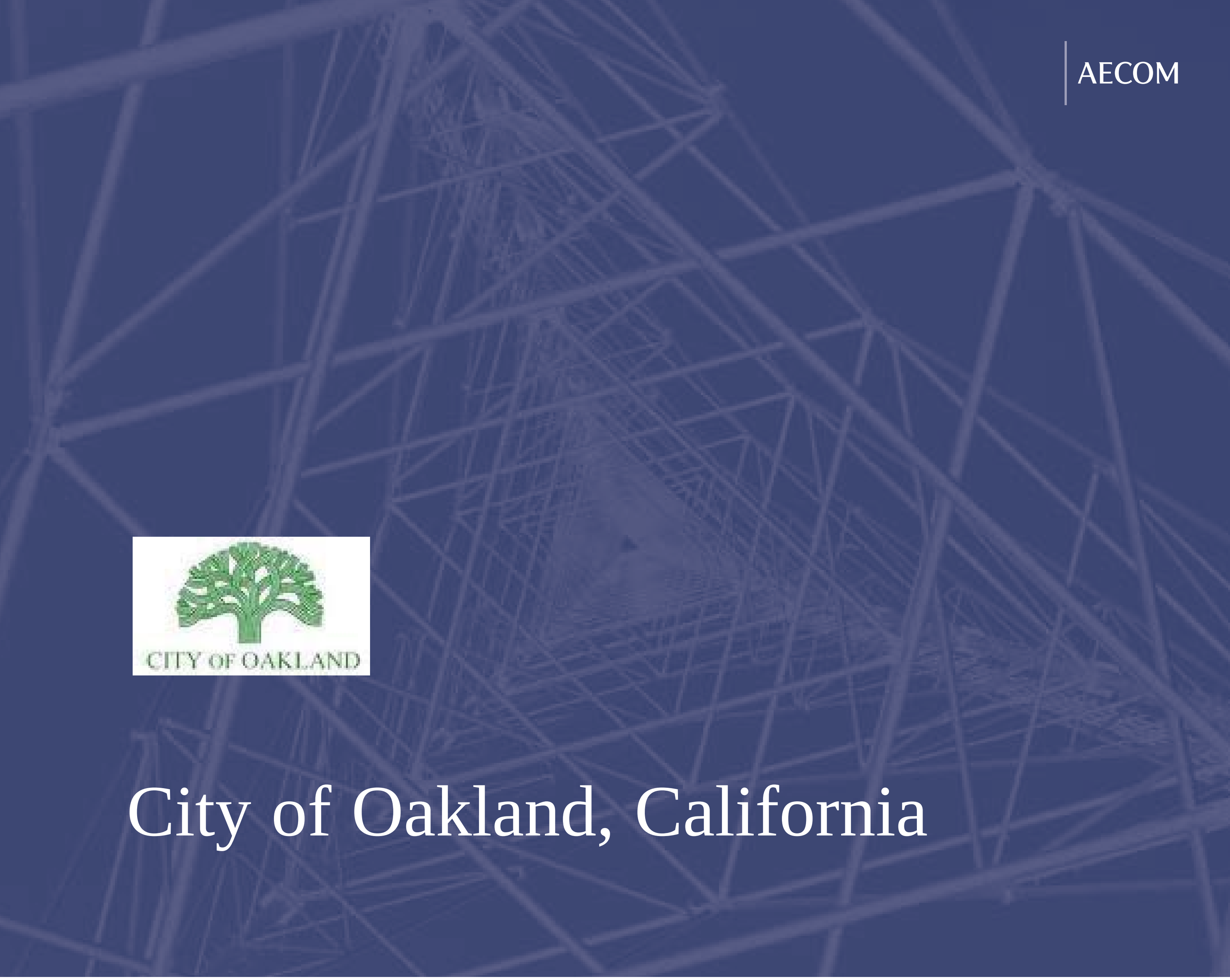

City of Oakland, California

Interoperability Study

PUBLIC REPORT

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All content that constitutes a breach of security or that would comprise the Public Safety Radio system has been removed from this report. Please contact the City of Oakland Department of Information Technology for access to the entire document. No pages that contain significant findings or critical decision criteria have been removed.

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Executive Summary

This Executive Summary provides a high level overview of the Interoperability Study report developed for the City of Oakland by CTA Communications (CTA). This project was focused on providing the City of Oakland with a technical roadmap for improved operability within the City and increased interoperability with those agencies in the Bay Area Super Urban Area Security Initiative (UASI).

The Interoperability Report describes the process CTA used to arrive at a jointly developed plan for wireless voice and supporting interconnect systems. The report considers the existing public safety communications system design and presents design alternatives based on available technology, frequency spectrum availability and operational feasibility. This project had 5 main goals or objectives:

1. Review and evaluate existing technology owned and operated by the City.
2. Establish a technical roadmap for full and seamless interoperability with BayRICS.
3. Provide a cost benefit analysis of the EBRCS JPA proposal.
4. Review the City's spectrum efficiencies (simulcast) and the leveraging of the City's equipment and investments as part of the EBRCS.
5. Provide recommendations for an interim solution for an Oakland EBRCS MOU.

CTA completed 14 tasks to achieve the goals outlined above. The report provides a detailed overview of each of the following 14 tasks:

TASK 1 SYSTEM COVERAGE - This Task includes an analysis of the existing two-site 800 MHz voice radio communications system. In addition, this Task includes an opinion of probable cost analysis that analyzes the costs associated with the City building their own P25 Phase 2 System.

TASK 2 SPECTRUM EFFICIENCY – This Task provides an overview of the current multi-site system including the advantages and disadvantages, and provides recommendations for improved system operation and utilization.

TASK 3 COVERAGE REDUNDANCY - This Task analyzes the coverage overlap between the City's radio system and the proposed EBRCS coverage area.

TASK 4 SIMULCAST TECHNOLOGY - This Task provides an overview of simulcast technology and evaluates the use of simulcast technology for the City of Oakland.

TASK 5 IN-BUILDING COVERAGE - This Task provides an analysis of the portable radio in-building coverage requirements and makes recommendations to improve in-building radio coverage within the City.

TASK 6 P25 MIGRATION - This Task provides an overview of P25 and evaluates the City's migration from its existing M/A-COM EDACS 800 MHz radio system to a Harris P25 Phase 2 standards based system.

TASK 7 SUBSCRIBER EVALUATION - This Task provides an evaluation of the backward compatibility of the City's newly purchased P25 subscriber radios with the BART's EDACS radio system and includes a comparison of feature/function sets.

TASK 8 INTEROPERABILITY WITH BART - This Task evaluates the City's upgrade and migration to a P25 radio system and the affect this will have on interoperability with BART.

TASK 9 This task has been purposely omitted from the report.

TASK 10 CHANNEL CAPACITY - This Task provides an analysis of the channel capacity of the existing radio system and addresses current and future channel capacity needs.

TASK 11 RETURN ON INVESTMENT (ROI) EVALUATION - This Task contains a review of the City's investments in communications and provides recommendations on the ROI analysis.

TASK 12 MAINTENANCE COSTS - This Task provides an analysis of maintenance / replacement costs for the City of Oakland. The analysis includes a comparison of the City's maintenance costs of its current radio communications system versus the buy-in, maintenance and ongoing system/equipment costs (monthly subscriber fees) of joining the EBRCSA.

TASK 13 CONTINUITY OF OPERATIONS - This Task provides an overview of the Oakland Radio Shop and an assessment of the radio shop's ability to provide the level of maintenance required to maintain the continuity of operations needed to support public safety communication.

TASK 14 GOVERNANCE - This Task outlines CTA's findings concerning the current EBRCSA JPA that are related to the technical, financial and implementation (timeline) aspects of the regional agreement and researches any cost savings to the City if it were to join the EBRCSA.

CTA has focused on providing an accurate assessment of the existing City of Oakland Radio System and has provided a detailed overview of the immediate concerns expressed by users and managers of the existing system. Based on this current system overview, CTA has made recommendations on how to improve the current system. These changes are areas that CTA has identified which will provide low cost, non-intrusive modifications to the existing system that will provide great benefits for all radio users. We also documented our recommended next steps that the City of Oakland should consider as they look toward the radio system that will support their needs 15 years into the future.

Summary of Completed Objectives

Because, the City of Oakland is part of the Bay Area Super Urban Area Security Initiative (UASI), the goals and vision of the UASI must be incorporated into the technical roadmap that is developed for the City. CTA's assessment and recommendation keeps the vision of BayRICS and the UASI in view, namely "the ability for any public safety radio in the region to communicate with any other public safety radio regardless of location, radio system, or frequency band and to seamlessly roam throughout all 10 Counties in the Bay Area." In addition, our recommendation also addresses the critical needs of the emergency responders in the City of Oakland. The summary and recommendations provided here are substantiated by the analysis and documentation provided in the report. Below, each objective of the project is summarized along with CTA's recommendations.

Objective 1: Review and evaluate existing technology owned and operated by the City.

CTA conducted interviews, radio site and dispatch surveys, additional meetings with the City of Oakland, and used an online surveyor tool, CTA Surveyor℠ to the gather the data needed to complete this task. Our research revealed that the City of Oakland's radio system meets the needs of the users and no significant channel sizing or coverage issues were reported. There are several areas where increased coverage is desired, and the system is nearing capacity limits, but meets the current needs of the users. However, as additional users are added, or if a major incident occurs, the system would likely exceed capacity limitations. Furthermore, current interoperability solutions are not robust and do not meet the goals stated by BayRICS. Our assessment of the radio shop, and the site surveys conducted revealed that your current system is well maintained and the radio shop is doing an excellent job in meeting the maintenance needs of the users in the City.

In order to meet the near term needs, our recommendations include:

1. Install low noise tower top amplifiers on APL and Seneca for use on the existing EDACS system.
2. After completion of the rebanding project, relicense the frequencies on APL for at least 100 Watts and conduct a thorough diagnosis of the APL site to ensure that the transmit and receive power are correct.
3. Issue one portable radio for each police officer, which would mean purchasing about 500 additional portable radios.
4. Research the cost of upgrading the existing EADS system to a simulcast system. This research will be used to determine if current system needs exceed capacity, this might be a viable short term solution as the City of Oakland decides if they should build out their own system, or join EBRCSA.
5. The existing Microwave upgrades should continue. Even if the City of Oakland joins EBRCS, the existing microwave loop could be incorporated into the EBRCS design. If the City builds its own system, the existing microwave system will need to be upgraded as planned.

Objective 2: Establish a technical roadmap for full and seamless interoperability with BayRICS.

This objective can be accomplished in two ways. The City of Oakland can build their own Harris P25 Phase 2 standards based system (Option 1) or they can join the EBRCS P25 Radio system (Option 2). Each choice has advantages and disadvantages as summarized in each of the categories below:

Operability:	Both options provide the same level of operability. The needs of the radio users on the City of Oakland System could be met by both options. It is possible, that due to the additional tower sites in Option 2, that better in-building coverage would be achieved with Option 2.
Interoperability:	Both options meet the interoperability goals outlined by the Bay Area UASI and by the California SCIP. If the City chooses Option 1, then EBRCS would need to define Interoperability Talkgroups that can be used on the EBRCS by City of Oakland Users.
Initial Cost:	The City of Oakland would have to find a funding source to fund the build out of the $5.67M dollar system for Option 1. At this time there is no initial cost with joining EBRCSA.
Maintenance Costs:	The clear advantage is Option 1. Option 1 is about $740K less per year than Option 2. If the annual replacement costs are removed, then this difference is even greater. Option 2 can make up some of this difference if the City of Oakland is able to provide maintenance support to the users in the ALCO Northwest cell as described above.
Coverage:	Option 2 provides the best coverage, provided the current ALCO Northwest design with sites at UC Berkeley, APL, Seneca and Skyline is installed. In addition, in-building coverage should be better with Option 2. Option 1 will provide increased coverage over the current system and will meet the needs of the City of Oakland users.
Redundancy and Reliability:	Option 1 provides increased redundancy and reliability over Option 2. Option 1 provides an additional layer of coverage and is a completely separate radio system from EBRCSA. Provided interoperability talkgroups are defined on each system, Option 1 can provide redundancy for users on EBRCSA and EBRCSA can provide redundancy for City of Oakland Users.
System Capacity:	Both options provide adequate capacity for the City of Oakland. However, it should be noted that if the multi-cell users (those that place calls from ALCO Northwest to other cells) significantly increases, then Option 2 could begin to see in increase in traffic. If Option 1 is chosen, this would not be an issue.

