites are highlighted in the table.

Table 35 – 700/800 MHz Sites for Dual-Band Trunked System

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Betteravia Bldg	Proposed New Tx/Rx	34.92173	-120.42889	ANT850Y10-WR / ANT850Y10-WR	700/800 Simulcast 2	50 / 50
Buellton Sheriff	Proposed New Rx	34.61373	-120.19594	None / Telewave ANT850F6	700/800 Rx-Only	None / 15
Chumash	Proposed New Tx/Rx	34.60802	-120.08757	Telewave ANT850F6 / Telewave ANT850F6	700/800 Stand-Alone	40 / 40
Cook Courthouse	Proposed New Tx/Rx	34.94857	-120.43238	Telewave ANT850F6 / Telewave ANT850F6	700/800 Simulcast 2	40 / 40

Site Name	Site Status	Latitude (Decimal – WGS84)	Longitude (Decimal – WGS84)	Antenna Model (TX / RX)	Simulcast Configuration	Antenna Height (ft.) (TX / RX)
Dispatch	Proposed New Tx/Rx	34.44409	-119.77607	Telewave ANT850F6 / Telewave ANT850F6	700/800 Simulcast 1	40 / 40
IV Foot Patrol	Proposed New Tx/Rx	34.41128	-119.85386	Telewave ANT850F6 / Telewave ANT850F6	700/800 Simulcast 1	30 / 30
Lompoc Civic Center	Proposed New Tx/Rx	34.63815	-120.45319	Telewave ANT850F6 / Telewave ANT850F6	700/800 Stand-Alone	60 / 60
Rincon	Existing Tx/Rx	34.37286	-119.42106	ANT850Y10-WR / SE414-SWBP2LDF(D00)	700/800 Simulcast 1	20 / 35
Solvang	Proposed New Rx	34.59658	-120.13550	None / Telewave ANT850F6	700/800 Rx-Only	None / 51
Vic Trace	Proposed New Tx/Rx	34.40564	-119.71505	SE414-SWBP2LDF(D00) / SE414-SWBP2LDF(D00)	700/800 Simulcast 1	60 / 60

4.1.4.2 Coverage Maps

Figures 25 and 26 are maps showing the predicted coverage for 700/800 MHz P25 trunked system.

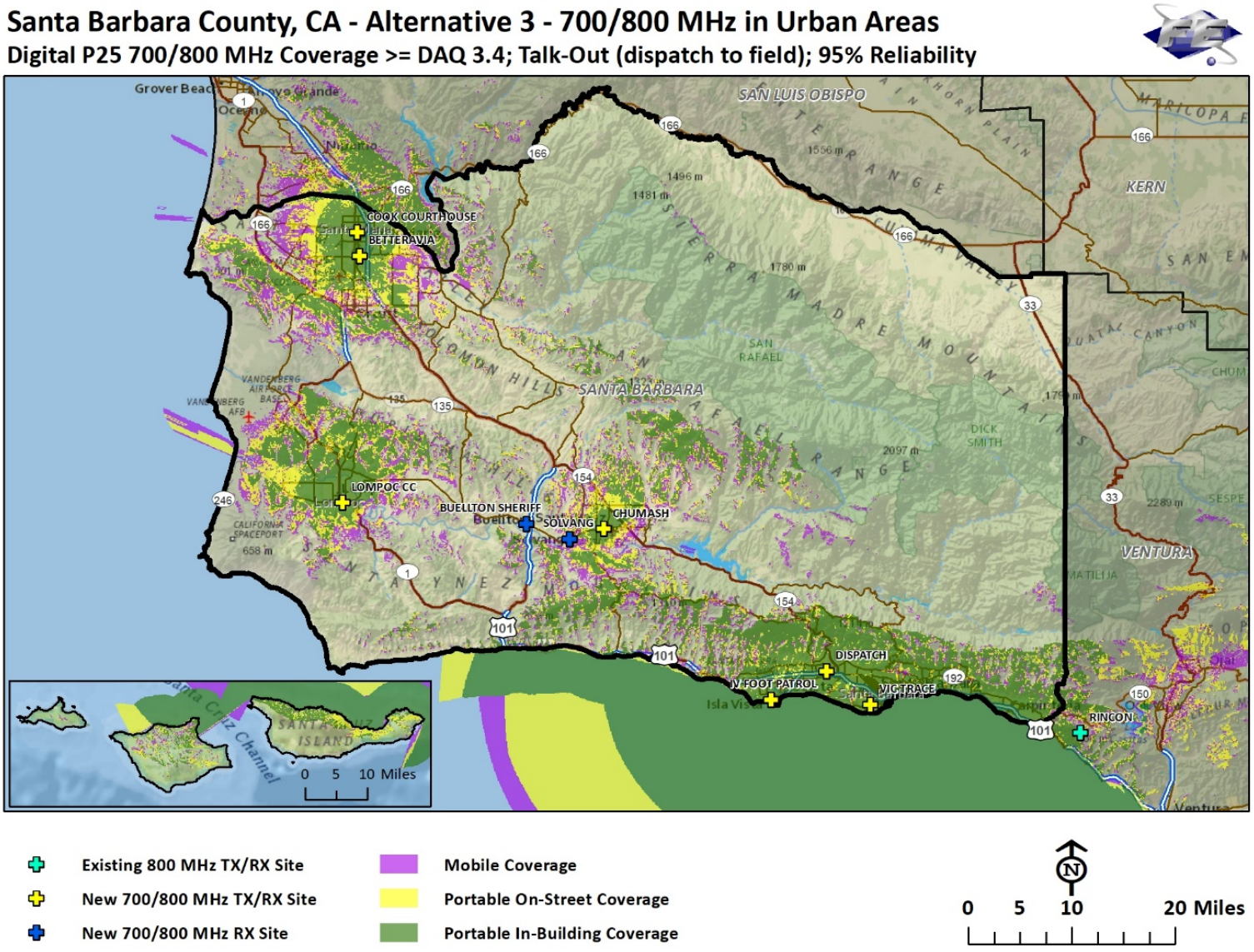

Figure 25 – 700/800 MHz P25 Trunked System – Talk-Out

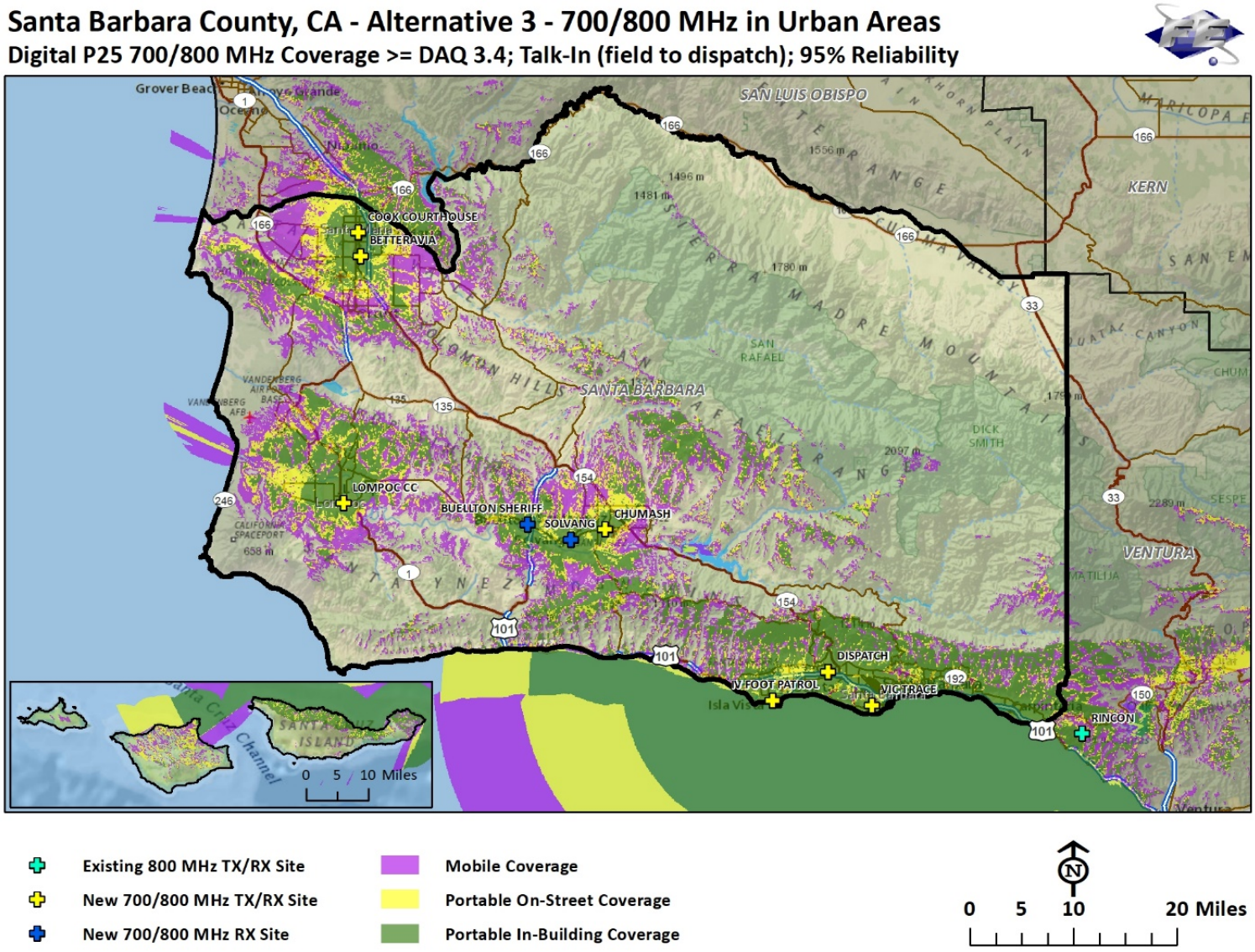

Figure 26 – 700/800 MHz P25 Trunked System – Talk-In

4.1.4.3 Simulcast Cells and Interference

The coverage maps and percentages presented in this section account for the possibility of TDI within the simulcast cells. Thus, ***FE*** believes that the system design presented here can be constructed, and the displayed coverage can be provided by the specified radio sites, provided the system manufacturer practices sound engineering to mitigate the possibility of TDI within the simulcast environment.

4.2 Channel Capacity Analysis

4.2.1 Methodology

FE used the same methodology as described in Section 3.2.1 for Alternative 2.

4.2.2 Results

The channel capacity requirements for the UHF portion of the dual-band trunked system are the same as for Alternative 2. Refer to Section 3.2.2.

The capacity requirements for the 700/800 MHz portion of the dual-band trunked system are the same as for the UHF portion, so that the channel capacity for the urban areas covered by 700/800 MHz are the same as the UHF channel capacity countywide. Therefore, all 700/800 MHz sites should have four channels.

4.3 LMR System Conceptual Design

Based on the results from the coverage and capacity analyses, this section provides a description of ***FE's*** conceptual design, including major system components for Alternative 3.

4.3.1 Design Criteria

The design criteria for Alternative 3 is the same as Alternative 2 (refer to Section 3.3.1), except for:

- The addition of 4-channel, 700/800 MHz RF sites to the shared UHF P25 Phase 2 trunked simulcast system for increased in-building coverage within the urban areas. Install the following new equipment:
    - Simulcast control and voting equipment at geographically diverse locations for redundancy
    - Site equipment (P25 Phase 2 digital repeaters and/or receivers)
    - Antenna systems (i.e. antennas, transmission lines, transmitter combiners and receiver multicouplers)
    - DC power systems
    - Grounding and lightning protection systems

- FCC licensing and coordination required for four new 700/800 MHz frequency pairs at the proposed urban sites

4.3.2 System Architecture

Figure 27 provides a high-level block diagram showing the architecture of the dual-band P25 trunked system. The Backhaul Network blocks shown in multiple areas of Figure 27 is a single network and is shown in detail in Figure 8, the microwave radio system logical architecture diagram.