Governance:	Option 1 is much less complicated from a governance perspective. The challenges with Option 2 are not significant, but will require more effort than Option 1.
Interoperability with BART:	Option 1 provides an advantage in this category. If Option 2 is chosen, then BART users cannot talk on the system unless they purchase P25 Phase II radios and they are defined on the Motorola system that is being built out for Option 2.

In order to determine which option will best meet the needs of the City of Oakland we recommend the following steps:

1. Aggressively look for grant funding opportunities to pay for a City of Oakland P25 radio system. If these grant funding sources can be found, then the City should move in this direction.
2. Aggressively work with EBRCSA to ensure the current site selections are those that are used in the final design for the EBRCSA ALCO Northwest Cell. Work closely with EBRCSA and negotiate site sharing details for Seneca and APL.
3. Work with EBRCSA to determine if a maintenance agreement can be put in place for the City of Oakland to provide all maintenance infrastructure and subscriber support for the agencies in the ALCO Northwest Cell. If an agreement can be made, it may be possible for the City of Oakland to defer most of the costs of using the EBRCS.
4. The final decision will depend on the answers to the steps listed above, since either solution is equally viable from an operational and interoperability perspective.

Objective 3: Provide a cost benefit analysis of the EBRCS JPA proposal.

The complete details of the maintenance costs for the EBRCS JPA were not finalized at the time of this report; however the major cost items needed for an accurate comparison were available. Our evaluation included the following comparison:

CTA estimate of the City of Oakland annual maintenance costs for their own P25 Phase 2 radio system:

City of Oakland Annual Maintenance Fee	$172,800
Software Support Services	$100,000
City of Oakland Annual Replacement Fee	$495,760
Additional City of Oakland Radio Shop Budget	$1,027,200
Annual Total	$1,795,760

CTA estimate of annual EBRCSA costs that the City of Oakland will have to pay based on 4,191 subscriber units on EBRCS:

EBRCSA Monthly Maintenance Fee	4191 times $15.25 = $63,912.60	
EBRCSA Monthly Replacement Fee	4191 times $14.75 = $61,817.30	
EBRCSA Annual Maintenance Fee		$766,953
EBRCSA Annual Replacement Fee		$741,807
Estimated City of Oakland Radio Shop Budget		$1,027,200
Annual Total		$2,535,960

One other significant cost comparison is the fact that if the City of Oakland decides to build their own P25 radio system, they will have to find a funding source for the cost of the new system shown below:

OPINION OF PROBABLE COST
CITY OF OAKLAND
P25 PHASE II SIMULCAST UPGRADE

	LIST COST			NEGOTIATED ESTIMATE		
RADIO INFRASTRUCTURE	100%	$	4,777,600	85%	$	4,061,000
MICROWAVE	100%	$	-	90%	$	-
PHYSICAL FACILITIES	100%	$	440,100	90%	$	396,100
VENDOR SERVICES	100%	$	861,000	85%	$	731,900
SPARES - FIXED	100%	$	47,800	100%	$	47,800
CONTINGENCY	100%	$	478,300	90%	$	430,500
TOTAL		**$**	**6,604,800**		**$**	**5,667,300**

Objective 4: Review the City's spectrum efficiencies (simulcast) and the leveraging of the City's equipment and investments as part of the EBRCS.

CTA evaluated the existing frequencies owned by the City of Oakland. Provided the City moves toward a P25 Phase 2 solution, which has the advantage of using 1 channel for 2 voice talkpaths, then the City will be able to meet the future radio system needs. Simulcast is another important step the City must take. Currently 60% of the City's radio traffic is using resources at both APL and Seneca due to the current system design. CTA recommends that the City move in the direction of a P25 Phase 2 simulcast radio system in order to meet current and future radio system capacity needs.

Objective 5: Provide recommendations for an interim solution for an Oakland EBRCSA MOU.

CTA recommends the following steps that will provide an interim solution for an Oakland EBRCSA MOU. Many of these steps were discussed above:

1. Work with EBRCSA to ensure the current site selections are those that are used in the final design for the EBRCSA ALCO Northwest Cell, which includes UC Berkeley, Seneca, APL, Skyline and Gwin. Work closely with EBRCSA and negotiate site sharing details for Seneca and APL. Any other site selections will not provide the level of coverage needed by the City of Oakland. These site selections should be agreed upon and included as part of the MOU.
2. The City of Oakland should work with EBRCSA and outline a maintenance agreement for the City of Oakland to provide all maintenance infrastructure and subscriber support for the agencies in the ALCO Northwest Cell. This agreement would provide the City of Oakland with an opportunity to defer most of the costs of using the EBRCS.
3. The City of Oakland has valuable frequency resources that may be needed by EBRCS. CTA recommends that the use of these frequencies by agencies in the ALCO Northwest Cell be included as part of the MOU.
4. Since the City of Oakland would be a major contributor, in maintenance support, frequency assets and number of users, CTA recommends that the City work out an agreement with EBRCSA for inclusion in the Board of Directors for EBRCSA.

Introduction

The City of Oakland is located east of San Francisco in northern Alameda County. The City has a population of over 420,000 people and encompasses a land area of 56 square miles. Oakland is located in the heart of the East Bay section of the San Francisco Bay area. The City of Oakland is a major west coast international sea port and manufacturing center and the Port of Oakland is one of the five largest container ports in North America.

The City has contracted with CTA Communications (CTA) to conduct an interoperability Study that focuses on five objectives outlined in the Scope of work. CTA will:

1. Review and evaluate existing technology owned and operated by the City.
2. Establish a technical roadmap for full and seamless interoperability with BayRICS.
3. Provide a cost benefit analysis of the EBRCS JPA proposal.
4. Review the City's spectrum efficiencies (simulcast) and the leveraging of the City's equipment and investments as part of the EBRCS.
5. Provide recommendations for an interim solution for an Oakland EBRCS MOU.

The City of Oakland is part of the Bay Area Super Urban Area Security Initiative (UASI). This study has been completed while keeping the vision of BayRICS and the UASI in view, namely "the ability for any public safety radio in the region to communicate with any other public safety radio regardless of location, radio system, or frequency band and to seamlessly roam throughout all 10 Counties in the Bay Area."

CTA has focused on providing an accurate assessment of the existing City of Oakland Radio System and has provided a detailed overview of the immediate concerns expressed by users and managers of the existing system. Based on this current system overview, CTA has made recommendations on how to improve the current system. These changes are areas that CTA has identified which will provide low cost, non-intrusive modifications to the existing system that will provide great benefits for all radio users.

CTA will then explore the next steps that the City of Oakland should consider as they look toward the radio system that will support their needs 15 years into the future.

Report Outline

CTA developed this needs assessment report using information obtained during interviews, radio site and dispatch surveys, additional meetings with the City of Oakland, and an online surveyor tool, CTA Surveyor^{SM}. The report is organized into sections that align with the fourteen tasks specified in the City's Interoperability Statement of Work:

INTRODUCTION – This section introduces the study.

SECTION 1 SYSTEM COVERAGE - This section includes an analysis of the existing two-site 800 MHz voice radio communications system. In addition this section includes an opinion of probable cost analysis that will analyze costs associated with the addition of City sites to the EBRCS.

SECTION 2 SPECTRUM EFFICIENCY – This section provides an overview of the current multi-site system including the advantages and disadvantages, and provides recommendations for improved system operation and utilization.

SECTION 3 COVERAGE REDUNDANCY - This section analyzes the coverage overlap between the City's radio system and the proposed EBRCS coverage area.

SECTION 4 SIMULCAST TECHNOLOGY - This section provides an overview of simulcast technology and evaluates the use of simulcast technology for the City of Oakland.

SECTION 5 IN-BUILDING COVERAGE - This section provides an analysis of the portable radio in-building coverage requirements and makes recommendations to improve in-building radio coverage within the City.

SECTION 6 P25 MIGRATION - This section provides an overview of P25 and evaluates the City's migration from its existing M/A-COM EDACS 800 MHz radio system to a P25 standards based system.

SECTION 7 SUBSCRIBER EVALUATION - This section provides an evaluation of the backward compatibility of the City's newly purchased P25 subscriber radios with the BART's EDACS radio system and includes a comparison of feature/function sets.

SECTION 8 INTEROPERABILITY WITH BART - This section evaluates the City's upgrade and migration to a P25 radio system and the affect this will have on interoperability with BART.

SECTION 9 This section has been purposely omitted from this report.

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SECTION 12 MAINTENANCE COSTS - This section provides an analysis of maintenance / replacement costs for the City of Oakland. The analysis includes a comparison of the City's maintenance costs of its current radio communications system versus the buy-in, maintenance and ongoing system/equipment costs (monthly subscriber fees) of joining the EBRCSA.

SECTION 13 CONTINUITY OF OPERATIONS - This section provides an overview of the Oakland Radio Shop and an assessment of the radio shop's ability to provide the level of maintenance required to maintain the continuity of operations needed to support public safety communication.

SECTION 14 GOVERNANCE - This section outlines CTA's findings concerning the current EBRCSA JPA that are related to the technical, financial and implementation (timeline) aspects of the regional agreement and researches any cost savings to the City if it were to join the EBRCSA.

SECTION 15 RECOMMENDATIONS – This section makes recommendations on a technical roadmap for a radio system that will meet the needs of the City of Oakland and that will provide seamless interoperability with BayRICS.

This appendix has been purposely omitted from this report.
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APPENDIX C – CTA SURVEYOR RESULTS – This section provides the survey results based on the online survey completed by individual agency users.

Appreciation

We wish to thank all of the departments and agencies who participated in this study for their cooperation and support. We especially wish to express our thanks and appreciation to Orval Badger and Gregg Tanner of the City of Oakland Department of Information Technology. All of the participants that assisted CTA with the preparation of this reported helped us provide accurate information that we have used to provide a technical roadmap for the future that meets the needs of the users.

1.0 System Coverage

1.1 Introduction

This section provides an analysis of existing radio coverage and opinion of probable cost in support of SOW Task #1. The assumption is that most readers of this report will begin here, so CTA begins to look at the available choices the City of Oakland faces as they develop a technical radio communications roadmap that best suits the needs of the City of Oakland radio users. CTA has considered and evaluated several options based on technical, operational, and cost factors. In this first section, we will refer to other sections of this document that provide the basis for some of the options discussed in this section.

The City of Oakland currently has an EDACS trunked radio system, originally supplied by Ericsson GE. Since the system was first installed, the vendor has gone through several acquisitions and subsequent name changes (Con Net, M/A-COM, Tyco Electronics, and as of June 1, 2009, Harris). However, throughout this report, the vendor will be referred to as "M/A-COM", which is the most familiar name to the City of Oakland.

As part of the analysis, CTA has evaluated the existing radio coverage of the three sites (APL, Gwin and Seneca) that provide coverage for the City of Oakland using CTA's Propagation, Coverage, and Loading Analyst (P-CALA^{SM}) software. In addition, we have compared existing City radio coverage with the proposed EBRCS radio coverage and identified leveraging opportunities for the City of Oakland.

CTA has also provided an opinion of probable cost analysis using our proprietary Cost Budgeting Analyst software. The analysis includes an opinion of probable cost for the viable options that are available to Oakland.

1.1.1 Presenting the Technical Solutions

Because this interoperability project focuses on developing a technical roadmap for full and seamless interoperability with the San Francisco Bay Area Regional Interoperable Communications System (BayRICS), CTA has considered several options that the City of Oakland can choose as it moves forward. These options are presented below and each of the 14 sections of this report is used to support CTA's final recommendation, which is presented in Section 15.

CTA considered several choices for the City of Oakland's future radio system:

1. Continue to maintain the current EDACS system.
2. Migrate to a true Multi-site EDACS system that supports automatic roaming.
3. Migrate to an EDACS simulcast system.
4. Migrate to a M/A-COM (Harris) P25 system.
5. Migrate to a M/A-COM (Harris) P25 simulcast system.
6. Join the EBRCS P25 simulcast system.

Options 1 through 5 all assume that the City of Oakland will continue to use its existing radio system in some form, while option 6 is unique in that it explores the possibility of moving entirely to the EBRCS. As a first step, CTA looked for opportunities to reduce the number of choices from 6 down to a manageable number so that the detailed analysis could be completed.

1.1.2 Reducing the Number of Technical Solutions

After completing the analysis contained in Section 2: Spectrum Efficiency and Section 4: Simulcast Analysis and reviewing the information provided to CTA during interviews and during the online survey, it is clear that the advantages of a simulcast system far outweigh the advantages of a pure multi-site system. A simulcast system is the clear choice based on user needs, technical feasibility, spectral efficiency, interoperability needs, operational effectiveness and cost benefits.

The choice of a simulcast system effectively reduces the choices to three: migrate to an EDACS simulcast system, migrate to a M/A-COM P25 Simulcast system or join the EBRCS P25 Simulcast System. Furthermore, because of the desire to provide “seamless interoperability” with BayRICS, these three choices can be reduced to two. If the City of Oakland decides to upgrade its existing EDACS radio system to a simulcast EDACS system, the main goal of achieving “seamless interoperability” with BayRICS will not be achieved. As the agencies, counties and municipalities throughout the Bay Area move toward P25 standards based systems, the City of Oakland must also move in this direction if they are to achieve truly interoperable communications with these surrounding agencies. If the City of Oakland stays with EDACS technology it will not be able to directly communicate with surrounding agencies as they implement P25 systems.

CTA recognizes that several temporary or functionally limited technical solutions are available to connect P25 networks with non-P25 networks; however these solutions do not meet the requirement to provide “seamless interoperability”. Although several “workarounds” exist that will enable some level of interoperability between an EDACS system and P25 standards based systems, they do not provide the level of interoperability required by the City of Oakland radio users. These needs are summarized in Section 7: Subscriber Analysis. In addition, the Appendices contain information gathered during interviews and from the online surveys that clearly indicate something more than a “workaround” is needed for interoperability.

If we eliminate the EDACS simulcast technology choice the number has effectively been reduced to down to 2:

1. Migrate to a M/A-COM (Harris) P25 simulcast system.
2. Join the EBRCS P25 simulcast system.

Choosing between these two options becomes increasingly difficult as the operational, technical, governance and costing considerations are evaluated. The remainder of this report will be used to further refine the details of implementing either of these two options. Another consideration is that as the City of Oakland migrates to a P25 system, several components, including the recently acquired EDACS rebanding equipment, will likely remain in place until a complete migration to a P25 standards based system is implemented.

As we begin to look at the needs of the radio users, it is clear that we must begin with coverage. The online survey as well as the interviews indicated that improved radio coverage was the number one concern of the radio users, which can be clearly seen in Table 7-4 and in Section 7. CTA began its analysis of radio coverage by first looking at existing radio coverage.

1.2 Existing Radio Coverage Analysis

CTA began to analyze system coverage by looking at existing radio coverage within the City of Oakland’s operational area. The City of Oakland’s coverage area includes the City of Oakland, City of Piedmont and the City of Emeryville. The coverage maps shown at the end of this section reflect portable Talk-In (the communication path from the portable to the tower) and mobile Talk-In coverage. In a properly designed system, Talk-In and Talk-out should be balanced, but users in the City of Oakland consistently described being able to hear dispatch, but not being able to be heard by dispatch. Since the existing City of Oakland system is not balanced for Talk-In and Talk-Out using low noise tower top amplifiers, Talk-In diagrams were selected due to the concern users consistently expressed during interviews about not being able to talk back to dispatch from their portable radio. User-reported coverage difficulties with portable radios far exceeded those indicated for mobile radios. As a result, CTA has chosen to reflect Talk-In coverage. .

Figures 1-1 and 1-2 reflect the existing portable and mobile Talk-In coverage for the APL site, Figures 1-3 and 1-4 for Seneca and Figures 1-5 and 1-6 for the new site at Gwin. The three sites in the Oakland system operate independently and automatic roaming between the sites is not supported at this time. If a user from the northern portion of the City wants to move to the southern portion, they must manually change from a talkgroup on APL to a talkgroup on Seneca. As a result, users typically have a primary site that they use for all communication. The coverage diagrams reflect the coverage that users are accustomed to as they operate from a **single** site. Simulcast coverage predictions are provided in Section 4.

The source of these coverage estimates is an RF coverage prediction program that is part of CTA's proprietary Propagation, Coverage, and Loading Analyst (P-CALA[SM]) software. These predictions are based on knowledge of radio signal propagation, and the factors which affect the signal as it travels through the air, over different terrain types, through different vegetation types, into and around buildings and other obstacles. Parameters, which affect the predictions, include:

- Transmitter power
- Line losses
- Combiner losses
- Connector losses and other expected losses
- Antenna Gain(s), beam width and directional orientation
- Antenna/Tower Height(s) - AGL
- Receiver Sensitivity, Receive height (head or hip)
- Terrain gradients
- Tree or foliage type, density and clutter height above ground (Morphology)
- RF Noise

Coverage predictions are based on the Longley-Rice point-to-point model as implemented in the Terrain Analysis Package (TAP™) by SoftWright, LLC. This implementation is based on version 1.2.2 of the Longley-Rice model. CTA participated in the early development of this implementation and continues to refine the accuracy of the model through our P-CALA™ suite of engineering tools and through actual field testing accomplished in our Radio Coverage Evaluator (RaCE[Patented]) mobile testing solution.

1.2.1 Potential Problem at APL site.

These coverage diagrams were compared to the coverage problems reported to CTA by the radio users during our interviews. CTA normally observes a close correlation between what the users are experiencing in the field and the coverage diagrams generated using P-CALA[SM], however that was not the case in Oakland. For the APL site in particular, CTA observed that the expected Portable Talk-In coverage was about 10 dB more optimistic than what users were reporting. The coverage reported by the users during interviews closely matched the user-adjusted coverage we show in Figure 1-7 for the APL Site. Many of the coverage gaps reported by the users are clearly seen in Figure 1-7 but they cannot be seen in the theoretical coverage prediction of Figure 1-1 for the APL site. Most notably are the coverage gaps in and around the City of Piedmont and in the City of Emeryville. Portable coverage in these areas is essential and many of the areas where officers and firefighters frequently respond do not have adequate coverage in Figure 1-7. These coverage problems were consistently mentioned during interviews, especially with the City of Emeryville.

Several factors could contribute to the difference in <u>user-adjusted</u> (Figure 1-7) versus <u>predicted</u> (Figure 1-1) coverage. Everything from connectors to equipment settings at the site could contribute to signal loss. Another factor, often overlooked, is the fact that the 800 MHz noise environment is dramatically different today than it was 10-15 years ago when Oakland's system was first operational. None of the sites in the Oakland system are utilizing low noise tower top amplifiers, which will reduce the system noise floor and improve Talk-In reception. Tower top amplifiers will significantly help the users in the City of Oakland by balancing Talk-in and Talk-out reception. Furthermore, the power output levels at the APL site should be verified.

Regardless of the cause, CTA recommends that further testing and evaluation are required to confirm the apparent 10 dB difference and identify the source of this difference. The testing should include gathering Talk-out RSSI data around the APL site and comparing this data with the expected signal levels based on ERP and Power Output. In addition, the site validation should include verification of transmitter settings and an electronic performance sweep of the RF transmission lines to ensure the return loss is within specification.

CTA is able to perform this testing upon request and will, at a minimum, discuss the details of the testing that is needed to isolate the source of the coverage differences. It should also be noted that if there is a problem that is causing a 10 dB difference, correcting the problem will dramatically improve radio coverage for all users affiliated with the APL site.

1.2.2 Low Power Level at APL site.

Another concern that CTA discovered was the low licensed power output level at the APL site. The APL site has a licensed ERP of 19 Watts. This power output is significantly lower than any of the surrounding sites, which typically have an ERP of 300 Watts. CTA verified this licensed low power output level with the City of Oakland radio technicians and with the FCC license for that site. We then began to research why the power level was set to 19 Watts.

We conducted a frequency search for the 16 channels that are licensed for APL, Gwin and Seneca. During this search we found three channels that could have been the reason for the lower power output level at APL. The first potential limiting power contributor was with Oakland Channel 868.5625 MHz, which has an adjacent channel interference with an Alameda County channel 868.5750 MHz. The Alameda channel is licensed as a county-wide mobile channel (talk-around) and there is no fixed equipment for this site. The second potential limiting power contributor was with Oakland Channel 867.0500 MHz, which has an adjacent channel interference with a Statewide temporary use channel of 867.0375 MHz. The third potential limiting power contributor is with Oakland Channel 866.4000 MHz, which has an adjacent channel interference with 866.3875 MHz licensed as a fixed site to Santa Clara Water. This third channel is likely the main cause of the lower ERP requirement by the FCC at the Oakland APL site.

CTA has identified some potential ways to obtain an FCC license with an increased power level for the APL site. First, the City of Oakland can move the three channels above to the Gwin site and license them at the lower ERP setting, which is not expected to have any FCC licensing difficulties. The remaining channels at APL could then operate at a higher transmit power under the existing license. Second, the City of Oakland can work with the 800 MHz regional coordinator and discuss licensing the remaining Oakland channels as an 800 MHz simulcast system at the higher ERP level (100 W or 300 W). Our preliminary research did not reveal anything that would prohibit this licensing process, however; we were unable to look at the effect rebanding would have on these channels since the Bay Area 800 MHz channels were repacked for rebanding.

One other licensing note is that the frequency 867.5750 MHz is licensed under a separate City of Oakland License (Call Sign WQGN458). This frequency is not currently assigned a channel, and the current license will expired on March 14th, 2009, but the FCC granted the City of Oakland a STA.

1.2.3 CTA Recommendations for APL site.

CTA recommends the following steps be taken to increase the coverage from APL.

1. Install low noise tower top amplifiers. This should be done at the Gwin and Seneca sites as well.
2. Relicense the frequencies at APL for 200 – 300 Watts, as described in Section 1.2.2. If the City of Oakland is unable to relicense these frequencies at a higher power level, then additional frequency resources should be sought after so that the APL can license all frequencies at that site at a higher power level.
3. Even after the installation of the new MASTR III repeaters that were received as a result of rebanding, APL still might not perform as expected. CTA recommends that the problem be thoroughly diagnosed to be sure that there is not a problem between the transmit and receive sides of the repeater. The diagnosis should include checking all connections between the repeater and the antenna. Upon request, CTA is able to perform this level of diagnostics.

1.2.4 Comparison between Existing Coverage and Proposed EBRCS

The requirement for the City of Oakland radio users is that they have 95% Portable Talk-In radio coverage. Often times radio coverage maps are provided that reflect the more optimistic Portable or Mobile Talk-Out path, which indicates that you can receive the signal from the repeater, but gives no indication that the repeater can receive your incoming portable radio signal. In a balanced system with low noise tower top amplifiers Talk-In and Talk-Out coverage is essentially the same. Since the City of Oakland is not using tower top amplifiers, CTA has provided portable talk-in maps, which is a more realistic coverage prediction for the existing system.

CTA compared existing and predicted simulcast City radio coverage with the coverage that could be expected within the City after **<u>all</u>** of the EBRCS sites are constructed and **operational in the Northwest Cell**. The City of Oakland is part of the Alameda County Northwest Cell (ALCO Northwest). The coverage provided for the City of Oakland is primarily provided by the 4 sites in the ALCO Northwest Cell. CTA has used our P-CALA^{SM} propagation tool to predict the EBRCS coverage provided for the City of Oakland's coverage area. The 4 sites in the ALCO Northwest Cell are configured as a P25 simulcast cell. Table 1-2 at the end of this section, provides the information used for coverage predictions, which includes: latitude, longitude, elevation, transmit antenna height and effective radiated power (ERP). The values in Table 1-2 were verified with data available from the Motorola design as of August 21, 2009.

Figure 1-8 shows the **portable talk-in / talk-out** EBRCS coverage for the City of Oakland that could be expected in the City of Oakland after the ALCO Northwest Cell is operational. In order to provide a better comparison, CTA has created a portable talk-in / talk-out coverage map for the proposed City of Oakland radio simulcast system (Figure 1-9) using APL and Seneca as the primary sites with the Gwin site used in a multisite configuration. The reasons for the selection of this simulcast system design are described in Section 4. Keep in mind that these maps provide coverage predictions and actual coverage may differ from what is reflected in these figures.