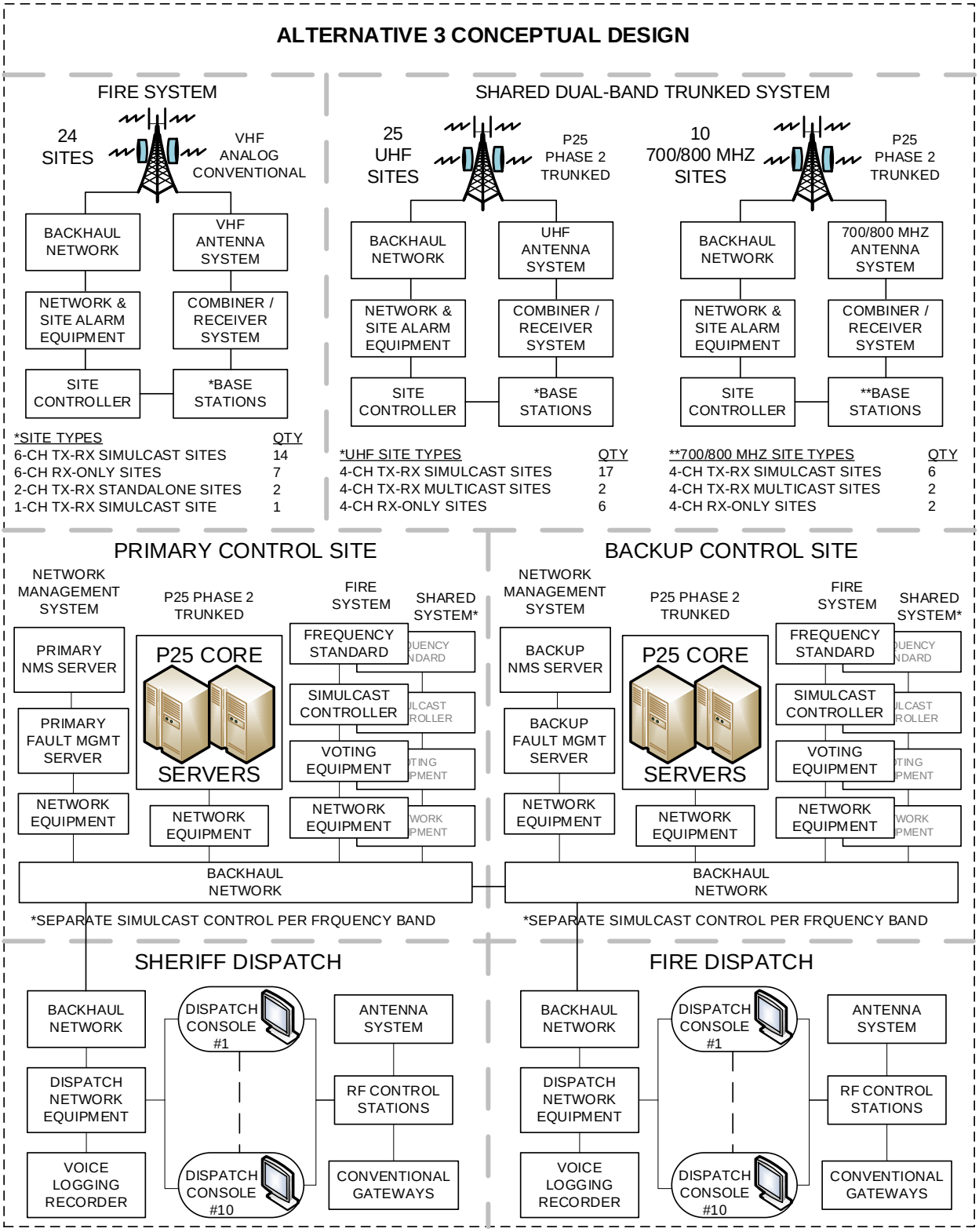

Figure 27 – Alternative 3 Conceptual Design

4.3.3 System Control Equipment

Refer to Section 3.3.3 for a description of the typical system control equipment as included with Alternative 2. The only difference with Alternative 3 is the additional licenses needed at the core to support the 700/800 MHz sites in the urban areas.

4.3.4 Simulcast and Voting Equipment

Refer to Section 3.3.4 for a description of the typical simulcast and voting equipment used for Alternative 2. The only difference with Alternative 3 is that three simulcast cells require the following equipment:

- Simulcast and voting equipment for a 6-channel Fire VHF analog conventional simulcast system
- Simulcast and voting equipment for a 4-channel Shared UHF P25 Phase 2 simulcast system
- Simulcast and voting equipment for a 4-channel Shared 700/800 MHz P25 Phase 2 simulcast system

Alternative 3 also includes redundant simulcast control and voting equipment at the Primary and Backup Control sites for each of the above simulcast cells.

4.3.5 Radio Site Equipment

Refer to Section 2.3.4 for a description of the typical radio site equipment. Differences with Alternative 3 include existing LG system users moving to the new shared countywide UHF trunked system and adding 700/800 MHz sites in the urban areas. The frequency band, number of channels, and configuration of base stations for Alternative 3 vary per system as follows:

- Fire – Six VHF analog conventional channels, requiring six base stations per site
- Shared System – Four UHF P25 Phase 2 trunked channels, requiring four base stations per site in non-urban areas
- Shared System – Four 700/800 MHz P25 Phase 2 trunked channels, requiring four base stations per site in urban areas

It is important to note that Med 10 is currently a State channel and would require licensing by the County for use as an additional UHF channel on the Sheriff trunked radio system.

4.3.6 Antenna Systems

Refer to Section 2.3.5 for a description of the typical antenna systems in the design. The difference is that Alternative 3 requires the following antenna systems:

- Fire System – VHF antenna systems at 17 transmit and receive sites and 7 receive-only sites
- Shared System – UHF antenna systems at 19 transmit and receive sites and 6 receive-only sites
- Shared System – 700/800 MHz antenna systems at 8 transmit and receive sites, and 2 receive-only sites in urban areas

4.3.7 System Features

The system features for the Fire VHF system would be the same as Alternative 1, as described in Section 2.3.6. System features for Alternative 3 would be the same as Alternative 2 (refer to Section 3.3.7), except that Alternative 3 would have the added capability for multi-band radios to roam seamlessly between the UHF sites and 700/800 MHz sites in the urban areas.

4.4 Dispatch

Refer to Section 2.4 for the dispatch conceptual design.

4.5 Subscriber Equipment

Sheriff and departments using the existing LG system would need to replace existing (end-of-life) subscriber units with mid-tier, multi-band radios with P25 Phase 2 trunking enabled. Fire would need to replace existing (end-of-life) subscriber units with mid-tier, single-band radios.

Subscriber replacement quantities provided in Alternative 1 are the same for Alternative 3 and have been adjusted to exclude radios that were recently purchased or will be purchased by Sheriff and Fire prior to the implementation of the new LMR systems. However, this alternative assumes replacement of existing radios with multi-band and P25 Phase 2 trunking capabilities. The radios also include optional features like AES encryption, OTAR, and OTAP. This approach provides a good average for budgetary purposes. While some agencies may purchase radios with added features, others may not. As part of the RFP, the County can specify the exact hardware and software

requirements for each department, which would allow the vendors to provide a more accurate cost proposal.

4.6 Microwave Backhaul Conceptual Design

Refer to Section 2.6 for the microwave backhaul conceptual design.

4.7 Network Management

Refer to Section 2.7 for the network management conceptual design.

4.8 Interoperability

4.8.1 Interoperability Continuum

Refer to Section 2.8.1 for a description of the Department of Homeland Security's Interoperability Continuum.

4.8.2 Interoperability Analysis

Looking at the DHS Interoperability Continuum, most County departments are meeting their interoperability needs through the sharing of radio channels with the other departments or agencies they interoperate with (i.e. they program the other agencies channels in their radios and vice versa). This works well for Fire because nearly all the fire agencies they need to interoperate with are also on the VHF Band. However, for Sheriff and EMS that are on UHF, and LG system users that are on 800 MHz, meeting their interoperability needs is more difficult. Table 36 shows how County departments currently interoperate with other departments or agencies in the County and how the Alternative 3 system upgrade would impact their ability to interoperate.

P25 digital trunked radio systems, as proposed for Alternative 3, the use of talkgroups allows users from different departments to communicate with each other. Although not included in the conceptual design, P25 digital trunked radio systems provide the following additional capabilities which can be implemented in the future:

- P25 digital trunked radio system allow connection to other P25 trunked radio systems (i.e. Santa Maria), allowing users on different systems to communicate with each other, regardless of frequency band, and if both systems are on the same frequency band users would be able to roam on the other system, as needed

- Gateways and console patches provide connectivity between a trunked P25 system and a conventional system

Table 36 – Radio Interoperability Comparison – Current vs. Alternative 3

County Department	Current Method	Alternative 3
Fire	1. All other agencies that Fire interoperates with also have VHF radio systems, so Fire programs the other agencies channels into their radios and vice versa. 2. Fire has some VHF/UHF dual-band portable radios, which they can use to communicate with the Sheriff. 3. Fire cannot interoperate with Santa Maria Fire because they moved to a 700 MHz trunked radio system	1. Fire would continue to be able to talk to other fire agencies in the County. 2. Fire would not be able to interoperate with the Sheriff unless they purchase multi-band P25-compatible subscriber units. 3. Fire would not be able to interoperate with Santa Maria Fire unless the purchase multi-band P25-compatible subscriber units.
EMS	1. EMS has UHF radios on their system and VHF radios to talk to County Fire and other fire agencies in the County. 2. EMS cannot communicate with Santa Maria Fire Department since they went to a 700 MHz trunked radio system. 3. Ambulances communicate with County base hospitals using standalone repeaters on Med 5, 6, 7 and 8 channels.	1. EMS is moving their operations to the County Fire 1 channel, which would improve their ability to interoperate with Fire and other fire agencies. 2. EMS radio users on the new dual-band trunked system (i.e. ambulances) would be able to communicate with Santa Maria Fire from their subscriber units. 3. Ambulances communications with the hospitals would move to the new dual-band trunked system. EMS would need to purchase new subscriber units that can operate on the new trunked radio system.
Sheriff	1. Sheriff currently interoperates with Santa Barbara police department (PD), Lompoc PD and San Luis Obispo Sheriff who also have UHF radio systems, by programming the other agencies channels in their radios and vice versa. 2. Sheriff can't interoperate with Santa Maria PD because they moved to a 700 MHz trunked system.	1. Sheriff would continue to be able to talk to other law enforcement agencies in the County on the UHF band and would be able to interoperate with agencies on the 700/800 MHz band, which they currently can't do. 2. Sheriff would be able to interoperate with Santa Maria using multi-band subscriber units.
Floods	1. Floods currently interoperates with Roads on the LG radio system. 2. Floods expressed interest in being able to interoperate with Sheriff and Fire, but, can't because they are on different frequency bands.	1. Floods would continue to be able to interoperate with Roads on the new dual-band P25 trunked system. 2. Floods would be able to interoperate with Sheriff on the new P25 trunked system but would require multi-band subscriber units to talk to Fire.

County Department	Current Method	Alternative 3
Parks	1. Parks would like to be able to interoperate with Fish and Wildlife and USFS but cannot because they are on a different frequency band; they currently use cell phones to talk to these agencies.	1. Parks would require multi-band subscriber units to talk to USFS and Fish and Wildlife.
Roads	1. Roads currently uses cell phones to talk to Caltrans. 2. Roads would like to be able to communicate with Floods.	1. Using multi-band subscriber units, Roads would be able to talk to Caltrans on their VHF High Band and 800 MHz systems. 2. Roads would be able to interoperate with Floods on the new dual-band P25 trunked system.
Public Health, Animal Services	1. Animal Services calls Dispatch to request that they monitor the LG 1 channel for after hours or emergency support. 2. Animal Services would like to be able to interoperate with CHP after hours but can't because CHP is on VHF Low Band.	1. Animal Services would be able to interoperate with Sheriff on the new dual-band P25 trunked system. 2. Animal Services would still not be able to interoperate with CHP.
District Attorney	1. The District Attorney (DA) uses cell phone or landline for most communications needs; they use the Sheriff system for operations with Sheriff deputies, for surveillance activities, and for mass casualties or disasters. 2. The DA needs radio interoperability with Santa Maria PD.	1. DA would be able to fully interoperate with the Sheriff on the new dual-band P25 trunked system. 2. DA would be able to interoperate with Santa Maria PD if they purchase multi-band radios for operation on the new dual-band P25 trunked system.
Probation	1. Probation uses the Sheriff radio system for primary operations and coordinate operations with Dispatch. 2. Probation needs to interoperate with Santa Maria PD but can't since Santa Maria PD moved to a 700 MHz trunked radio system. 3. Probation mostly uses cell phones but have radios for officer safety.	1. Probation would be able to interoperate with Sheriff on the new dual-band P25 trunked system. 2. Probation would be able to interoperate with Santa Maria PD if they purchase multi-band radios for operation on the new dual-band P25 trunked system. 3. Probation may choose to expand their radio use with the improved coverage and interoperability provided by the new dual-band P25 trunked system.