It should be noted that during the course of the City of Oakland project, EBRCSA has made several adjustments to their system design, many of which have been of great value to the City of Oakland. These changes included separating the ALCO West cell into the Northwest and the Southwest. In addition, the ALCO Northwest cell has been sized to include all the Oakland users and sites in the that cell have been relocated to co-locate with existing City of Oakland Sites. At the time of this report the assumption is that the ALCO Northwest cell will have sites at APL, Seneca, UC Berkeley and Skyline. Gwin will be used in the Northwest cell as a fill-in site in the same what that Oakland is using it today.

A careful comparison between the coverage shown in the EBRCS ALCO Northwest Cell map (Figure 1-8) and that shown in the Oakland Sites map (Figure 1-9) shows similar coverage between the two coverage maps. Figures 1-10 and 1-11 show mobile coverage. Because of the additional sites of UC Berkeley, and Skyline, the coverage offered by EBRCS is superior to that of what Oakland would expect from a simulcast system that only consisted of APL and Seneca. The City of Oakland should make every effort to keep the site selections as indicated in Table 1-2 for the ALCO Northwest Cell, any other site selection will likely mean degraded coverage for the City.

1.2.5 Leveraging “Not Yet Constructed” EBRCS Sites

Construction on most of the sites used in the EBRCS coverage described in Section 1.2 is not complete. At the time of this report none of the EBRCS sites are operational; however, construction has begun on some sites. As the EBRCSA continues to move forward in the construction of radio sites, the City of Oakland has several important leveraging opportunities. Most of the leveraging or sharing opportunities listed below have a relatively short lead time. The short lead time means that coordination is required as soon as possible with EBRCSA to ensure that the leveraging opportunities that exist today are not missed as the project moves forward.

One important difference between the two coverage areas shown in Figure 1-8 and Figure 1-9 is the additional coverage that the EBRCS sites provide outside the City’s area of operation. During interviews, many users expressed the need for improved interoperability coverage outside the City. In some cases this interoperability coverage was needed to support vehicle pursuits and other incidents that require mutual aid. In other cases, coverage was needed so that officers and firefighters who live outside the City have the ability to use their radios while in route to and from incidents from their place of residence. Regardless of the need, the additional interoperability coverage provided outside the City by the EBRCS sites in the ALCO West and the surrounding EBRCS cells can be used to dramatically improve interoperability for those users responding outside the City.

Three of the EBRCS sites in the original design (Glen Dyer Jail, Lawrence Berkeley Lab and Skyline Reservoir) are either in, or on the border of the City of Oakland and are in close proximity to some of the existing City of Oakland sites. The Glen Dyer Jail EBRCS site in particular, is within ¼ mile of the City of Oakland APL site. In conversations with EBRCSA, CTA and EBRCSA have agreed that the APL site is superior to the Glen Dyer Jail site due to reduction in number of microwave links, cost savings based on using the APL existing infrastructure and the superior coverage due to the height of APL. In addition, the Skyline Reservoir site provides additional coverage over the APL / Seneca design used by the City of Oakland. Originally EBRCSA planned to use a site at the Lawrence Berkeley Lab but this site has been moved to UC Berkeley. The UC Berkeley site is in close proximity to the Gwin Site, but does provide additional coverage that the Gwin site does not provide, especially in the Northeast corner of the city.

As the City of Oakland continues to examine the two long term communication solutions, either installing their own P25 standards based M/A-COM system or joining the EBRCS P25 simulcast system, additional leveraging opportunities exist for sharing sites between the two systems. Regardless of the long term solution chosen, collocating sites or sharing sites provides sufficient cost savings. If Oakland decides not to join EBRCS, the following factors should be considered for site sharing opportunities between EBRCS and the City of Oakland.

Because of the close proximity of the sites discussed above, they were selected as potential candidates for collocating EBRCS and City of Oakland sites. A collocated site indicates that the site may share a shelter, tower, power, backup power, grounding or other physical components, but the two radio systems remain separate. In the event Oakland joins EBRCS, these sites would be considered EBRCS sites. The details of how to “share” these sites would have to be determined by each of the governing authorities. As part of this evaluation, CTA has included several technical factors that must be considered if any of the sites is selected as a collocated site.

These factors include:

1. Existing LMR Site - Is the site an existing LMR site? A significant cost savings can be realized if an existing LMR site is already in place.
2. Shelter – Does the Shelter have physical room for additional equipment? If the shelter does not have physical room, is there room at the site for an additional shelter?
3. Rack Space – Is their sufficient rack space in the shelter for additional equipment?
4. Power – Is the power at the site sufficient to support additional equipment?
5. Backup Power - Is the backup power at the site sufficient to support additional equipment?
6. Tower Condition – Is the existing tower able to support additional antennas and equipment?
7. Coverage – If the sites are collocated, will the resulting coverage be essentially the same as when the sites remain separate?
8. Microwave – Can the existing microwave connectivity and capacity support additional equipment and traffic? Each of the sites must be linked together in a microwave network, or at a minimum have some type of high capacity backbone connectivity in place. In the case where an established microwave connection is in place, the connection can be considered a “known good” path. For any new sites a microwave path analysis and capacity study should be completed to verify that the connectivity network can support the additional sites. A thorough analysis of the City of Oakland microwave connectivity is contained in Section 9.
9. Cost Savings – What is the anticipated cost savings for both the City of Oakland and EBRCSA if the sites were collocated?

CTA used the above factors to determine which of the three combinations of sites provides the best opportunity for collocating sites. The comparison of the EBRCS sites is based on information available from EBRCSA and Motorola as of January 21, 2009 and subsequent design modifications up through August 21, 2009. Each of the three possible site combinations was evaluated based on the above criteria. The nine factors above are summarized for each site in Table 1-3 at the end of section 1. CTA did not conduct a site survey for the EBRCS sites, and additional research should be completed prior to making a final decision to collocate EBRCS and City of Oakland sites. The factors in Table 1-3 are included with this report so that a comparison of EBRCS sites and Oakland sites can be documented for future reference. At the time of this report the EBRCS ALCO Northwest design had chosen the following sites: APL, Seneca, Skyline, and UC Berkeley. CTA believes these are the best sites for the ALCO Northwest Cell from the City of Oakland’s perspective. Gwin is included as a four channel stand alone site.

1.2.6 Potential Leveraging Benefits

If the City of Oakland were to build their own P25 system and they are able to reach a “sharing” or collocation agreement with the EBRCSA they would have a location that houses both EBRCS equipment and City of Oakland equipment. A collocated site of this type offers many advantages. One important advantage of a co-located site will be the fact that physical equipment from two separate radio systems will have a common location which will better facilitate further system integration. This collocated site would be a significant advantage if the City of Oakland decides to move toward a M/A-COM P25 simulcast system.

If the M/A-COM P25 simulcast option is chosen, both the EBRCSA and the City of Oakland would be moving toward P25 standards based systems and a collocated site would help facilitate the implementation of an interface between the two systems. The P25 interface known as the Inter RF Subsystem Interface, or ISSI, is an IP-based Ethernet interconnection that allows users from different P25 radio systems the ability to roam across multiple radio systems. **The ISSI is an**

interface standard, not an actual device. System interfaces that are ISSI compliant are being developed and will be available on P25 systems in the near future. Once ISSI interfaces are developed, they will need a physical connection between adjacent radio systems and utilizing a shared site easily facilitates this shared path. It should be noted, however, that an ISSI interface is not absolutely critical. Since the City of Oakland and EBRCSA are both P25 systems, it is possible to define talkgroups on each system that can facilitate interoperability without the use of an ISSI interface provided proper planning and coordination is completed.

Another important leveraging activity will be the interoperable use of EBRCS sites through the ISSI. It would be cost prohibitive for Oakland to build additional sites that could provide significant coverage outside the City. The City of Oakland should begin work developing MOU's with the EBRCSA now in order to coordinate the shared use of any EBRCS P25 standards based sites that will provide coverage in and around the Oakland area. This EBRCS coverage will facilitate most of the interoperability needs in the areas that surround the City of Oakland and throughout Contra Costa and Alameda County.

It is also important to realize that some of the same challenges the City of Oakland faced when implementing the Stargate with BART and the City of Richmond will exist when implementing a P25 standards based interoperability solution with EBRCSA through an ISSI. These challenges include identifying users, talkgroups and physical radios that will be allowed to roam between the two systems. Essentially, an active ISSI will require coordinating users, talkgroups and system databases between the EBRCSA and City of Oakland radio systems.

However, if these efforts are coordinated now, before either P25 system is completely built out, it will be easier to overcome these difficulties. Additionally, coordination now will help each agency understand the amount and level of interoperability that must be planned into each system as it is developed so that traffic loading, site development and other activities can be coordinated. It is also important to note that if these planning activities occur now, the ISSI interoperability between the two systems is not expected to have an adverse affect on either existing system. This potential exists if proper planning is not done in advance.

1.2.7 FCC Site License Modifications

The statement of work requires CTA to analyze the FCC site license modifications required to leverage City equipment associated with applicable EBRCS sites. Furthermore, CTA is required to analyze license issues associated with applicable EBRCS sites.

First, it is important to understand the rules and regulations that mandate a change to an FCC license. FCC licenses include administrative details of the licensee and technical details such as antenna location and elevation, frequency, emissions, effective radiated power (ERP), mobile area of operation and other information. The FCC requires a new license (or a license modification) for the addition or modification of any combination of antenna location and frequency. This includes, but is not limited to, (1) adding a new frequency at a new antenna location, (2) moving an existing antenna more than one arc minute, (3) adding a new frequency to an existing antenna location or (4) adding a new antenna location to an existing frequency.

If the City chooses to expand its radio system to an EBRCS site, it must obtain a license for new antennas and frequencies at that site. Likewise if the EBRCSA expands its radio system to a City of Oakland site, it must obtain a license.

If the City of Oakland enters an agreement with the EBRCSA to use the EBRCS, a new FCC license is not required as long as there are no new antennas or frequencies added. In fact, no modifications to the EBRCSA's FCC license would be needed, unless the number of mobile units exceeds the number on the license or the area of operation is expanded.

Although an FCC license modification may not be required, a memorandum of understanding (MOU) between the City of Oakland and the EBRCSA is recommended. The MOU will outline the specific frequencies that the City of Oakland is allowed to use and will outline the conditions for use. A similar agreement would be needed for any of the EBRCS users that need to use City of Oakland frequencies. The MOU is the first step in the critical coordination process that must be put in place to support interoperability.

1.3 Opinion of Probable Cost

Estimates were developed for the major categories of equipment as they apply to the options currently available to the City of Oakland. The costing information is obtained from historical CTA cost files and vendor pricing of comparable projects. The various costs are compared and weighted in order to derive an average "list price" type of estimate. Although CTA cannot guarantee bid price levels, successful competitive bidding typically results in savings on the list price costs. The Opinion of Probable Cost includes the following options:

1. Cost associated with upgrading to M/A-COM P25 Simulcast system.
2. Cost associated with joining the EBRCS P25 Simulcast system.

Option 2 is discussed in detail in later sections of the report and the costs for Option 1 are provided below. The Opinion of Probable Costs calculated here will be used to develop a technical roadmap for the City of Oakland that incorporates cost considerations, available technology and the ability to support operational needs as identified by the radio users.

Several tables are included in this section reflecting our opinion of the probable costs of the project. These display tables contain elements and categories that drive the reflected cost estimate numbers.

Cost Element
Cost Elements are categories of equipment that make up the system design and costs. Each of these cost elements are discussed in section 1.4 of this document.

List Estimate
Items and categories of equipment are applied to the List Costs database that CTA has created. This database is created by our compilation of all known costs converted to this list costs status, creating a common basis of estimation. List Costs figures are the inputs for all of our calculations and all estimates begin with a List Cost level.

Negotiated Estimate
We have adjusted the List Costs for the effect of negotiating with a sole source vendor or system integrator. The Lists Costs are reduced by the percentages that we have typically seen in this type procurement. Each cost element is affected in differing ratios based on the experience in previous procurements.

Competitive Estimate
Estimates are further reduced to reflect the cost reduction we have seen in highly competitive areas, and the cost elements are reduced in differing ratios to account for the impact of competition on purchasing.

1.4 Cost Elements

1.4.1 Radio Infrastructure

The estimate display for Voice Infrastructure contains several cost elements. These are generally the fixed equipment contained at the transmission and control sites. This includes transmitters, receivers, repeaters, antennas, multicouplers and combiners, voters, and site control equipment. The following assumptions and elements are included:

The system and site control and support equipment and facilities installed are sized for the overall system. The number of transmitters and other equipment is based on the number of channels expected to be in use initially when the system is activated.

For the basic system, additional, specialized equipment that is included within the Infrastructure categories are:

A. Dispatch Equipment
   Consoles are required to allow functionality for the dispatch operations. Based on our assessment all the existing consoles will need to be replaced when the City upgrades to a P25 standards based system.

B. System Management Equipment
   The system management subsystem provides the means of infrastructure programming and daily radio operation. This includes the subscriber permissions database, key management for encrypted operation, and the radio programming equipment. One system management terminal is included in the design at each dispatch location.

C. Alarm and Diagnostic System
   A network typically requires alarm and diagnostic equipment. Such subsystems are included to significantly ease the task of critical maintenance. One alarm monitoring terminal is included in the design at each dispatch location. Typical alarms are:
   - Voice network diagnostics, management and monitoring
   - Mobile data network maintenance system
   - Connectivity network maintenance system
   - Tower site facilities monitoring - power, temperature, fire, intrusion, etc.

1.4.2 Microwave

This opinion of probable cost does not include any costing for microwave connectivity as indicated in the scope of work for this project; however it is expected that the current microwave connectivity upgrades will be completed. Since the microwave connectivity is currently being upgraded, CTA did not want to duplicate those costs in this cost estimate.

1.4.3 Physical Facilities

This category is perhaps the most difficult to identify. Contained here are tower upgrades, foundations, tower analysis surveys, site clearing, security fencing, shelters, generators, UPS power supplies, HVAC, solar power, utilities connections, and grounding.

The existing facilities at all of the tower site locations have been evaluated. The different sites are in various levels of readiness. The sites will require some additional development before they are ready to support a simulcast system. Much of the system's reliability will rely on the sites' condition.

1.4.4 Vendor Services

Purchasing a communications system is a complex and detailed process. Some of the effort on the part of a major radio retailer and/or a systems integrator would be outsourcing those efforts not part of their core business.

As expected in the outsourcing, the price for the service is escalated with pass through fees and administrative add-ons, as well as risk factors for unanticipated activities.

In the cost estimate there is a category for Vendor Services. This accounts for the expenses experienced for the Vendor to perform procedures for professional engineering, design, project management, user train the trainer sessions, and their own verification of performance for these elements to match your requirements. This category's cost information is obtained from historical CTA cost files and vendor pricing for comparable projects.

1.4.5 Spares Infrastructure

This cost element is a simple 2% factor of the value of the Fixed Infrastructure costs; including consoles.

1.4.6 Subscriber Radio Equipment

The Opinion of Probable Cost does not include any subscriber or non-fixed equipment costs since the City has already procured non-fixed equipment needed through a combination of rebanding requirements and recent subscriber purchases. This non-fixed equipment is P25 Phase I capable, but will likely need a software upgrade to P25 Phase II.

1.4.7 Contingency

In any radio project, unexpected occurrences and expenditures will be required. All of the estimates and all of the proposals will be predicated on such terms as "normal soils conditions", that there will be no zoning appeals and/or delays, suitable access will be available, and other such codicils. While successful and detailed negotiations can assist in protecting the project; there will be the unexpected. In our experience a viable cost element for contingencies should be set aside at 10% of the project without the non-fixed element.

Often this cost element is identified early on as a place for cost reduction. CTA strongly encourages the project to leave the Contingency funds in place until the end of the project.

1.5 Radio System Cost Summaries

The costs of a modern radio communication system includes a number of interrelated factors:

- Present and future requirements
- Coverage
- Interoperability
- Performance
- Capacity
- System reliability
- Maintainability
- Features

The voice system design will be based on the cost associated with upgrading to M/A-COM P25 Phase II Simulcast system. Although the sites currently have M/A-COM Master III repeaters, they will need to be updated to repeaters that support P25 Phase II. We have not included the cost of upgrading the microwave in the costs below because the assumption is that the current microwave and connectivity network upgrades will support the new system.

The costs in Table 1-4 are based on 8 Phase II Voice channels and one control channel. This would provide 16 P25 talkpaths and one control channel at APL and Seneca. In addition two additional Phase II voice channels (4 talkpaths) and one control channel on Gwin for a total of three transmitters on Gwin. From a costing perspective this means there are 9 transmitters at APL and Seneca.

Table 1-1 has purposely been omitted from this report.

Table 1-2
Potential EBRCS ALCO Northwest Coverage in the City of Oakland

SITE NAME	LATITUDE	LONGITUDE	Transmit Antenna Height (feet)	ERP (Watts)
APL (See Note 2)	37 48 09.78	122 16 22.86	366	19.0
UC Berkeley	37 52 39.64	122 14 48.36	60	309.0
Skyline Reservoir	37 49 13.1	122 11 5.1	90	147.9
Seneca	37 45 22.02	122 09 26.34	60	173.8
Gwin	37 51 45.66	122 13 21.24	60	173.8

Note1: The antenna type, directional azimuth and tilt were factored into the coverage prediction
Note2: The Transmit Antenna height for APL includes the building that the 20 foot tower sits on.

Table 1-3
EBRCS / City of Oakland Collocation Factors

Factor	EBRCS Sites		City of Oakland Sites		
	Skyline Reservoir	UC Berkeley	APL	Seneca	Gwin
Existing LMR Site	Usable	New	Good	Good	Good
Shelter	New	New	Good	Usable	Good
Rack Space	New	New	Good	Usable	Poor
Power	Good	Good	Good	Good	Good
Backup Power	New	New	Good	Poor	Poor
Tower Condition	Good	New	Good	Good	Poor
Coverage	Figure 1-8	Figure 1-8	Figure 1-9	Figure 1-9	Figure 1-9
Microwave	Planned	Planned	Good	Good	Good

Unknown	**Requires a Site Survey to Determine Condition**
New	**Requires a new site construction or is planned for a complete replacement**
Poor	**Requires complete replacement or significant upgrade**
Usable	**Possible to reuse, but will cost at least 50% of complete replacement**
Good	**Reusable, but may need slight refurbishment with only minor expenditure**

TABLE 1-4
OPINION OF PROBABLE COST
CITY OF OAKLAND
P25 PHASE II SIMULCAST UPGRADE

	LIST COST			NEGOTIATED ESTIMATE		
RADIO INFRASTRUCTURE	100%	$	4,777,600	85%	$	4,061,000
MICROWAVE	100%	$	-	90%	$	-
PHYSICAL FACILITIES	100%	$	440,100	90%	$	396,100
VENDOR SERVICES	100%	$	861,000	85%	$	731,900
SPARES - FIXED	100%	$	47,800	100%	$	47,800
CONTINGENCY	100%	$	478,300	90%	$	430,500
TOTAL		**$**	**6,604,800**		**$**	**5,667,300**
INFRASTURE & SOFTWARE MAINTENANCE	2nd Year	$	272,800	2nd Year	$	272,800
	3rd Year	$	279,600	3rd Year	$	279,600
	4th Year	$	286,600	4th Year	$	286,600
	5th Year	$	293,800	5th Year	$	293,800

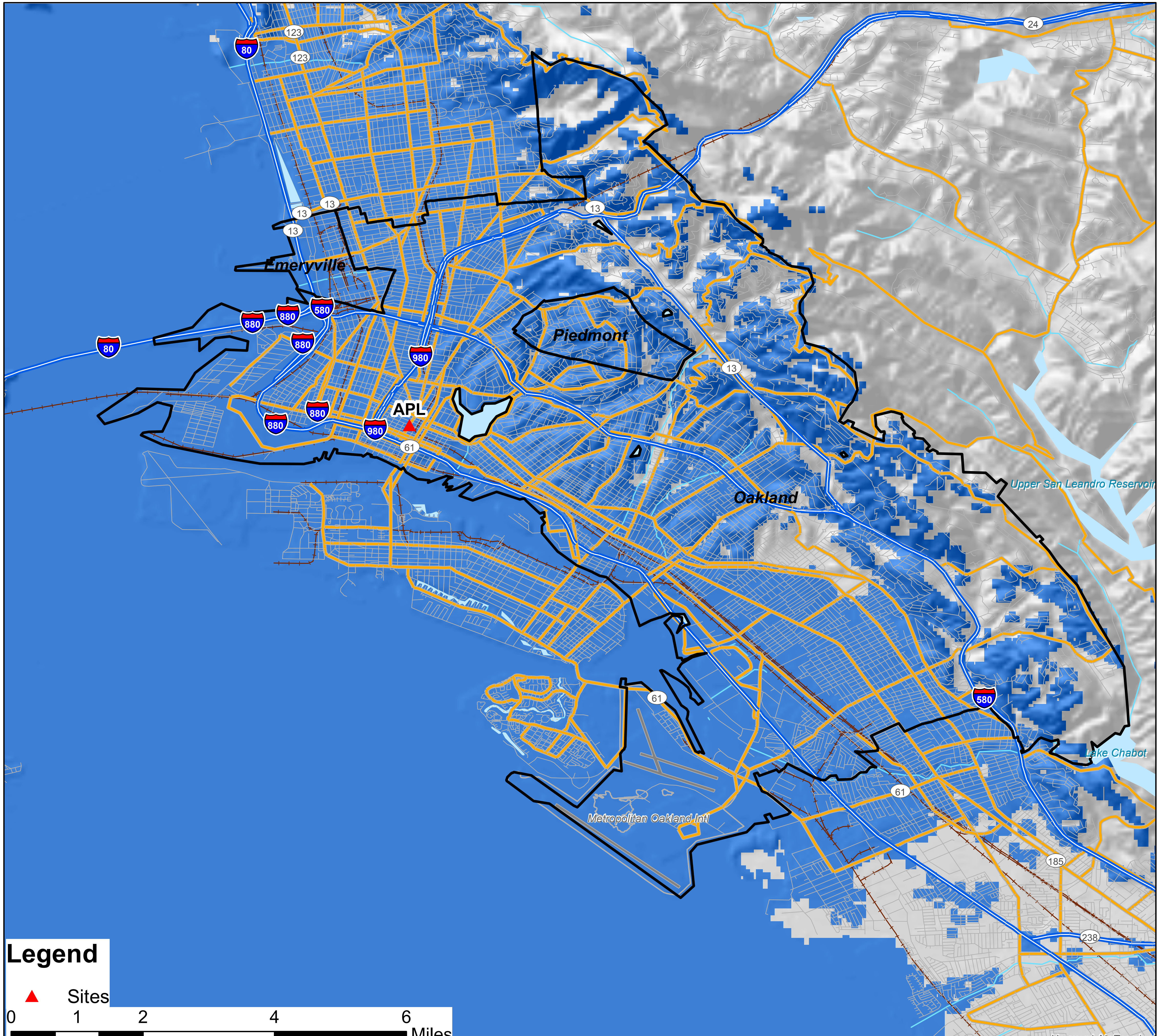

Figure 1-1 Existing APL Talkin Portable Outdoors 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Portable Outdoors Coverage Prediction Talkin (Portable to Base) 800MHz Prediction Based on FCC License

Site: APL

Longely-Rice 90/90 with Land Clutter/Land Use

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: WNC 15 December 2008

Drawn: TRM 29 January 2009

Checked: WNC 30 January 2009

Approved: HWW 30 January 2009

File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-1 Existing APL Talkin Portable Outdoors 800MHz Coverage rev1.pdf