4.9 Cost Analysis

FE developed cost assumptions and budgetary estimates for the Alternative 3 conceptual design using the same methodology as the other two alternatives (refer to Section 2.9). The cost estimates prepared for the conceptual design reflect non-discounted (list)

pricing, an 8.75% Sales Tax on equipment hardware and software, and 10% contingency as requested by the County.

4.9.1 Cost Assumptions

Table 37 summarizes the cost assumptions that ***FE*** used for Alternative 3. Refer to Table 14 in Section 2.9 for notes referencing Alternative 1.

Table 37 – Alternative 3 System Assumptions

Alternative 3 Assumptions	QTY	Notes
General Assumptions		
Fire VHF System	1	Same as Alternative 1
LG 800 MHz System	N/A	LG migrates to Dual-Band Trunked System
EMS UHF System	N/A	EMS MED10 operation migrates to the Fire 1 channel. EMS operations on MED5, MED6, MED7 and MED8 migrates to the Shared UHF Trunked System
Microwave System	1	Same as Alternative 1
Network Management System	1	Same as Alternative 1
Sheriff/Fire Dispatch Center	1	Same as Alternative 1
Subscriber Equipment	1	Quantities same as Alternative 1, add multi-band P25 Phase 2 capability
Implementation Services	1	Same as Alternative 1
OPEX Assumptions	1	Same as Alternative 1
Shared Dual-Band Trunked System		
P25 Phase 2 Core Network Sites	2	Redundant / geographically separated with redundant networking equipment
Over the Air Rekeying Server	2	Hardware, software and licensing
Over the Air Programming Server	2	Hardware, software and licensing
GPS Application Interface	2	Hardware, software and licensing
Number of Simulcast Control Sites	6	Redundant / geographically separated; one UHF simulcast cell and two separate 700/800 MHz simulcast cells
UHF 4-CH Tx/Rx Simulcast Sites	19	Same as Alternative 2
UHF 4-CH Receive-Only Sites	6	Same as Alternative 2
UHF Tx/Rx Antenna System	19	Same as Alternative 2
UHF Rx-only Antenna System	6	Same as Alternative 2
7/800 MHz 4-CH Tx/Rx Simulcast Sites	6	Simulcast Cell 1: Dispatch, Rincon, IV Foot Patrol, Vic Trace Simulcast Cell 2: Cook Courthouse and Betteravia Bldg
7/800 MHz 4-CH Tx/Rx Multicast Sites	2	Chumash Casino (PG) and Lompoc Civic Center

Alternative 3 Assumptions	QTY	Notes
7/800 MHz 4-CH Rx-Only Equipment	2	Buellton Sheriff and Solvang
7/800 MHz Tx/Rx Antenna System	8	All new transmission lines, combiners, multicouplers, and antennas
7/800 MHz Rx-only Antenna System	2	All new transmission lines, combiners, multicouplers, and antennas
Site Networking Equipment	30	Routing and switching at each radio site
FCC licensing and coordination	104	Simulcast frequency pairs needed for expansion
ISSI Hardware and Software	1	Optional equipment for one ISSI connection
Site Improvements		
Tower Structural Analysis	10	Quantity based on site survey results and County feedback
Existing Site Renovations	12	Quantity based on site survey results and County feedback
New Self-Supported Tower	13	Quantity based on site survey results and County feedback
New Prefabricated Shelter	11	Quantity based on site survey results and County feedback
Generator/Transfer switch/fuel tank	13	Quantity based on site survey results and County feedback
Uninterruptible Power Supply (UPS)	12	Quantity based on site survey results and County feedback
A&E, Environmental Compliance	15	Per Industry Best Practices, new structure
Site Acquisition Cost	3	County provided estimate of $2,200,000

The microwave system and site improvements assumptions described in Section 2.9.1 for Alternative 1 apply to Alternative 3.

4.9.2 Fire System

The budgetary estimate for the Fire radio system equipment and services included in Section 2.9.2 for Alternative 1 is the same for Alternative 3.

4.9.3 Dual-Band System

Table 38 summarizes the estimated costs for the dual-band trunked system equipment and services.

Table 38 – Alternative 3 Dual-Band Trunked System Cost Estimate

Alternative 3 Shared Dual-Band Trunked System Cost Estimate			
Primary Core Network	*Quantity*	*Unit Cost*	*Extended Cost*
P25 Phase 2 Core Equipment	1	$962,000	$962,000
Core Networking Equipment	1	$147,000	$147,000
Over the Air Rekeying Server	1	$218,000	$218,000
Over the Air Programming Server	1	$33,000	$33,000
GPS Application Interface	1	$163,000	$163,000
Subtotal			**$1,523,000**
Backup Core Network	*Quantity*	*Unit Cost*	*Extended Cost*
P25 Phase 2 Core Equipment	1	$962,000	$962,000
Core Networking Equipment	1	$147,000	$147,000
Over the Air Rekeying Server	1	$218,000	$218,000
Over the Air Programming Server	1	$33,000	$33,000
GPS Application Interface	1	$163,000	$163,000
Subtotal			**$1,523,000**
Primary Simulcast Control	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	3	$69,000	$207,000
GPS Frequency Standard	3	$37,000	$111,000
Voting Equipment	6	$64,000	$384,000
Networking Equipment	3	$73,000	$219,000
Subtotal			**$921,000**
Backup Simulcast Control	*Quantity*	*Unit Cost*	*Extended Cost*
Simulcast Controller	3	$69,000	$207,000
GPS Frequency Standard	3	$37,000	$111,000
Voting Equipment	6	$64,000	$384,000
Networking Equipment	3	$73,000	$219,000
Subtotal			**$921,000**
Remote RF Site Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
UHF 4-CH Tx/Rx Simulcast Equipment	19	$258,000	$4,902,000
UHF 4-CH Receive-Only Equipment	6	$90,000	$540,000
UHF Tx/Rx Antenna System	19	$16,000	$304,000
UHF Rx-only Antenna System	6	$11,000	$66,000
7/800 MHz 4-CH Tx/Rx Simulcast Equipment	6	$249,000	$1,494,000
7/800 MHz 4-CH Tx/Rx Multicast Equipment	2	$222,000	$444,000
7/800 MHz 4-CH Rx-Only Equipment	2	$90,000	$180,000
7/800 MHz Tx/Rx Antenna System	8	$28,000	$224,000
7/800 MHz Rx-only Antenna System	2	$11,000	$22,000
Site Networking Equipment	30	$13,000	$390,000
Subtotal			**$8,566,000**
Equipment Subtotal			**$13,454,000**

Alternative 3 Shared Dual-Band Trunked System Cost Estimate			
FCC Licensing and Coordination	*Quantity*	*Unit Cost*	*Extended Cost*
LMR FCC License Fees	104		$24,000
LMR Frequency Coordination Fees	104		$50,000
LMR Engineering Services Fees	104		$24,000
Subtotal			**$98,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$673,000
Santa Barbara Sales Tax	8.75%		$1,178,000
Project Management	10%		$1,346,000
Installation	10%		$1,346,000
Engineering	10%		$1,346,000
Removal of Existing Equipment	2%		$270,000
Training	1%		$135,000
Staging	5%		$673,000
Acceptance Testing	1%		$135,000
Documentation	1%		$135,000
Contingency	10%		$1,346,000
Subtotal			**$8,583,000**
Services Total			**$8,681,000**
Equipment and Services Total			**$22,135,000**

4.9.4 Microwave System

The budgetary estimate for the microwave system equipment and services included in Section 2.9.6 for Alternative 1 is the same for Alternative 3.

4.9.5 Network Management System

The budgetary estimate for the NMS equipment and services included in Section 2.9.7 for Alternative 1 is the same for Alternative 3.

4.9.6 Site Improvements

With the additional 700/800 MHz sites, Alternative 3 has additional site improvements. Table 39 shows the estimated site improvements costs for Alternative 3. Refer to Table 14 for detailed breakdown of the required improvements for the sites in Alternative 3.

Table 39 – Alternative 3 Site Improvements Cost Estimate

Alternative 3 Site Improvements Cost Estimate			
Site Improvements	*Quantity*	*Unit Cost*	*Extended Cost*
Tower Structural Analysis	10	$5,000	$50,000
Existing Site Renovations	12	$15,000	$180,000
New Self-Supported Tower	13	$283,000	$3,679,000
New Prefabricated Shelter	11	$109,000	$1,199,000
Generator/Transfer switch/fuel tank	13	$30,000	$390,000
UPS (20 KVA 208V 2-hour runtime)	12	$30,000	$360,000
A&E, Environmental Compliance	15	$14,000	$210,000
Subtotal			**$6,068,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Spare / Test Equipment	5%		$304,000
Santa Barbara Sales Tax	8.75%		$531,000
Project Management	10%		$607,000
Installation	10%		$607,000
Engineering	10%		$607,000
Removal of Existing Equipment	2%		$122,000
Training	1%		$61,000
Staging	5%		$304,000
Acceptance Testing	1%		$61,000
Documentation	1%		$61,000
Contingency	10%		$531,000
Services Total			**$3,796,000**
Site Acquisition Cost	3		$2,200,000
Equipment and Services Total			**$12,064,000**

4.9.7 Dispatch System

The budgetary estimate for the dispatch equipment and services included in Section 2.9.9 for Alternative 1 is the same for Alternative 3.

4.9.8 Subscriber Equipment

The subscriber quantities provided in Alternative 1 are the same for Alternative 3. However, the cost estimate is higher due to multi-band capability and additional software and licensing required for Alternative 3. Table 40 shows the estimated costs for subscriber equipment and services.

Table 40 – Alternative 3 Subscriber Equipment Cost Estimate

Alternative 3 Subscriber Equipment Cost Estimate			
Subscriber Equipment	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	658	$6,500	$4,277,000
Portable Radios	736	$6,000	$4,416,000
Control Stations	44	$8,000	$352,000
Subtotal (Rounded)			**$9,045,000**
Implementation Services	*Quantity*	*Unit Cost*	*Extended Cost*
Radio Programming	1438	$100	$143,800
Radio Installation	702	$200	$140,400
Subtotal (Rounded)			**$285,000**
Equipment and Services Total			**$9,330,000**
Contingency	10%		$933,000
Total (with Contingency)			**$10,263,000**

Appendix A provides a detailed breakdown of each departments subscriber unit costs.

4.9.9 Cost Summary

Table 41 summarizes the total cost for Alternative 3, including LMR, microwave, NMS, dispatch, subscribers, and site improvements.

Table 41 – Alternative 3 Total Cost Estimate

Alternative 3 Total Cost Estimate			
Item	*Equipment*	*Services*	*Total Cost*
Fire VHF Radio System	$3,386,000	$2,186,000	$5,572,000
Shared Dual-Band Trunked System	$13,454,000	$8,681,000	$22,135,000
Digital Microwave System	$3,265,000	$1,817,000	$5,082,000
Network Management System	$820,000	$526,000	$1,346,000
Site Civils / Improvements	$6,068,000	$3,796,000	$9,864,000
Site Acquisition Cost	$0	$2,200,000	$2,200,000
Sheriff Dispatch	$866,000	$557,000	$1,423,000
Fire Dispatch	$866,000	$557,000	$1,423,000
Subscriber Equipment	$9,045,000	$1,218,000	$10,263,000
Total	**$37,770,000**	**$21,538,000**	**$59,308,000**

4.9.10 Optional Costs

The budgetary estimate for the P25 ISSI equipment and services included in Section 3.9.10 for Alternative 2 is the same for Alternative 3.