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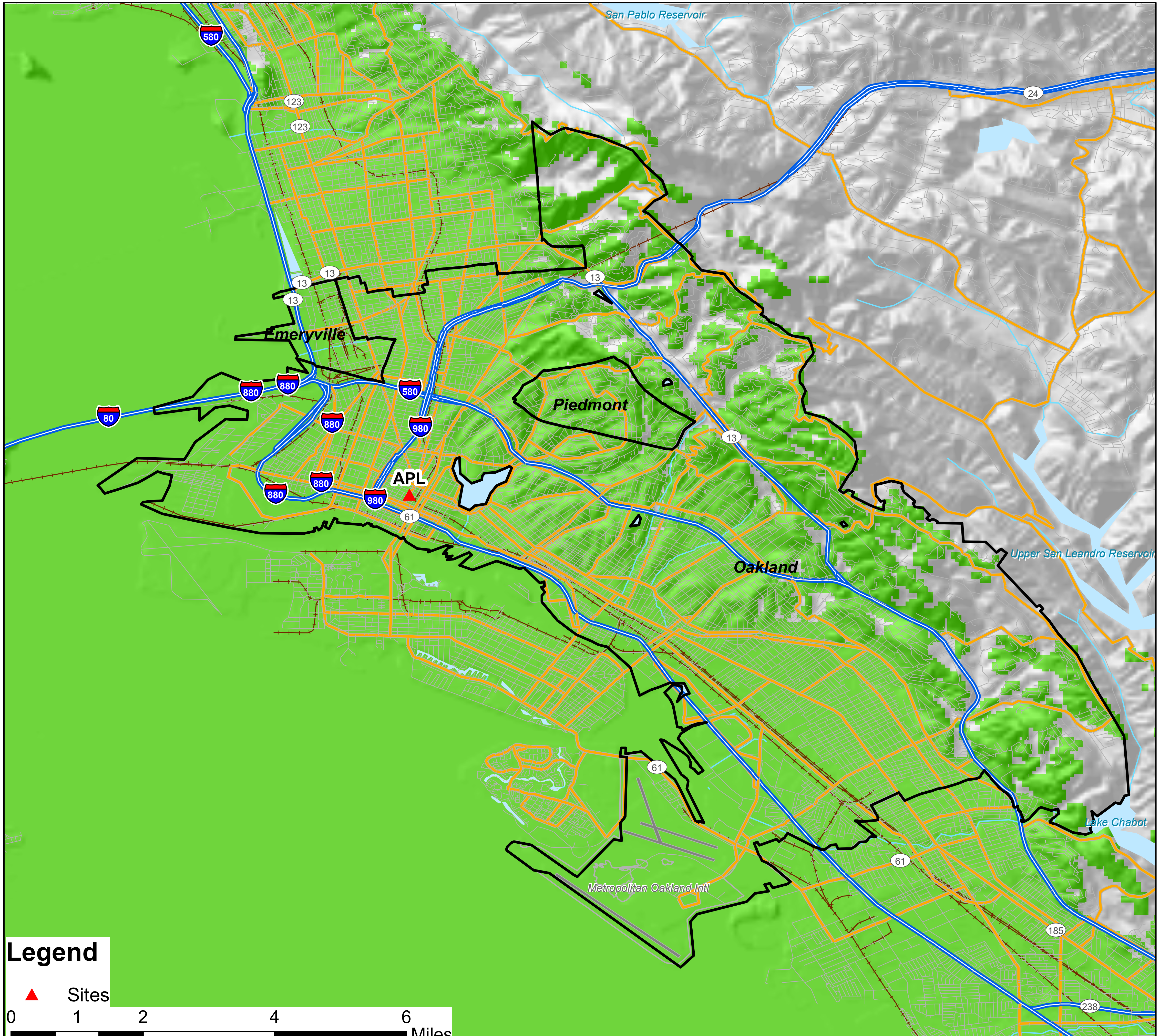

Figure 1-2
Existing APL Talkin Mobile 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Mobile Coverage Prediction Talkin (Mobile to Base) 800MHz Prediction Based on FCC License

Site: APL

Longely-Rice 90/90 with Land Clutter/Land Use

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

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M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-2 Existing APL Talkin Mobile rev1.pdf

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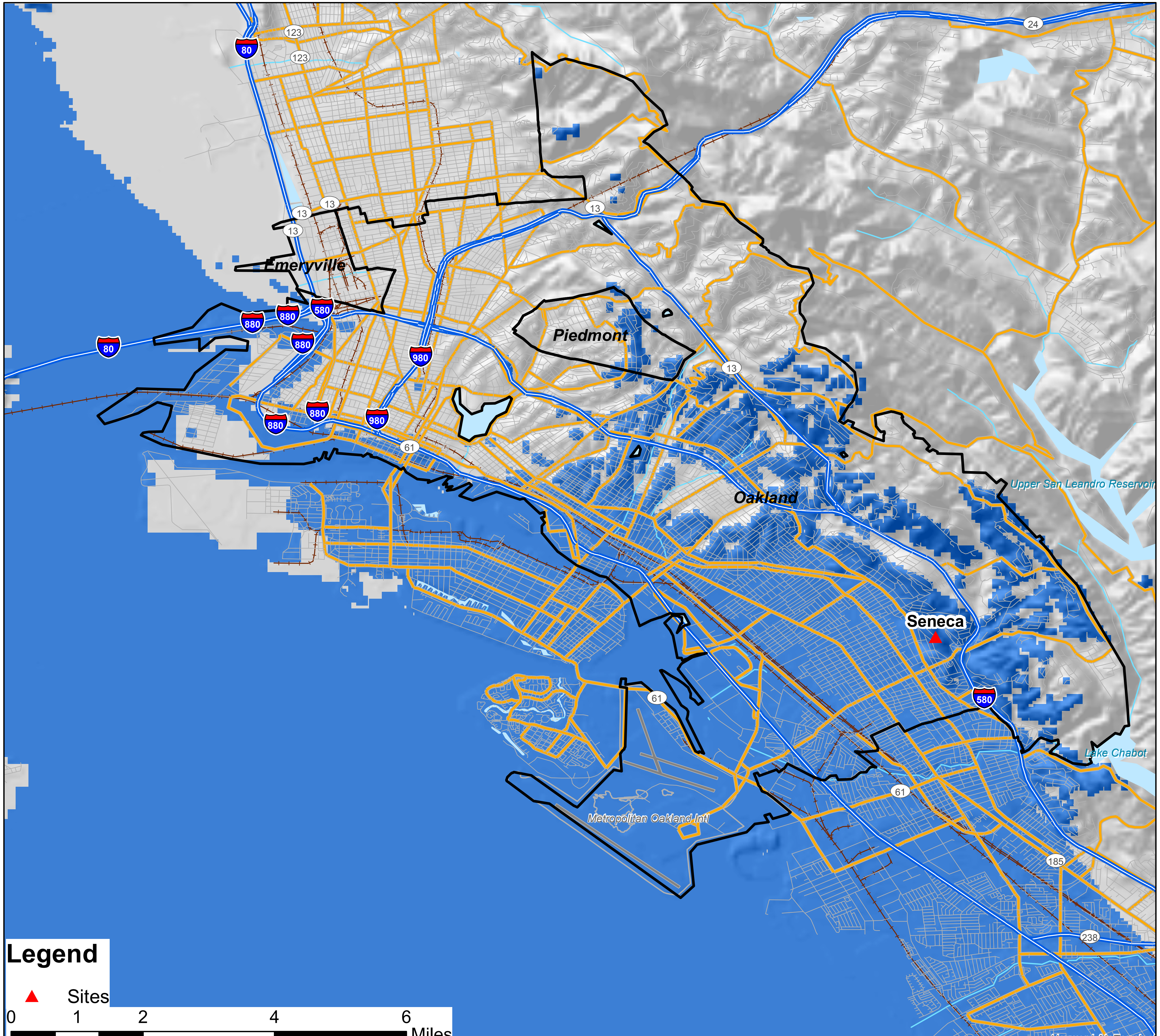

Figure 1-3 Existing Seneca Talkin Portable Outdoors 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Portable Outdoors Coverage Prediction Talkin (Portable to Base) 800MHz Prediction Based on FCC License

Site: Seneca

Longely-Rice 90/90 with Land Clutter/Land Use

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

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File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-3 Existing Seneca Talkin Portable Outdoors 800MHz Coverage rev1.pdf

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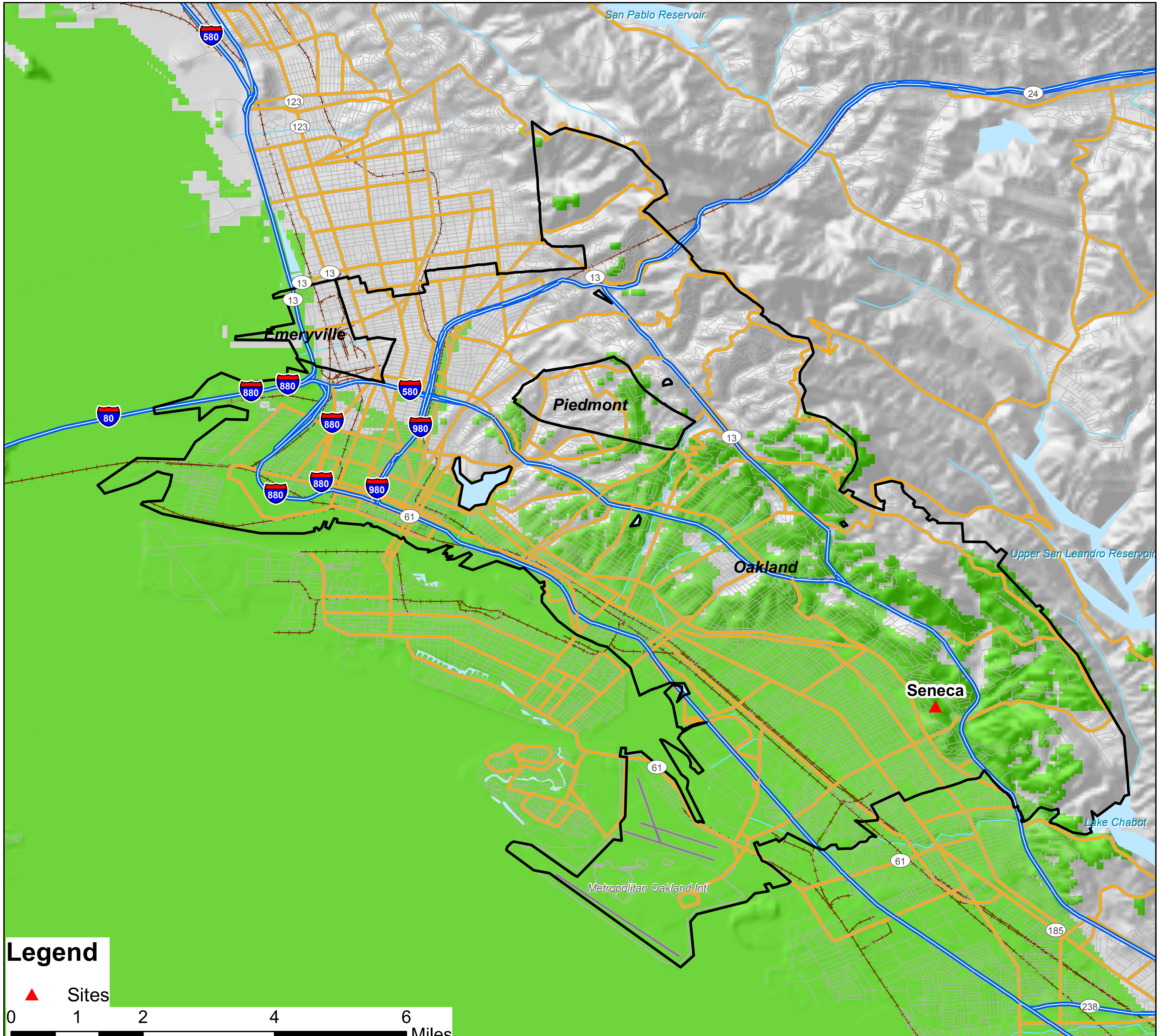

Figure 1-4 Existing Seneca Talkin Mobile 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Mobile Coverage Prediction Talkin (Mobile to Base) 800MHz Prediction Based on FCC License

Site: Seneca

Longely-Rice 90/90 with Land Clutter/Land Use

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: WNC 15 December 2008

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Approved: HWW 30 January 2009

File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-4 Existing Seneca Talkin Mobile rev1.pdf

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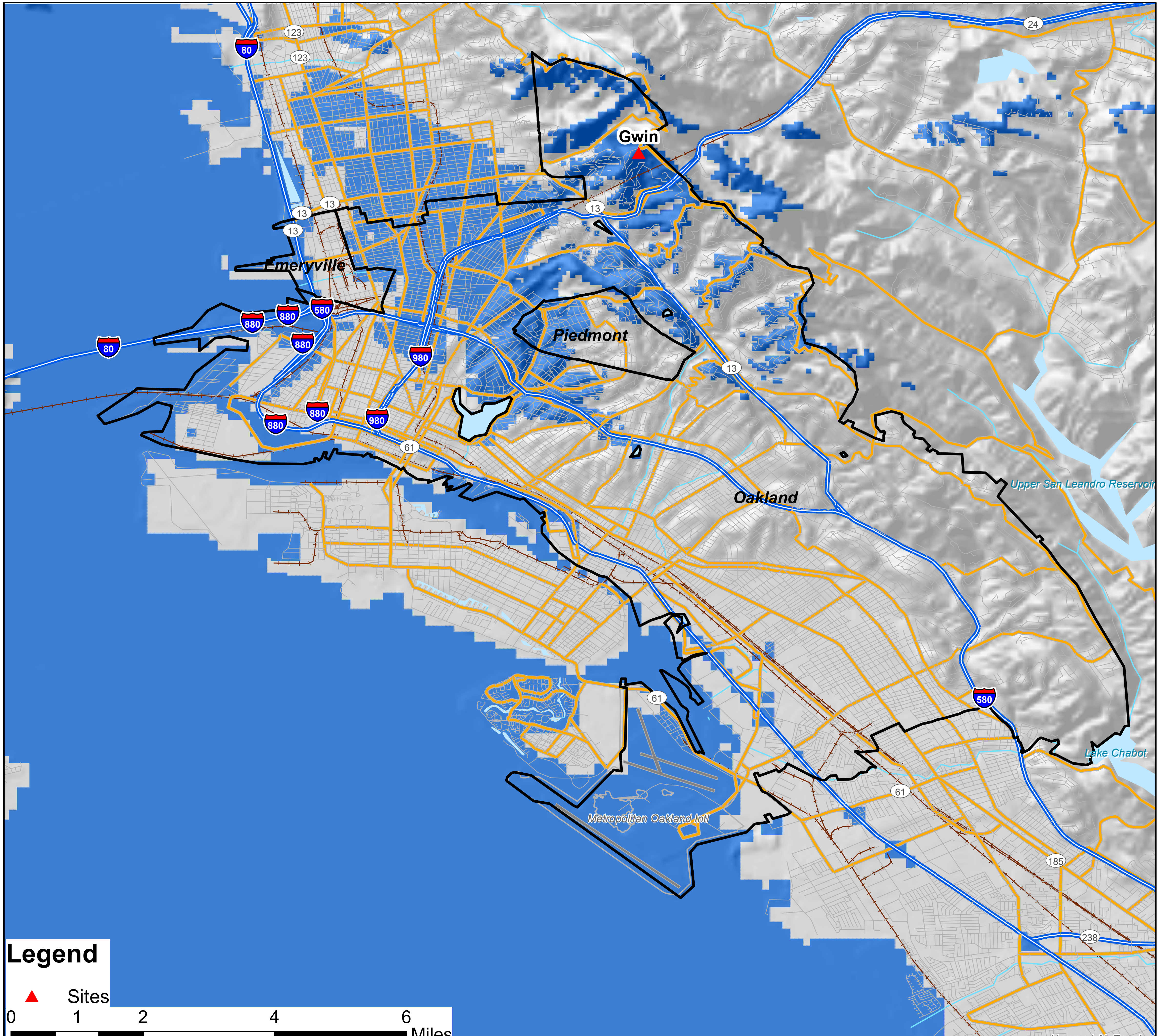

Figure 1-5 Existing GWIN Talkin Portable Outdoors 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Portable Outdoors Coverage Prediction Talkin (Portable to Base) 800MHz Prediction Based on FCC License

Site: GWIN

Longely-Rice 90/90 with Land Clutter/Land Use

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Design: WNC 15 December 2008

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Approved: HWW 30 January 2009

File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-5 Existing Gwin Talkin Portable Outdoors 800MHz Coverage rev2.pdf

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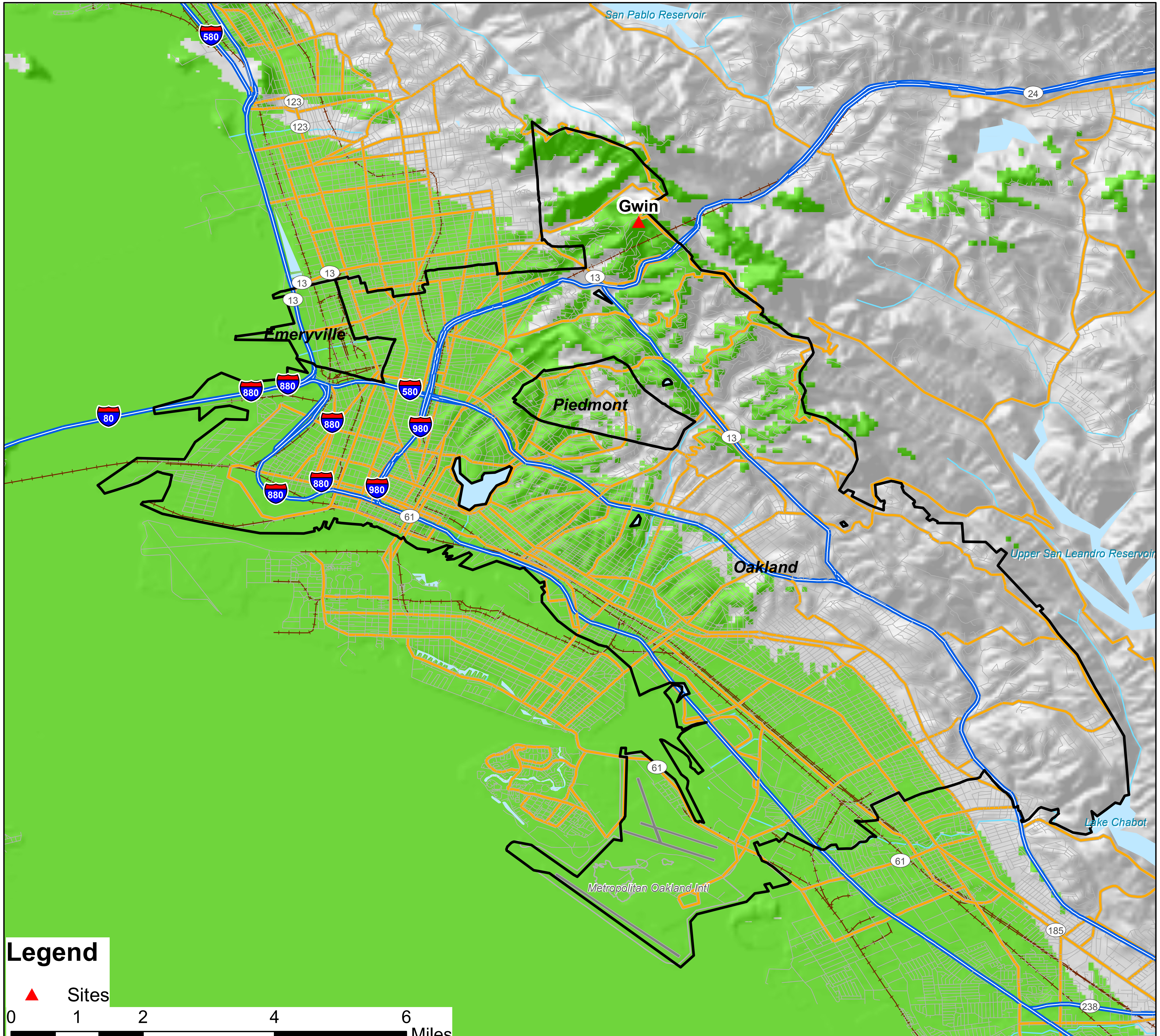

Figure 1-6
Existing Gwin Talkin Mobile 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Mobile Coverage Prediction Talkin (Mobile to Base) 800MHz Prediction Based on FCC License

Site: Gwin

Longely-Rice 90/90 with Land Clutter/Land Use

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: WNC 15 December 2008

Drawn: TRM 28 January 2009

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File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-6 Existing Gwin Talkin Mobile rev2.pdf

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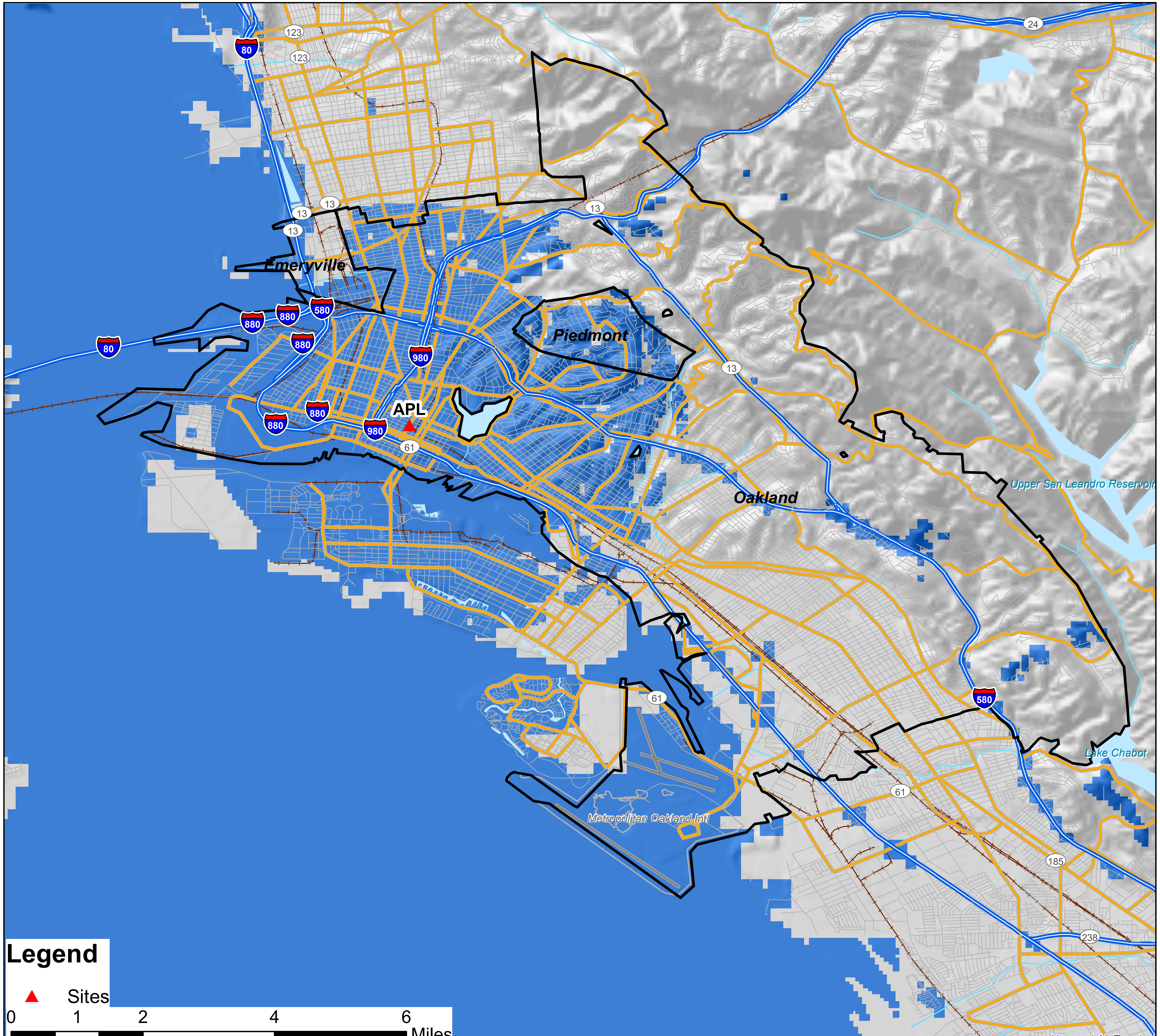

Figure 1-7
APL User Reported Coverage

Client: City of Oakland

Commission No. 20177A

Existing System Portable Outdoors Coverage Prediction Talkin (Portable to Base) 800MHz Prediction Based on FCC License

Site: APL

Longely-Rice 90/90 with Land Clutter/Land Use

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: WNC 15 December 2008

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File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-7 APL User Reported Coverage rev1.pdf