4.9.11 Operational Costs

Table 42 summarizes the 15-year operational cost estimate for Alternative 3. The estimate does not include the optional equipment nor any current operational expenses such as LMR and microwave system maintenance contracts, site maintenance, site leases, staff salaries, or other recurring expenditures. The estimate includes only the new LMR, microwave, NMS, dispatch center, and subscriber equipment that are part of this alternative.

Table 42 – Alternative 3 15-Year Operational Cost Estimate

Alternative 3 Operating Costs Estimate					
Operating Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Technical Support	$0	$0	$0	$647,000	$667,000
Software/Hardware Upgrades	$0	$0	$0	$1,294,000	$1,333,000
Subscriber Growth	$0	$222,000	$226,000	$230,000	$235,000
Subscriber Attrition	$0	$111,000	$113,000	$113,000	$115,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$0**	**$333,000**	**$339,000**	**$2,284,000**	**$2,350,000**
Operating Costs	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Technical Support	$688,000	$709,000	$731,000	$753,000	$776,000
Software/Hardware Upgrades	$1,373,000	$1,415,000	$1,458,000	$1,502,000	$1,548,000
Subscriber Growth	$239,000	$244,000	$249,000	$255,000	$260,000
Subscriber Attrition	$116,000	$116,000	$118,000	$119,000	$120,000
Subscriber Refresh	$0	$0	$0	$0	$10,263,000
Estimated Annual Cost	**$2,416,000**	**$2,484,000**	**$2,556,000**	**$2,629,000**	**$12,967,000**
Operating Costs	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
Technical Support	$800,000	$824,000	$849,000	$875,000	$902,000
Software/Hardware Upgrades	$1,595,000	$1,643,000	$1,693,000	$1,744,000	$1,797,000
Subscriber Growth	$265,000	$270,000	$275,000	$280,000	$286,000
Subscriber Attrition	$121,000	$123,000	$124,000	$125,000	$127,000
Subscriber Refresh	$0	$0	$0	$0	$0
Estimated Annual Cost	**$2,781,000**	**$2,860,000**	**$2,941,000**	**$3,024,000**	**$3,112,000**

4.10 Migration Strategy

The general migration strategy for Alternative 3 is the same as Alternative 1. Refer to Section 2.10.1.

4.10.1 Fire VHF Migration

The Fire VHF migration for Alternative 3 is the same as Alternative 1. Refer to Section 2.10.2.

4.10.2 Shared Dual-Band Trunked System Migration

The Shared UHF Trunked System migration described in Alternative 2 applies to Alternative 3 (refer to Section 2.10.3). A key difference with the dual-band trunked system migration is the increased effort required for site readiness and installation of additional 700/800 MHz hardware in urban areas, which the County could complete as a second phase after the UHF trunked system implementation. The awarded vendor could install, test and optimize the 700/800 MHz system while the UHF system remains fully operational. To address the in-building coverage requirement and to maintain the desired grade of service, the conceptual design includes the following 700/800 MHz sites:

- Buellton Sheriff: Rx-only, four 700/800 MHz channels
- Chumash Casino Parking Garage: multicast, four 700/800 MHz channels
- Dispatch: Simulcast Cell 1, four 700/800 MHz channels
- Rincon: Simulcast Cell 1, four 700/800 MHz channels
- Solvang: Rx-only, four 700/800 MHz channels
- Cook Courthouse: Simulcast Cell 2, four 700/800 MHz channels
- Betteravia: Simulcast Cell 2, four 700/800 MHz channels
- Lompoc Civic Center: multicast, four 700/800 MHz channels
- IV Foot Patrol: Simulcast Cell 1, four 700/800 MHz channels
- Vic Trace: Simulcast Cell 1, four 700/800 MHz channels

To achieve the same channel capacity in-building as on-street, the 700/800 MHz sites would have four channels just like the UHF sites. The dual-band trunked system provides a control channel and three RF channels per site, yielding six voice paths on each frequency band.

With the new digital trunked system and multi-band radios, radio users would not need to manually switch to new channels when roaming between UHF and 700/800 MHz coverage footprints or between simulcast and multicast footprints. This operation would be seamless and transparent to the users when programmed correctly at the core and in the subscriber units. Re-use of 700/800 MHz frequencies at different sites may be possible, but it is also possible that each simulcast cell and/or multicast site would need

their own unique channels. Based on 700/800 MHz frequency availability, licensing new channels at the new sites should be feasible.

Migration to the dual-band trunked system would depend heavily on the awarded vendor design, technology and experience. However, a migration plan based on the conceptual design for this alternative would require the following major tasks, with the first five tasks common for all County radio systems:

- Replace the Comm Center site as a primary control site, with implementation of a geo-redundant backup control site (both the primary and backup sites to be determined)
- Site readiness, including but not limited to improvements to site grounding, backup generator(s), shelter/equipment rooms, and towers (in compliance with TIA-222, latest revision)
- Procuring and deploying RF infrastructure equipment to replace and expand the existing backhaul system
- Procuring and deploying infrastructure equipment to replace the existing dispatch equipment, including logging recorder, dispatch consoles, RF control stations, and implementation of a backup dispatch center
- Procuring and deploying infrastructure equipment to replace and expand the existing network management system
- FCC licensing and coordination for additional UHF frequency pairs at existing sites and new frequency pairs at new UHF and 700/800 MHz sites
- Procuring and deploying infrastructure equipment to replace the existing Sheriff UHF and LG 800 MHz systems with a dual-band trunked system
- Procuring and deploying new multi-band radios for all agencies (except Fire) that may use the dual-band trunked system
- Complete coverage testing per requirements to be specified in the RFP
- Complete fleetmapping and training (technical and operator), with the latter being as close to cutover as possible
- Preliminary acceptance and functional testing of the shared dual-band trunked system and subscriber equipment

- Migration and cutover of radio users, by user groups, from the existing systems to the dual-band trunked system
- Final testing and acceptance of the dual-band trunked system
- Finalize system and project documentation
- Decommissioning of the existing Sheriff UHF, EMS UHF and LG 800 MHz systems
- Punch list resolution and project closeout

Agencies currently using the existing Sheriff UHF or LG 800 MHz systems would have to procure and deploy new multi-band radios that can operate on UHF and 700/800 MHz, with P25 Phase 2 trunking software and licensing.

4.10.3 Microwave Backhaul Migration

The microwave backhaul migration strategy for Alternative 3 is the same as Alternative 1. Refer to Section 2.10.5.

4.11 Project Implementation Schedule

Following is the implementation schedule for the upgrade of the County's LMR and Public Safety Microwave Radio System, showing the projected sequence and duration of tasks and the dependencies between the tasks.

4.11.1 Overall Project Implementation Schedule

Project implementation follows the delivery of this report, the *County of Santa Barbara Land Mobile and Microwave Radio Conceptual Design*. Figure 28 is the overall schedule, showing major project phases and timeframes, including the development of the RFP, system procurement and system implementation.

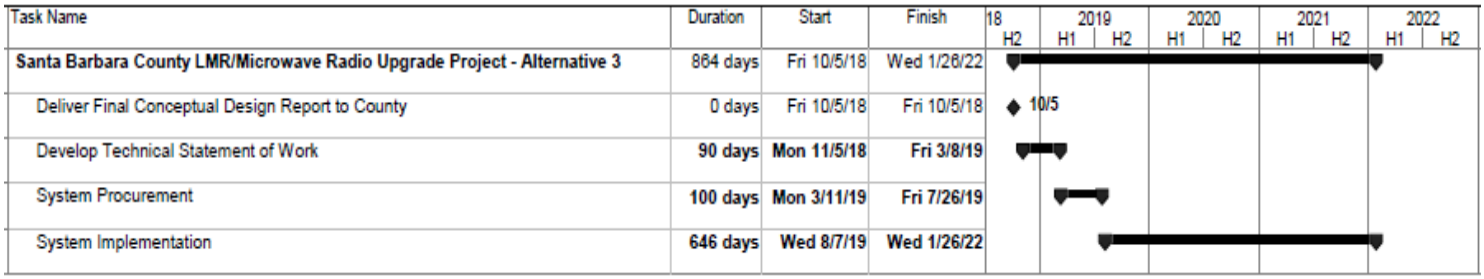

Figure 28 – Overall Implementation Schedule – Alternative 3

4.11.2 RFP Development Schedule

Figure 29 is a breakdown of the tasks required to produce the RFP, beginning with the development of the technical statement of work (SOW) and ending with the inclusion of the SOW into the County's RFP.

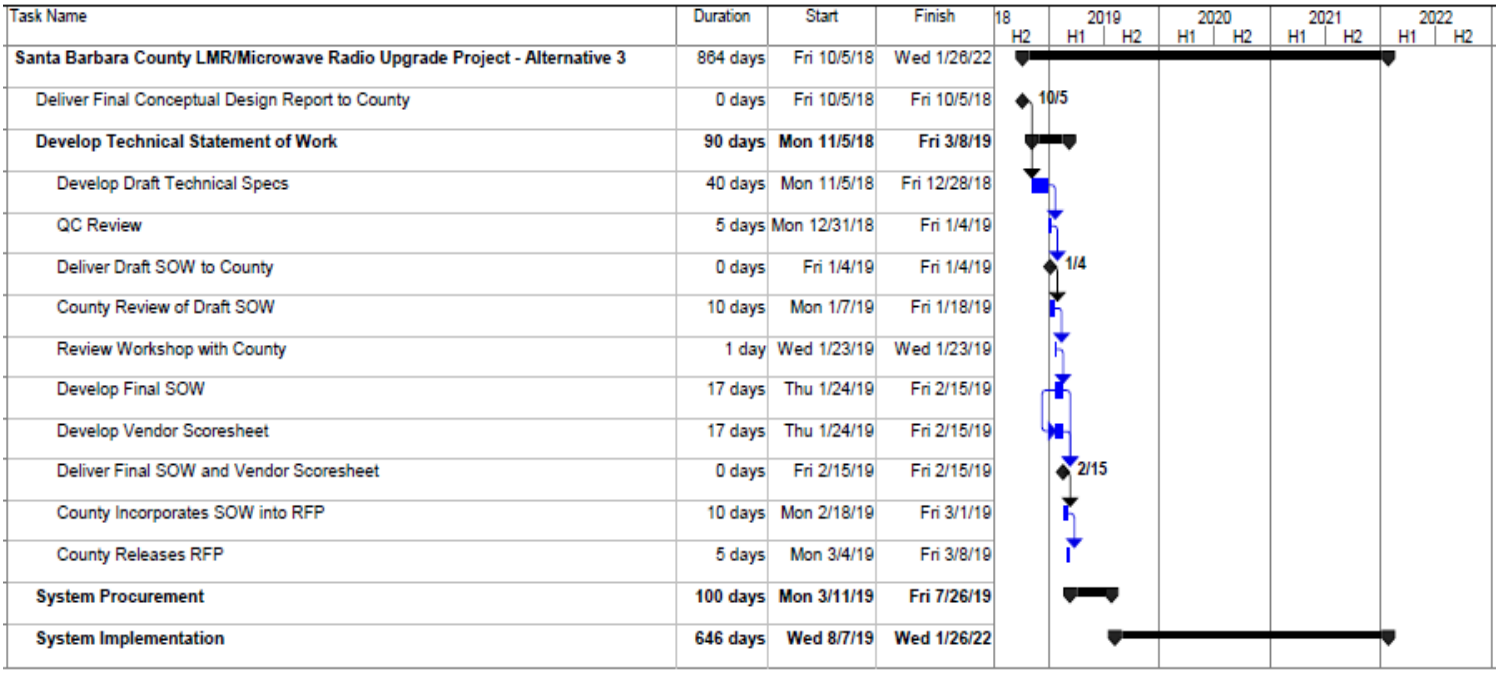

Figure 29 – RFP Development Schedule – Alternative 3

4.11.3 System Procurement Schedule

Figure 30 shows the tasks required to procurement the new LMR and microwave radio backhaul systems, beginning with the release of the RFP by the County and ending with a negotiated contract with the selected vendor.

Task Name	Duration	Start	Finish
Santa Barbara County LMR/Microwave Radio Upgrade Project - Alternative 3	864 days	Fri 10/5/18	Wed 1/26/22
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	**90 days**	**Mon 11/5/18**	**Fri 3/8/19**
System Procurement	**100 days**	**Mon 3/11/19**	**Fri 7/26/19**
Pre-Bid Meeting/Site Visits	4 days	Tue 3/12/19	Fri 3/15/19
Respond to Bidder Questions	25 days	Mon 3/11/19	Fri 4/12/19
Bidder Proposal Development	40 days	Mon 3/11/19	Fri 5/3/19
Bidder Proposals Due	0 days	Fri 5/3/19	Fri 5/3/19
Vendor Proposal Review	20 days	Mon 5/6/19	Fri 5/31/19
Vendor Presentations	2 days	Wed 6/5/19	Thu 6/6/19
Evaluation Meeting	1 day	Fri 6/7/19	Fri 6/7/19
Vendor Selection	5 days	Mon 6/10/19	Fri 6/14/19
Vendor Contract Negotiation	30 days	Mon 6/17/19	Fri 7/26/19
Vendor Contract Execution	0 days	Fri 7/26/19	Fri 7/26/19
System Implementation	**646 days**	**Wed 8/7/19**	**Wed 1/26/22**

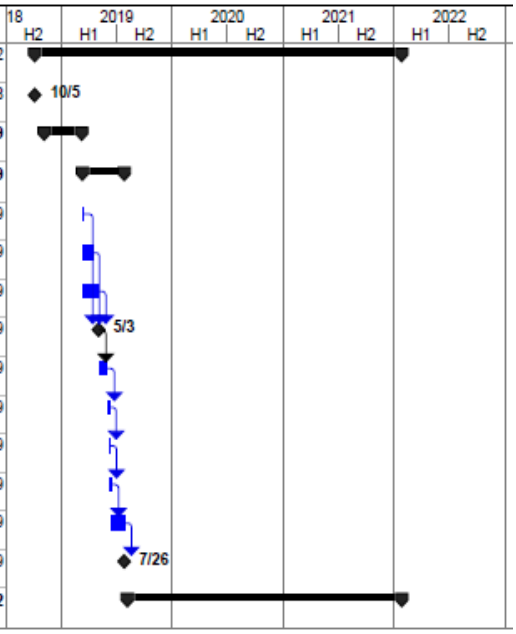

Figure 30 – System Procurement Schedule – Alternative 3

4.11.4 System Implementation Schedule

Figure 31 shows the tasks to be completed by the vendor, detailed system design, equipment installation, final testing and system acceptance.

Task Name	Duration	Start	Finish
Santa Barbara County LMR/Microwave Radio Upgrade Project - Alternative 3	864 days	Fri 10/5/18	Wed 1/26/22
Deliver Final Conceptual Design Report to County	0 days	Fri 10/5/18	Fri 10/5/18
Develop Technical Statement of Work	**90 days**	**Mon 11/5/18**	**Fri 3/8/19**
System Procurement	**100 days**	**Mon 3/11/19**	**Fri 7/26/19**
System Implementation	**646 days**	**Wed 8/7/19**	**Wed 1/26/22**
Implementation Kickoff Meeting with Vendor	1 day	Wed 8/7/19	Wed 8/7/19
Detailed Design	192 days	Thu 8/8/19	Fri 5/1/20
Site Acquisition/Lease Agreements	120 days	Thu 8/8/19	Wed 1/22/20
Equipment Manufacture and Factory Staging	60 days	Mon 5/4/20	Fri 7/24/20
Factory Acceptance Testing	10 days	Mon 7/27/20	Fri 8/7/20
Package and Ship Equipment	10 days	Mon 8/10/20	Fri 8/21/20
Equipment Installation, Testing and Cutover	480 days	Thu 1/23/20	Wed 11/24/21
LMR and Microwave RF Site Improvements	190 days	Mon 2/10/20	Fri 10/30/20
Microwave System	100 days	Mon 11/2/20	Fri 3/19/21
Dispatch Centers	**30 days**	**Mon 8/24/20**	**Fri 10/2/20**
Fire System	45 days	Mon 3/22/21	Fri 5/21/21
Shared Dual-Band Trunked System	**480 days**	**Thu 1/23/20**	**Wed 11/24/21**
Coverage Testing	30 days	Thu 11/25/21	Wed 1/5/22
Final System Acceptance Test	15 days	Thu 1/6/22	Wed 1/26/22
LMR and MW Systems Accepted	0 days	Wed 1/26/22	Wed 1/26/22

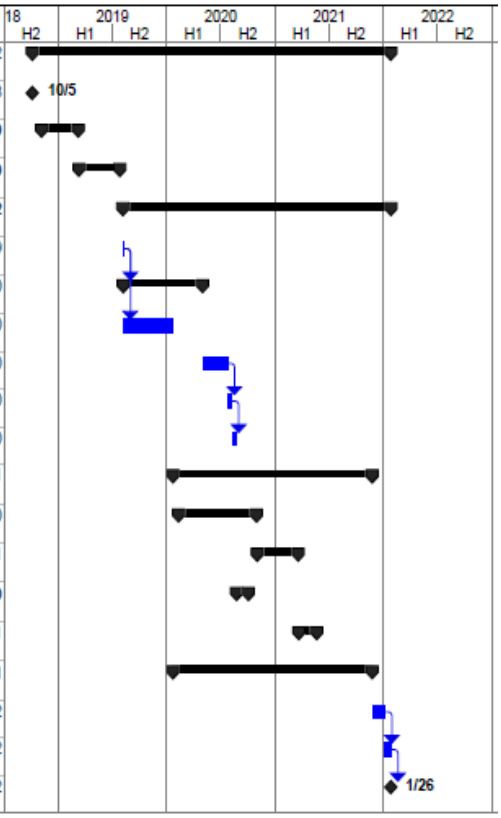

Figure 31 – System Implementation Schedule – Alternative 3

5. LMR Alternatives Comparison

As described throughout this report, ***FE*** began by evaluating the existing County LMR and Public Safety Microwave Radio systems and worked with County stakeholders to identify requirements for the system upgrade in Phase 1 of the project. This analysis led ***FE,*** with input from the County, to develop the following alternatives for consideration:

- **Alternative 1** – Upgrade the existing Fire, Sheriff and LG LMR systems. Alternative 1 does not include the upgrade of the EMS UHF system (Med 10 channel) because EMS operations is moving to the Fire 1 channel. However, Alternative 1 includes the replacement of the standalone repeaters for the Med 5, 6, 7 and 8 channels

- **Alternative 2** – Replace the existing Sheriff, EMS and LG LMR systems with a countywide shared UHF P25 digital trunked radio system and upgrade the existing 6-channel Fire VHF system for continued use by Fire and EMS (EMS is moving operations to the Fire 1 channel). EMS communications with the hospitals would shift to the UHF trunked system

- **Alternative 3** – Replace the existing Sheriff, EMS and LG LMR systems with a countywide shared dual-band P25 digital trunked radio system and upgrade the existing 6-channel Fire VHF system for continued use by Fire and EMS (EMS is moving operations to the Fire 1 channel). EMS communications with the hospitals would shift to the dual-band trunked system

Each LMR alternative includes all new equipment (i.e. radios, antenna systems and DC power), additional sites to provide the necessary radio coverage, and site improvements (i.e. new towers/equipment shelters and grounding and lightning protection system upgrades) to support the new LMR and microwave radio systems. The conceptual design for each alternative also addresses issues and vulnerabilities identified by County stakeholders by:

- Improving radio coverage for mobile radios and on-street portable radios

- Providing additional channel capacity for the Sheriff

- Removing the Comm Center as an LMR site

- Adding a backup dispatch center

- Redesigning the Public Safety Microwave Radio System architecture to provide redundant paths to key LMR sites and to provide connectivity to new LMR sites

- Adding a geographically diverse backup simulcast control and/or trunked system core site
- Adding a network management system to remotely monitor and troubleshoot LMR and microwave radio sites, and for equipment configuration, software updates and alarm reporting
- Providing options for improved interoperability

The following sections provide a comparison of the three alternatives.

5.1 Radio Coverage

Table 43 is a comparison of the radio coverage for each of the three alternatives as it applies to Fire, Sheriff, EMS and LG radio system users.

Table 43 – LMR Alternatives Radio Coverage Comparison

System	Alternative 1	Alternative 2	Alternative 3
Fire VHF	Fire VHF radio system upgrade is the same for all three alternatives and it would provide much improved coverage over what currently exists. FE added sites to the existing Fire VHF system based on input from County stakeholders to provide coverage in areas that currently do not have it.		
Sheriff UHF	Radio coverage improvements for the Sheriff are the same with Alternative 1 and 2, with both providing much improved coverage over the existing analog system by moving to digital P25 systems and by adding new radio sites to supplement coverage.		Alternative 3 is a dual-band (UHF and 700/800 MHz) digital P25 trunked radio system with countywide UHF coverage the same as Alternatives 1 and 2. However, with the addition of 700/800 MHz RF sites in urban areas (i.e. Santa Maria, Santa Ynez Valley and Santa Barbara areas), Alternative 3 provides improved in-building portable radio coverage over the other two alternatives.

System	Alternative 1	Alternative 2	Alternative 3
EMS	EMS is moving radio operations to the Fire 1 channel, so they would have the same coverage as described above for Fire. The repeaters for Med 5, 6, 7 and 8 would be replaced with new repeaters and would continue to provide communications between ambulances and the hospitals.	EMS is moving radio operations to the Fire 1 channel, so they would have the same coverage as described above for Fire. Ambulance communications with the hospitals would be shifted to the new UHF trunked system, so the coverage is as described in Alternative 2 for the Sheriff.	
LG	The addition of several RF sites to the LG system would provide improved radio coverage over the current system.	LG system users would shift to the shared countywide trunked radio system, so coverage would be the same as described in Alternatives 2 and 3 for the Sheriff.	

5.2 Channel Capacity

Table 44 compares the channel capacity requirements for each of the three alternatives as it applies to Fire, Sheriff, EMS and LG radio system users.

Table 44 – Comparison of LMR Channel Capacity Requirements

System	Alternative 1	Alternative 2	Alternative 3
Fire VHF	The existing Fire VHF analog conventional system has six channels, which is sufficient for Fire operations. Alternatives 1, 2 and 3 would also be VHF analog conventional systems (with new equipment) and would also utilize six channels.		
Sheriff UHF	The existing Sheriff UHF conventional system has two channels, Ops 1 for dispatch operations and Ops 2 for administrative traffic. Alternative 1 would add two channels to that, with one channel for North County operations and the other for South County operations.	The Sheriff would shift to a four-channel (one control channel and six voice paths) shared trunked system, which would provide improved operations and less channel congestion.	

System	Alternative 1	Alternative 2	Alternative 3
EMS	EMS is moving radio operations to the Fire 1 channel, so no additional channels are required. They would continue the use of standalone repeaters for ambulance communications with the hospitals (Med 5, 6, 7 and 8 channels).	EMS is moving radio operations to the Fire 1 channel, so no additional channels are required. Ambulance communications with the hospitals would shift to the new shared trunked system.	
LG	LG would continue to operate with the same two channels as the existing system.	LG system users would shift to the shared countywide trunked radio system, which would provide improved operations and less channel congestion.	

5.3 Technology

Table 45 compares system functionality and features for the LMR upgrade alternatives.

Table 45 – LMR Technology Comparison

	Alternative 1	Alternative 2	Alternative 3
Technology Type	Fire system would use analog conventional simulcast technology, which meets a critical need to be able to interoperate with other fire agencies in the County that are on VHF conventional analog systems. Sheriff and LG users would transition from analog conventional to digital conventional systems, which would provide some additional features (i.e. encryption) but would still be using older technology (i.e. conventional).	Fire system would use analog conventional simulcast technology, which meets a critical need to be able to interoperate with other fire agencies in the County that are on VHF conventional analog systems. Sheriff and current LG system users would transition to a new standards-based digital P25 trunked radio system.	
Channel Efficiency	Fire, Sheriff and LG systems would remain conventional, requiring one channel per talk path.	Fire system would remain conventional, requiring one channel per talk path. New 4-channel digital P25 trunked radio system would provide two talk paths per channel (six total), with one channel used as the trunking control channel.	

	Alternative 1	Alternative 2	Alternative 3
Channel Congestion	Alternative 1 utilizes conventional radio systems, where each channel is assigned for a specific user group (i.e. Roads, Floods and Animal Health) and/or function (i.e. operations and administrative), can result in inefficient channel use, where some channels are heavily loaded, and others are lightly loaded.	Alternatives 2 and 3 utilize trunked systems, which assign channels to pre-assigned user groups (talkgroups) on demand, which results in more efficient channel use and eliminates the situation where some channels are heavily loaded and other are lightly loaded.	
Roaming	Radio users must manually switch their radios when transitioning from a simulcast area into and out of an area covered by a standalone repeater.	Manual intervention is not required by users when moving into and out of a multicast coverage area, it is done automatically by the system.	Manual intervention is not required by users when moving into and out of a multicast coverage area or moving between UHF and 700/800 MHz coverage areas, it is done automatically by the system.
Upgradability	Full system changeout may be required to upgrade to a P25 trunked system, depending on the awarded vendor and the base station/repeater model deployed.	The only additional equipment that would be required to transition from a UHF trunked system to a dual-band trunked system would be the 700/800 MHz RF site equipment in the urban areas. All existing system core/control equipment would be reusable. The purchase of new 700/800 MHz equipment could be more expensive if the vendor knows it is a sole source, but the RFP can be written to lock in the equipment cost to a preset timeframe.	Being a dual-band trunked radio system, the only upgrade that may be required during the lifespan of the system would be additional 700/800 MHz RF sites to expand in-building portable radio coverage.
Priority Access	Priority user access is not available on conventional systems.	Multiple levels of priority user access are available on P25 trunked radio systems.	
Voice Quality	The digital conventional P25 Sheriff and LG systems would provide improved audio quality as compared to their existing analog conventional systems.	The use of digital P25 technology would provide improved audio quality as compared to existing analog conventional systems.	

	Alternative 1	Alternative 2	Alternative 3
System Features	The digital P25 conventional Sheriff and LG systems would provide additional features, such as encryption and over-the-air programming, as compared to existing analog systems.	A P25 trunked radio system would provide many additional features as compared to an analog conventional system, such as encryption, over-the-air programming, over-the-air rekeying, GPS location, user authentication and remote radio inhibit.	

5.4 Dispatch

The dispatch design is the same for all three alternatives; there will be Sheriff and Fire dispatch centers that will back each other up. Locations to be determined.

5.5 Microwave Backhaul

The microwave backhaul design is the same for all three alternatives; LMR sites are connected to the primary and backup dispatch, and primary and backup simulcast control/system core sites by an IP/MPLS microwave backhaul system, with path redundancy to all key sites. Leased T1 lines connect other LMR sites (i.e. small Tx/Rx and Rx-only) to the primary and backup simulcast control/system core sites.

5.6 Network Management System

The NMS design is the same for all three alternatives, providing access to all microwave and LMR site for activities such as system configuration, performance monitoring, system troubleshooting, software updates and alarm reporting.

5.7 Interoperability

Table 46 compares the ability and effectiveness of each alternative to meet the interoperability needs of Fire, Sheriff, EMS and LG radio system users.

Table 46 – LMR System Interoperability Comparison

System	Alternative 1	Alternative 2	Alternative 3
Fire VHF	As with their existing system, Fire would continue to interoperate with other fire agencies in the County by programming their channels into the Fire subscriber units and vice versa. However, Fire would need to purchase multi-band P25-compatible radios to interoperate with Sheriff and Santa Maria Fire.		
Sheriff UHF	Sheriff would continue to be able to talk to other law enforcement agencies on the UHF Band. Sheriff is purchasing multi-band P25-compatible subscriber units that would allow them to talk to Santa Maria PD on their 700 MHz system.	Sheriff would continue to be able to talk to other law enforcement agencies on the UHF Band. Sheriff is purchasing multi-band P25-compatible subscriber units that would allow them to talk to Santa Maria PD on their 700 MHz system.	
EMS	EMS is moving their operations to the County Fire 1 channel, which would improve their ability to interoperate with Fire and other fire agencies. EMS would need purchase multi-band P25-compatible subscriber units to talk to Santa Maria Fire. Ambulances would continue to communicate to the hospitals on the Med 5, 6, 7 and 8 channels.	EMS is moving their operations to the County Fire 1 channel, which would improve their ability to interoperate with Fire and other fire agencies. EMS would need purchase multi-band P25-compatible subscriber units to talk to Santa Maria Fire. Ambulances communications with the hospitals would shift to the new trunked system.	
LG	LG system users would continue to be able to interoperate with other LG system users but would need to purchase multi-band radios to interoperate with agencies in other bands (i.e. Sheriff and Fire).	Current LG system users would continue to be able to interoperate with other current LG system users. Current LG system users would be able to interoperate with the Sheriff but would require new multi-band subscriber units to talk to Fire.	Current LG system users would continue to be able to interoperate with other current LG system users. Current LG system users would be able to interoperate with the Sheriff and would be able to talk to Fire using new multi-band subscriber units.

5.8 Cost

Table 47 provides a side-by-side comparison of the cost estimates for all three alternatives.

Table 47 – Alternatives Cost Estimate Comparison

Alternatives Cost Estimate Comparison			
Item	*Alternative 1*	*Alternative 2*	*Alternative 3*
LMR System			
Fire VHF Radio System	$5,572,000	$5,572,000	$5,572,000
Sheriff UHF Radio System	$5,587,000	N/A	N/A
LG 800 MHz Radio System	$2,696,000	N/A	N/A
EMS UHF Radio System	$355,000	N/A	N/A
Shared UHF Trunked System	N/A	$15,480,000	N/A
Shared Dual-Band Trunked System	N/A	N/A	$22,135,000
Subtotal	**$14,210,000**	**$21,052,000**	**$27,707,000**
Microwave System			
Digital Microwave System	$5,082,000	$5,082,000	$5,082,000
Network Management System	$1,346,000	$1,346,000	$1,346,000
Subtotal	**$6,428,000**	**$6,428,000**	**$6,428,000**
Dispatch Centers			
Sheriff Dispatch	$1,423,000	$1,423,000	$1,423,000
Fire Dispatch	$1,423,000	$1,423,000	$1,423,000
Subtotal	**$2,846,000**	**$2,846,000**	**$2,846,000**
Site Civils / Improvements	**$9,053,000**	**$9,053,000**	**$9,864,000**
Site Acquisition Cost	**$2,200,000**	**$2,200,000**	**$2,200,000**
Subscriber Equipment	**$6,309,000**	**$7,100,000**	**$10,263,000**
Total	**$41,046,000**	**$48,679,000**	**$59,308,000**

Alternative 1 is the least expensive option, however, it does not provide the same capabilities as the other two. Alternative 2 is approximately $7.6 million more than Alternative 1, but it provides a countywide shared trunked system with additional capacity and features. Alternative 3 is approximately $10.6 million more than Alternative 2, but it provides multi-band radios and improved in-building coverage in urban areas.

5.9 Overall Comparison

Table 48 compares the key aspects of the three upgrade alternatives that ***FE*** used to make a recommendation.

Table 48 – Overall Comparison of LMR Alternatives[7]

	Alternative 1	Alternative 2	Alternative 3
Channel Congestion	• Use conventional systems with specific channel assignments that often results in some channels being very busy while others are lightly loaded	√ • Use trunked technology which assigns channels on demand, resulting in more efficient channel use and avoids the scenario where some channels are heavily loaded while others are lightly loaded	
Technology Type	• Fire would continue to use analog conventional technology • Sheriff and LG systems would use digital conventional technology providing some additional features	√ • Fire system would continue to use analog conventional technology • Sheriff and current LG system users would use a UHF P25 trunked radio system	
Features	• The P25 digital conventional systems used for the Sheriff and LG systems would provide some additional features, such as encryption	√ P25 trunked radio systems would provide many additional features over the County's existing analog systems, such as: • Encryption • Over-the-air programming • Over-the-air rekeying • GPS location • User authentication • Remote radio inhibit	
Interoperability	• Fire, Sheriff and LG system users would continue to use shared channels with interoperability partners	√ • Use P25 trunked radio systems that provide the highest level of interoperability, allowing full interoperability between all system users • The County P25 system could be connected to other P25 systems for interoperability (i.e. Santa Maria 700 MHz system)	
Voice Quality	• The Sheriff and LG conventional P25 digital systems would provide improved audio quality as compared to the County's existing analog conventional systems	√ • P25 digital trunked systems would provide improved audio quality as compared to the County's existing conventional analog systems	

[7] Checkmarks placed under the alternative(s) represent the best solution for each of the comparison criteria.

	Alternative 1	Alternative 2	Alternative 3
Priority System Access	• Priority user access is not available on conventional systems	√ • Multiple levels of priority user access are available on P25 trunked systems	
Radio Coverage	• Includes additional sites for improved radio coverage, with the primary focus on mobile and on-street portable coverage	• Includes additional sites for improved radio coverage, with the primary focus on mobile and on-street portable coverage	√ • Includes additional sites for improved radio coverage, with the primary focus on mobile and on-street portable coverage • Includes additional 700/800 MHz sites in urban areas to improve in-building portable coverage
Roaming	• Requires radio users to switch channels when transitioning between simulcast and standalone repeater areas	√ • System automatically switches channels as users transition between simulcast and multicast areas	√ • System automatically switches channels as users transition between simulcast and multicast areas or between UHF and 700/800 MHz areas
LMR Upgradeability	• All three systems would most likely require a complete equipment changeout to transition to a standards-based P25 trunked system in the future	√ • Upgrading from the UHF trunked system in Alternative 2 to the dual-band trunked system in Alternative 3 would require additional 700/800 MHz RF sites in the urban areas	• A potential upgrade that may be required for the lifespan of the system would be additional 700/800 MHz sites to further improve in-building portable radio coverage
Dispatch	√ • All alternatives include upgraded equipment at Sheriff Dispatch and Fire Dispatch		
NMS	√ • A new NMS would be provided for all three alternatives, providing remote access to all microwave and LMR sites for system configuration, performance monitoring, system troubleshooting, software updates and alarm reporting		
Microwave Backhaul	√ • The microwave backhaul upgrade would be the same for all three alternatives, providing improved system redundancy and reliability		
Subscriber Units	• Systems require single-band subscriber units	√ • Trunked system requires single-band subscriber units	• Trunked system requires more expensive multi-band (UHF and 700/800 MHz) subscriber units
Cost	√ $41,046,000	$48,679,000	$59,308,000

6. Recommendation

Based on the existing system assessment, requirements analysis and understanding of the County's long-term planning goals, ***FE*** recommends the County of Santa Barbara consider implementing Alternative 2. As additional funding becomes available, the County can add 700/800 MHz sites for improved in-building coverage in urban areas, as described for Alternative 3. ***FE's*** recommendation is based on the following factors:

- The UHF P25 trunked system in Alternative 2 is the latest, standards-based LMR technology
- The shared UHF P25 trunked radio system in Alternative 2 would have less channel congestion (i.e. busies) than the conventional systems in Alternative 1. A P25 Phase 2 trunked radio system provides two talk paths per channel as compared to one talk path per channel for conventional systems and due to system automation, trunked radio systems are more efficient in the way that they assign radio channels
- Migration from the conventional systems in Alternative 1 to the P25 trunked radio system in Alternative 2 in the future would most likely require a full system changeout
- Alternative 2 substantially addresses stakeholder requirements for an estimated cost of $48.7 million, which is $10.6 million less than Alternative 3
- Alternative 2 allows for a phased approach for the County to move towards Alternative 3, where the County implements new technology for the UHF trunked and microwave radio systems; and after an evaluation period, can expand the system for improved in-building coverage as identified in Alternative 3

In addition, Alternative 2 addresses issues and vulnerabilities identified by County stakeholders by:

- Improving radio coverage for mobile radios and on-street portable radios
- Providing additional channel capacity for the Sheriff
- Removing the Comm Center as an LMR site
- Adding a backup dispatch center

- Redesigning the Public Safety Microwave Radio System architecture to provide redundant paths to key LMR sites and to provide connectivity to new LMR sites
- Adding a geographically diverse backup simulcast control and/or trunked system core site
- Adding a network management system to remotely monitor and troubleshoot LMR and microwave radio sites, and for equipment configuration, software updates and alarm reporting
- Providing options for improved interoperability

Next Steps

Once the County chooses an upgrade alternative and obtains approval from the County Board of Supervisors, the next step would be for the County to commit funding for the selected alternative and prepare a Request for Proposals (RFP) for the procurement, installation and testing of the new system.

Appendix A - Detailed Subscriber Costs

This appendix provides a detailed breakdown of subscriber equipment services cost for each alternative on a departmental basis.

Table A.1 – Alternative 1 Subscriber Cost Estimates

Alternative 1 Subscriber Cost Estimates			
CEO	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	6	$4,000	$24,000
Portable Radios	5	$3,500	$17,500
Control Stations	2	$5,500	$11,000
Radio Programming	13	$100	$1,300
Radio Installation	8	$200	$1,600
Subtotal			**$55,400**
Courts	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	0	$4,000	$0
Portable Radios	36	$3,500	$126,000
Control Stations	0	$5,500	$0
Radio Programming	36	$100	$3,600
Radio Installation	0	$200	$0
Subtotal			**$129,600**
District Attorney	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	13	$4,000	$52,000
Portable Radios	13	$3,500	$45,500
Control Stations	0	$5,500	$0
Radio Programming	26	$100	$2,600
Radio Installation	13	$200	$2,600
Subtotal			**$102,700**
Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	150	$4,000	$600,000
Portable Radios	0	$3,500	$0
Control Stations	22	$5,500	$121,000
Radio Programming	172	$100	$17,200
Radio Installation	172	$200	$34,400
Subtotal			**$772,600**
General Services	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	13	$4,000	$52,000
Portable Radios	34	$3,500	$119,000
Control Stations	0	$5,500	$0
Radio Programming	47	$100	$4,700
Radio Installation	13	$200	$2,600

Alternative 1 Subscriber Cost Estimates			
Subtotal			**$178,300**
Parks	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	9	$4,000	$36,000
Portable Radios	32	$3,500	$112,000
Control Stations	2	$5,500	$11,000
Radio Programming	43	$100	$4,300
Radio Installation	11	$200	$2,200
Subtotal			**$165,500**
Probation	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	16	$4,000	$64,000
Portable Radios	142	$3,500	$497,000
Control Stations	0	$5,500	$0
Radio Programming	158	$100	$15,800
Radio Installation	16	$200	$3,200
Subtotal			**$580,000**
Public Health - Animal Control	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	12	$4,000	$48,000
Portable Radios	18	$3,500	$63,000
Control Stations	0	$5,500	$0
Radio Programming	30	$100	$3,000
Radio Installation	12	$200	$2,400
Subtotal			**$116,400**
Public Health - EMS	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	5	$4,000	$20,000
Portable Radios	21	$3,500	$73,500
Control Stations	1	$5,500	$5,500
Radio Programming	27	$100	$2,700
Radio Installation	6	$200	$1,200
Subtotal			**$102,900**
Public Works - Flood Control	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	41	$4,000	$164,000
Portable Radios	10	$3,500	$35,000
Control Stations	3	$5,500	$16,500
Radio Programming	54	$100	$5,400
Radio Installation	44	$200	$8,800
Subtotal			**$229,700**
Public Works - Resource Recovery	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	47	$4,000	$188,000
Portable Radios	66	$3,500	$231,000
Control Stations	0	$5,500	$0
Radio Programming	113	$100	$11,300

Alternative 1 Subscriber Cost Estimates			
Radio Installation	47	$200	$9,400
Subtotal			**$439,700**
Public Works - Roads	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	85	$4,000	$340,000
Portable Radios	23	$3,500	$80,500
Control Stations	3	$5,500	$16,500
Radio Programming	111	$100	$11,100
Radio Installation	88	$200	$17,600
Subtotal			**$465,700**
Public Works (Miscellaneous)	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	0	$4,000	$0
Portable Radios	3	$3,500	$10,500
Control Stations	0	$5,500	$0
Radio Programming	3	$100	$300
Radio Installation	0	$200	$0
Subtotal			**$10,800**
Sheriff	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	261	$4,000	$1,044,000
Portable Radios	333	$3,500	$1,165,500
Control Stations	11	$5,500	$60,500
Radio Programming	605	$100	$60,500
Radio Installation	272	$200	$54,400
Subtotal			**$2,384,900**
Total (Rounded)			**$5,735,000**
Contingency	10%		$574,000
Total (with Contingency)			**$6,309,000**

Table A.2 – Alternative 2 Subscriber Cost Estimates

Alternative 2 Subscriber Cost Estimates			
CEO	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	6	$4,500	$27,000
Portable Radios	5	$4,000	$20,000
Control Stations	2	$6,000	$12,000
Radio Programming	13	$100	$1,300
Radio Installation	8	$200	$1,600
Subtotal			**$61,900**
Courts	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	0	$4,500	$0
Portable Radios	36	$4,000	$144,000
Control Stations	0	$6,000	$0
Radio Programming	36	$100	$3,600
Radio Installation	0	$200	$0
Subtotal			**$147,600**
District Attorney	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	13	$4,500	$58,500
Portable Radios	13	$4,000	$52,000
Control Stations	0	$6,000	$0
Radio Programming	26	$100	$2,600
Radio Installation	13	$200	$2,600
Subtotal			**$115,700**
Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	150	$4,500	$675,000
Portable Radios	0	$4,000	$0
Control Stations	22	$6,000	$132,000
Radio Programming	172	$100	$17,200
Radio Installation	172	$200	$34,400
Subtotal			**$858,600**
General Services	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	13	$4,500	$58,500
Portable Radios	34	$4,000	$136,000
Control Stations	0	$6,000	$0
Radio Programming	47	$100	$4,700
Radio Installation	13	$200	$2,600
Subtotal			**$201,800**
Parks	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	9	$4,500	$40,500
Portable Radios	32	$4,000	$128,000
Control Stations	2	$6,000	$12,000

Alternative 2 Subscriber Cost Estimates			
Radio Programming	43	$100	$4,300
Radio Installation	11	$200	$2,200
Subtotal			**$187,000**
Probation	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	16	$4,500	$72,000
Portable Radios	142	$4,000	$568,000
Control Stations	0	$6,000	$0
Radio Programming	158	$100	$15,800
Radio Installation	16	$200	$3,200
Subtotal			**$659,000**
Public Health - Animal Control	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	12	$4,500	$54,000
Portable Radios	18	$4,000	$72,000
Control Stations	0	$6,000	$0
Radio Programming	30	$100	$3,000
Radio Installation	12	$200	$2,400
Subtotal			**$131,400**
Public Health - EMS	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	5	$4,500	$22,500
Portable Radios	21	$4,000	$84,000
Control Stations	1	$6,000	$6,000
Radio Programming	27	$100	$2,700
Radio Installation	6	$200	$1,200
Subtotal			**$116,400**
Public Works - Flood Control	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	41	$4,500	$184,500
Portable Radios	10	$4,000	$40,000
Control Stations	3	$6,000	$18,000
Radio Programming	54	$100	$5,400
Radio Installation	44	$200	$8,800
Subtotal			**$256,700**
Public Works - Resource Recovery	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	47	$4,500	$211,500
Portable Radios	66	$4,000	$264,000
Control Stations	0	$6,000	$0
Radio Programming	113	$100	$11,300
Radio Installation	47	$200	$9,400
Subtotal			**$496,200**
Public Works - Roads	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	85	$4,500	$382,500
Portable Radios	23	$4,000	$92,000

Alternative 2 Subscriber Cost Estimates			
Control Stations	3	$6,000	$18,000
Radio Programming	111	$100	$11,100
Radio Installation	88	$200	$17,600
Subtotal			**$521,200**
Public Works (Miscellaneous)	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	0	$4,500	$0
Portable Radios	3	$4,000	$12,000
Control Stations	0	$6,000	$0
Radio Programming	3	$100	$300
Radio Installation	0	$200	$0
Subtotal			**$12,300**
Sheriff	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	261	$4,500	$1,174,500
Portable Radios	333	$4,000	$1,332,000
Control Stations	11	$6,000	$66,000
Radio Programming	605	$100	$60,500
Radio Installation	272	$200	$54,400
Subtotal			**$2,687,400**
Total (Rounded)			**$6,454,000**
Contingency	10%		$646,000
Total (with Contingency)			**$7,100,000**

Table A.3 – Alternative 3 Subscriber Cost Estimates

Alternative 3 Subscriber Cost Estimates			
CEO	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	6	$6,500	$39,000
Portable Radios	5	$6,000	$30,000
Control Stations	2	$8,000	$16,000
Radio Programming	13	$100	$1,300
Radio Installation	8	$200	$1,600
Subtotal			**$87,900**
Courts	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	0	$6,500	$0
Portable Radios	36	$6,000	$216,000
Control Stations	0	$8,000	$0
Radio Programming	36	$100	$3,600
Radio Installation	0	$200	$0
Subtotal			**$219,600**
District Attorney	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	13	$6,500	$84,500
Portable Radios	13	$6,000	$78,000
Control Stations	0	$8,000	$0
Radio Programming	26	$100	$2,600
Radio Installation	13	$200	$2,600
Subtotal			**$167,700**
Fire	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	150	$6,500	$975,000
Portable Radios	0	$6,000	$0
Control Stations	22	$8,000	$176,000
Radio Programming	172	$100	$17,200
Radio Installation	172	$200	$34,400
Subtotal			**$1,202,600**
General Services	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	13	$6,500	$84,500
Portable Radios	34	$6,000	$204,000
Control Stations	0	$8,000	$0
Radio Programming	47	$100	$4,700
Radio Installation	13	$200	$2,600
Subtotal			**$295,800**
Parks	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	9	$6,500	$58,500
Portable Radios	32	$6,000	$192,000

Alternative 3 Subscriber Cost Estimates			
Control Stations	2	$8,000	$16,000
Radio Programming	43	$100	$4,300
Radio Installation	11	$200	$2,200
Subtotal			**$273,000**
Probation	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	16	$6,500	$104,000
Portable Radios	142	$6,000	$852,000
Control Stations	0	$8,000	$0
Radio Programming	158	$100	$15,800
Radio Installation	16	$200	$3,200
Subtotal			**$975,000**
Public Health - Animal Control	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	12	$6,500	$78,000
Portable Radios	18	$6,000	$108,000
Control Stations	0	$8,000	$0
Radio Programming	30	$100	$3,000
Radio Installation	12	$200	$2,400
Subtotal			**$191,400**
Public Health - EMS	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	5	$6,500	$32,500
Portable Radios	21	$6,000	$126,000
Control Stations	1	$8,000	$8,000
Radio Programming	27	$100	$2,700
Radio Installation	6	$200	$1,200
Subtotal			**$170,400**
Public Works - Flood Control	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	41	$6,500	$266,500
Portable Radios	10	$6,000	$60,000
Control Stations	3	$8,000	$24,000
Radio Programming	54	$100	$5,400
Radio Installation	44	$200	$8,800
Subtotal			**$364,700**
Public Works - Resource Recovery	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	47	$6,500	$305,500
Portable Radios	66	$6,000	$396,000
Control Stations	0	$8,000	$0
Radio Programming	113	$100	$11,300
Radio Installation	47	$200	$9,400
Subtotal			**$722,200**
Public Works - Roads	*Quantity*	*Unit Cost*	*Extended Cost*

Alternative 3 Subscriber Cost Estimates			
Mobile Radios	85	$6,500	$552,500
Portable Radios	23	$6,000	$138,000
Control Stations	3	$8,000	$24,000
Radio Programming	111	$100	$11,100
Radio Installation	88	$200	$17,600
Subtotal			**$743,200**
Public Works (Miscellaneous)	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	0	$6,500	$0
Portable Radios	3	$6,000	$18,000
Control Stations	0	$8,000	$0
Radio Programming	3	$100	$300
Radio Installation	0	$200	$0
Subtotal			**$18,300**
Sheriff	*Quantity*	*Unit Cost*	*Extended Cost*
Mobile Radios	261	$6,500	$1,696,500
Portable Radios	333	$6,000	$1,998,000
Control Stations	11	$8,000	$88,000
Radio Programming	605	$100	$60,500
Radio Installation	272	$200	$54,400
Subtotal			**$3,897,400**
Total (Rounded)			**$9,330,000**
Contingency	10%		$933,000
Total (with Contingency)			**$10,263,000**

Appendix B - Microwave Radio Path Profiles and Calculations

Appendix C - Glossary

AC	Alternating Current
AES	Advanced Encryption Standard (successor of DES) will be a new Federal Information Processing Standard (FIPS) Publication that will specify a cryptographic algorithm for use by U.S. Government organizations to protect sensitive (unclassified) information. NIST also anticipates that the AES will be widely used on a voluntary basis by organizations, institutions, and individuals outside of the U.S. Government (see FIPS 140-1).
Agency	Term that applies generically to any local, state, federal entity or organization, such as; a department, division, city/town, or bureau. Includes: government, quasi-government and private groups.
Analog	Radio signal that uses continuous changes in the amplitude or frequency of a radio transmission to convey information.
ANSI	American National Standards Institute
APCO	Association of Public-Safety Communications Officials
AVL	Automatic Vehicle Location
backhaul	The transporting of radio communications traffic between distributed sites (i.e. LMR base stations, dispatch center and control/core sites)
band	The spectrum between two defined limited frequencies
bandwidth	The capacity of a telecom line or channel to carry signals. The necessary bandwidth is the amount of spectrum required to transmit the, signal without distortion or loss of information. FCC rules require suppression of the signal outside the band to prevent interference. *High-Level Final Statewide Public Safety Communications Interoperability* Plan, December 04, Page 159
base station	A fixed, land station in the land mobile service (*e.g.*, the radio located at a fire or police station that either communicates directly or through a repeater to field subscriber units).
blocked call	Whenever there are insufficient channels to grant a communication request, usually indicated by a fast busy signal.
bps	Bits per second.

CAI	The P25 Common Air Interface (CAI) enables over-the-air interoperability between P25 radios regardless of manufacturer. If another agency in the County had a P25 radio system, the County could program their P25 mobile and portable radios with talkgroups on the other P25 system, and vice versa.
channel	The route through which a message is sent. A connection between initiating and terminating nodes of a circuit. A single path provided by a transmission medium via an electrical separation, such as by frequency or frequency pairs.
conventional	A radio system with dedicated, single-purpose channels (can be shared between several users with different operational needs; *i.e.,* fire and police), user must select the specific channel to be used.
coverage	The geographic area included within the range of a wireless radio system.
CPC	Channel Performance Criterion
CSSI	Console Subsystem Interface
DAQ	Delivered Audio Quality, a subjective measure of the quality of audio transmissions. A DAQ of 3.4 is the target for public safety communications; meaning speech understandable with repetition only rarely required (some noise/distortion).
data throughput	the average rate of successful message delivery over a communication channel
dB	Decibel
DC	Direct Current
dead spot	Geographic area within the normal coverage envelope where signals are below specification for minimal quality (also: blind spot).
DHS	Department of Homeland Security (federal)
digital	Radio transmission method, replacing analog FM systems, that transmits binary 1's and 0's much like a computer. Generally digital signals can travel greater distances (better coverage), however once the signal levels are below minimum no communications are possible. As data is normally digital, data transmissions are very compatible with digital. *High-Level Final Statewide Public Safety Communications Interoperability Plan*, December 04, Page 161

	radios. Digital radios are generally small and consume significantly less power (longer battery life) than FM radios.
dropped call	Radio call that is unintentionally discounted due to a system problem, lack of channel availability, or dead spot in coverage.
dual band	Radio equipment that operates on two frequency bands.
dual mode	Radio equipment that operates on both analog and digital networks.
EIA	Electronic Industries Alliance (publisher of standards)
EMS	Emergency Medical Service
encryption	The reversible transformation of data from the original (plain text) to a difficult to interpret format as a mechanism for protecting its confidentiality, integrity and sometimes its authenticity. Encryption uses an encryption algorithm and one or more encryption keys.
Ethernet	A number of wiring and signaling standards providing a means of network access and a common addressing format. Ethernet is standardized as IEEE 802.3. Ethernet also refers to the combination of the twisted pair versions of Ethernet for connecting end systems to the network, along with the fiber optic versions for site backbones, is the most widespread, wired LAN technology.
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FIPS	Federal Information Processing Standard
FIPS 140-1	Federal Information Processing Standard, U.S. government standard for implementations of cryptographic modules, that is, hardware or software that encrypts and decrypts data or performs other cryptographic operations (such as creating or verifying digital signatures). The FIPS 140-1 standard was created by the National Institute of Standards and Technology (NIST); it specifies requirements for the proper design and implementation of products that do cryptography.
Four 9's	A two-way annual microwave radio path availability of 99.99%
Five 9's	A two-way annual microwave radio path availability of 99.999%
FM	Frequency modulation, whereby a signal transmission is constant in signal strength, but the center frequency varies in proportion to the

	voice being transmitted; eliminates most interference sources. Used for public safety communications since the 1940s replacing AM - now being replaced by digital modulation. Note FM gradually fades away as signal strength is reduced by distance from the transmitter.
frequency	The number of cycles or events of a periodic process in a unit of time. High-Level Final Statewide Public Safety Communications Interoperability Plan December 04 Page 162
LMR frequency bands	The spectrum of transmission space where mobile radio systems operate in the United States. They are (from low to high): Low VHF 30-50 MHz High VHF 150-174 MHz Low UHF 450-470 MHz 700 MHz 764-776 & 7940806 MHz 800 MHz 806-869 MHz
gateway	A device that can transparently interconnect radio audio paths so that agencies can patch into each other's radio channels in real time. This can be done at the baseband level or using IP. A gateway provides interconnection between two networks with different communications protocols.
GHz	gigahertz (1 billion hertz)
GoS	Grade of Service
GPS	Global Positioning System, a U.S. satellite system that lets persons/systems determine their position with extreme accuracy using GPS receivers, used by AVL technologies.
handoff	Process that automatically switches a user from the original tower site to an adjacent site with better signal quality.
HVAC	Heating Ventilation and Air Conditioning
Hz	Hertz (same as cycles per second)
ID	Identification
IEEE	Institute of Electrical and Electronic Engineers

IETF	Internet Engineering Task Force
infrastructure	Dedicated telecommunications networks; the hardware and software needed to complete and maintain a public safety communications system.
interference	Extraneous energy, from natural or man-made sources, that impedes the reception of desired signals.
Interoperability	A property referring to the ability of diverse systems and organizations to work together (inter-operate). In public safety, the ability of personnel to exchange voice and data communications with staff from other agencies, on demand and in real time.
IP	Internet Protocol
ISSI	The P25 Inter-RF Subsystem Interface (ISSI) interconnects different P25 cores, regardless of frequency band or manufacturer, to allow roaming of user radios between networks. ISSI supports many common P25 features, including Caller ID, group calls, encryption and emergency calls. A user roaming into a foreign system must have radios which are on the same frequency or multi-band compatible with the foreign host.
kbps	Kilo bytes per second
kHz	kilo Hertz (1000 Hertz)
Land mobile radio	A public or private radio service providing two-way communication, service paging and radio signaling on land.
LG	Local Government
LMR	Land Mobile Radio
Mbps	Mega bit per second (1 million bits per second)
MHz	Megahertz (1,000,000 Hz)
MPLS	Multiprotocol Labeling System
Multicoupler	Cavity filter system that allows multiple receivers to share the same antenna
mutual aid	Generally describes a situation where a major emergency or incident requires a large number of agencies, including agencies from remote locations, working together to mitigate the crisis.

mutual aid channel	A radio channel specifically allocated for use during emergency mutual aid situations.
Network Topologies	The shape of a local-area network or other communications system. Topologies are either *physical* or *logical*.
NMI	Network Management Interface
NMS	Network Management System
OTAP	Over-The-Air-Programming
OTAR	Over-The-Air-Rekeying
P25	APCO Project 25; a suite of digital radio communications standards that facilitates interoperability between public safety agencies.
path	In communications systems a route between any two points. In public safety communications, the route that (a) lies between a transmitter and a receiver and (b) may consist of two or more concatenated sites. Note: Examples of paths are line-of-sight paths and ionospheric paths.
Project 25 (P25)	A suite of standards for digital radio communications for use by federal, state/province and local public safety agencies in North America to enable them to communicate with other agencies and mutual aid response teams in emergencies.
PSAP	Public Safety Answering Point, usually a 9-1-1 call center
PTT	Push-to-Talk
receiver	The component(s) of a radio device that converts the radio waves into audible signals.
repeater	A special receiver/transmitter combination that receives a signal on one frequency and retransmits a new signal on another frequency, usually within the same frequency band, sometimes referred to as a relay station.
RF	Radio Frequency
RFP	Request For Proposal
Roaming	Use of a wireless phone or public safety mobile communication equipment outside of the "home" service area defined by a service

	provider or system. Allows a user to travel statewide and communicate as if they were still in within their local area.
Rx	Receive
Simulcast	Signaling technique that transmits the same signal from multiple sites. *High-Level Final Statewide Public Safety Communications Interoperability Plan*, December 04, Page 166
Subscriber unit	User's equipment (usually a mobile or portable radio).
T1	A data circuit that runs at 1.544 Mbps, capable of 24 DS-0s (non-compressed voice channels), data, video, or any combination (see DS-1). A signaling scheme standard in telecommunications in North America and Japan to transmit voice and data between devices.
Talkgroup	Users assigned to a specific group that normally communicate with each other. Primarily preprogrammed into a trunk system, but can be assigned on-the-fly to add other users to interoperate with the group during emergencies or joint operations.
Talk-in	Radio path from a mobile or portable radio to a base station
Talk-out	Radio path from a base station to a mobile or portable radio
TDI	Time Delay Interference
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
Topology	the study of qualitative properties of certain objects (called topological spaces) that are invariant under certain kind of transformations
Transceiver	Combination transmitter and receiver (Tx/Rx), public safety mobile communication base stations, mobiles and portables are examples.
Transmit Combiner	Cavity filter system that allows multiple transmitters to share the same antenna
Trunked	A radio communication system consisting of a control channel and a group of channels available and assigned as needed to specific "groups" or uses. All channels are automatically system assigned

	while in-use, then released for other users. This configuration maximizes traffic in a minimum number of channels.
Tx	Transmit
TSB	Technical Services Bulletin
UHF	Ultra High Frequency; a range with a short antenna(band) of electromagnetic waves with frequencies between 300 MHz and 3 GHz
UPS	Uninterruptible Power Supply
VHF	Very High Frequency; the part of the radio spectrum from 30 to 300 MHz, which includes broadcast TV Channels 2-13, the FM broadcast band and some marine, aviation and land mobile services.
Voting receiver	Multiple remote receivers tied together through a comparator device at a transmitter site to improve portable coverage, signal strength is compared from each receiver, and the best receiver becomes the receiver during a specific transmission. Also called a satellite receiver.
VSWR	Voltage Standing Wave Ratio