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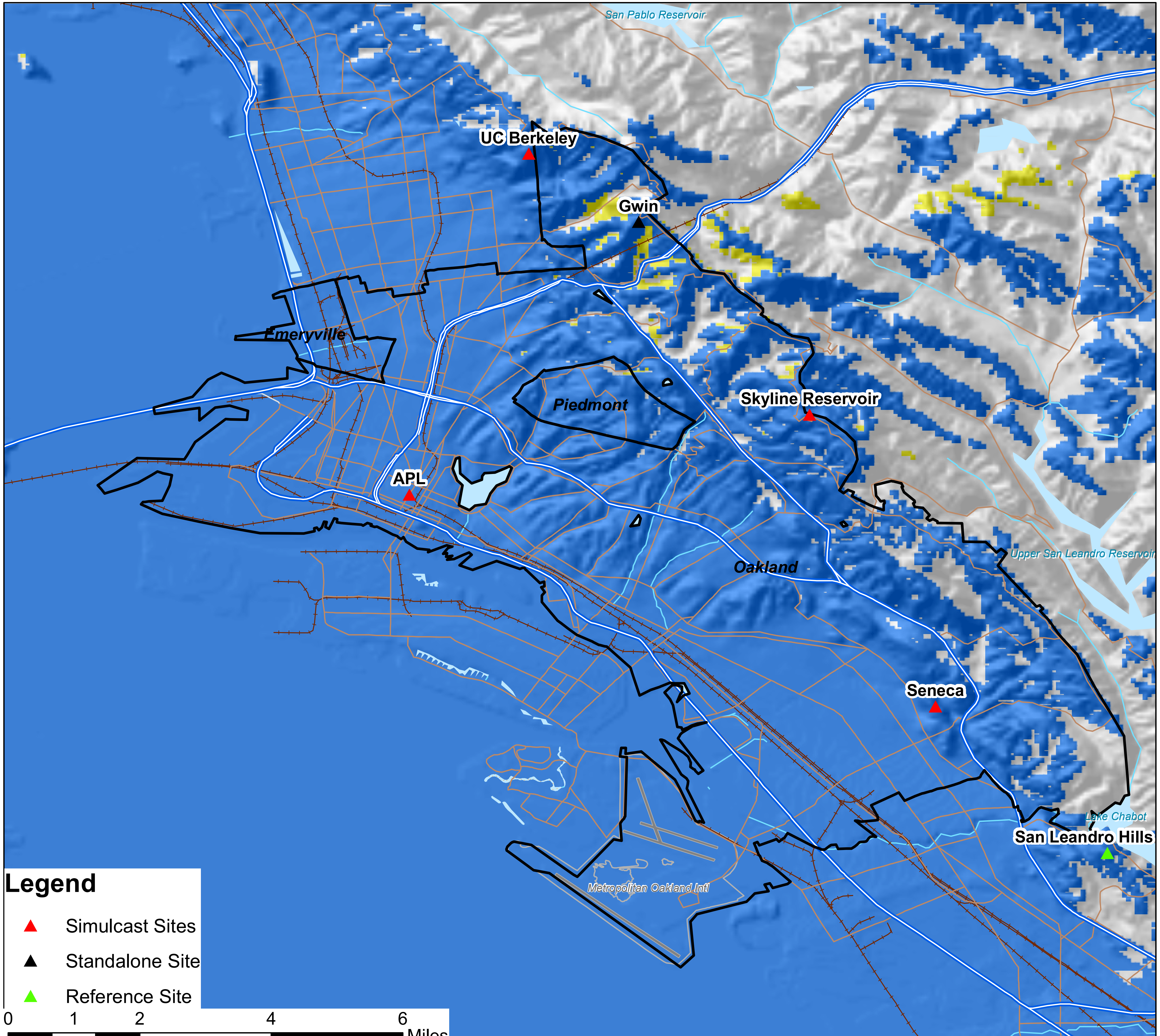

Figure 1-8 Proposed EBRCS Interoperability Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Outdoors Coverage Prediction (Base to Portable) 800MHz Prediction Based on FCC License

Simulcast Sites: APL
Seneca
Skyline Reservoir
UC Berkeley

Standalone Site: GWIN

Design: TRM 15 December 2008

Drawn: TRM 14 September 2009

Checked: WNC 15 September 2009

Approved: WNC 15 September 2009

File Name:
M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-8 Proposed EBRCS Interoperability Coverage rev5.pdf

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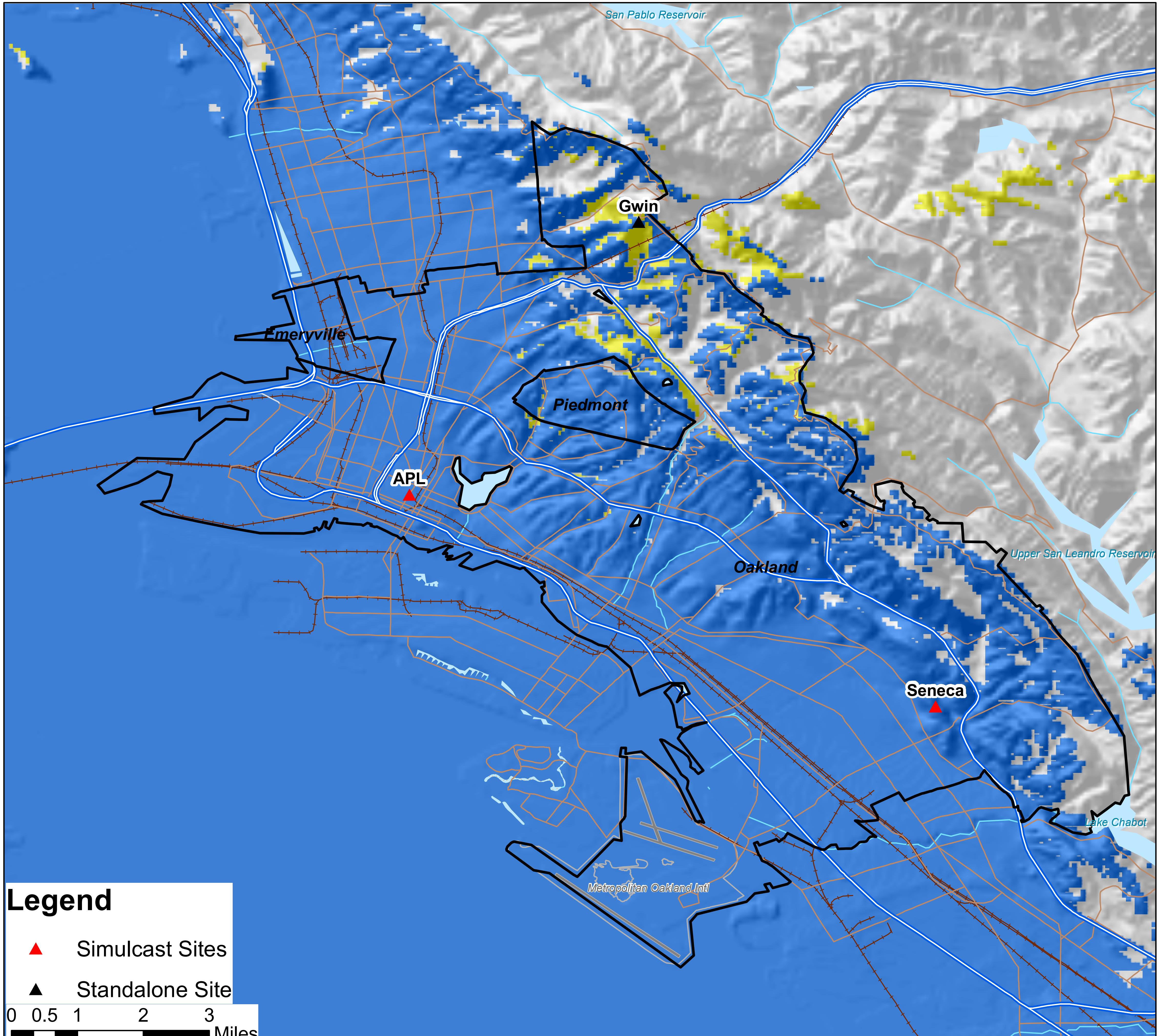

Figure 1-9 Predicted Oakland Simulcast Portable Outdoors 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Predicted Oakland Simulcast System Portable Outdoors Coverage (Base to Portable) 800MHz Prediction Based on FCC License

Simulcast Sites: APL Seneca

Standalone Site: GWIN

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Drawn: TRM 28 January 2009

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File Name:

M:\Projects\Radio Projects\60091365_20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-9 Predicted Oakland Simulcast Portable Outdoors 800MHz Coverage rev1a.pdf

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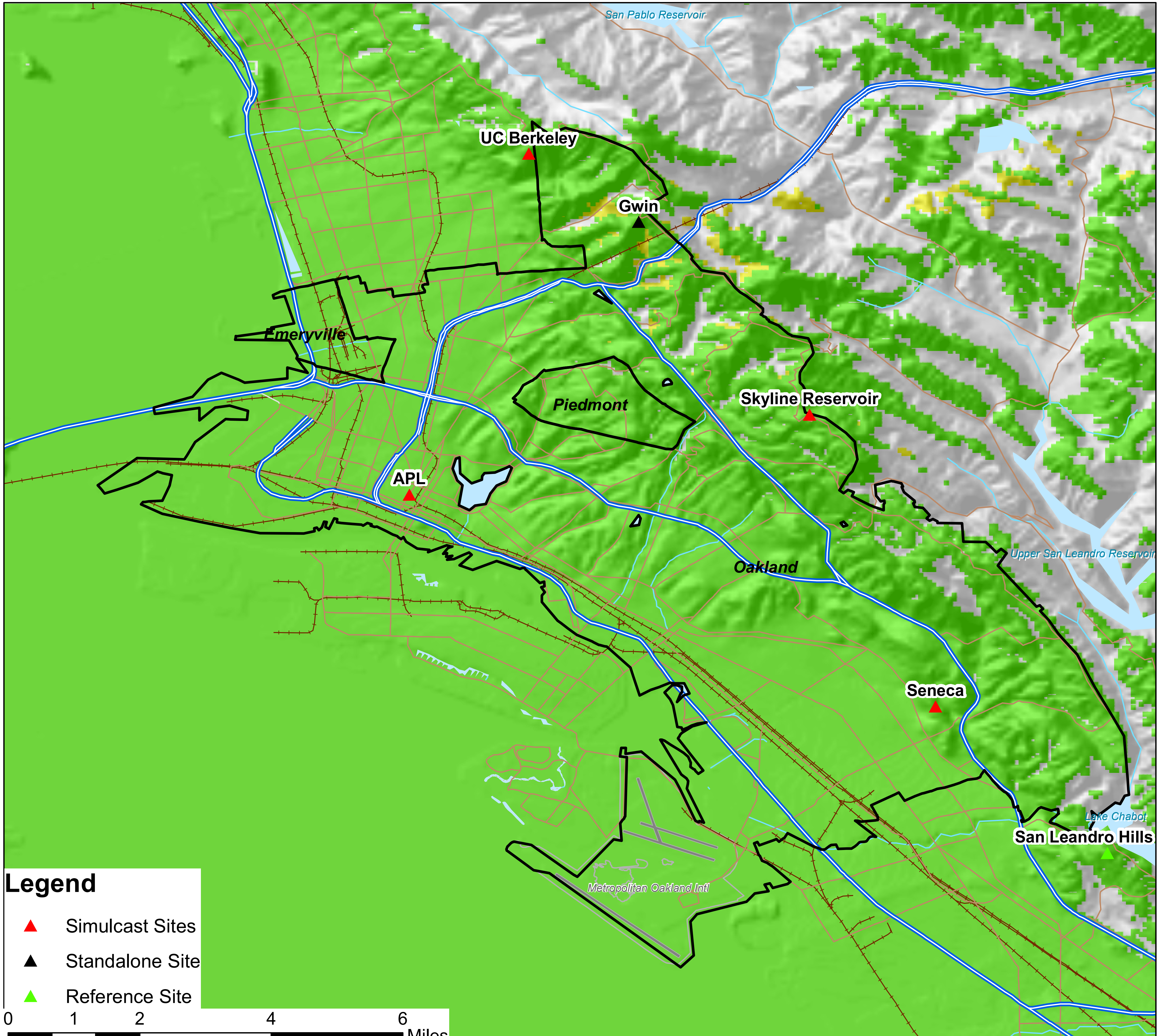

Figure 1-10
Proposed EBRCS Interoperability Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Mobile
Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Seneca
Skyline Reservoir
UC Berkeley

Standalone Site: GWIN

Design: TRM 15 December 2008

Drawn: TRM 14 September 2009

Checked: WNC 15 September 2009

Approved: WNC 15 September 2009

File Name:

M:\Projects\Radio Projects\20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-10 Proposed EBRCS Interoperability Coverage.pdf

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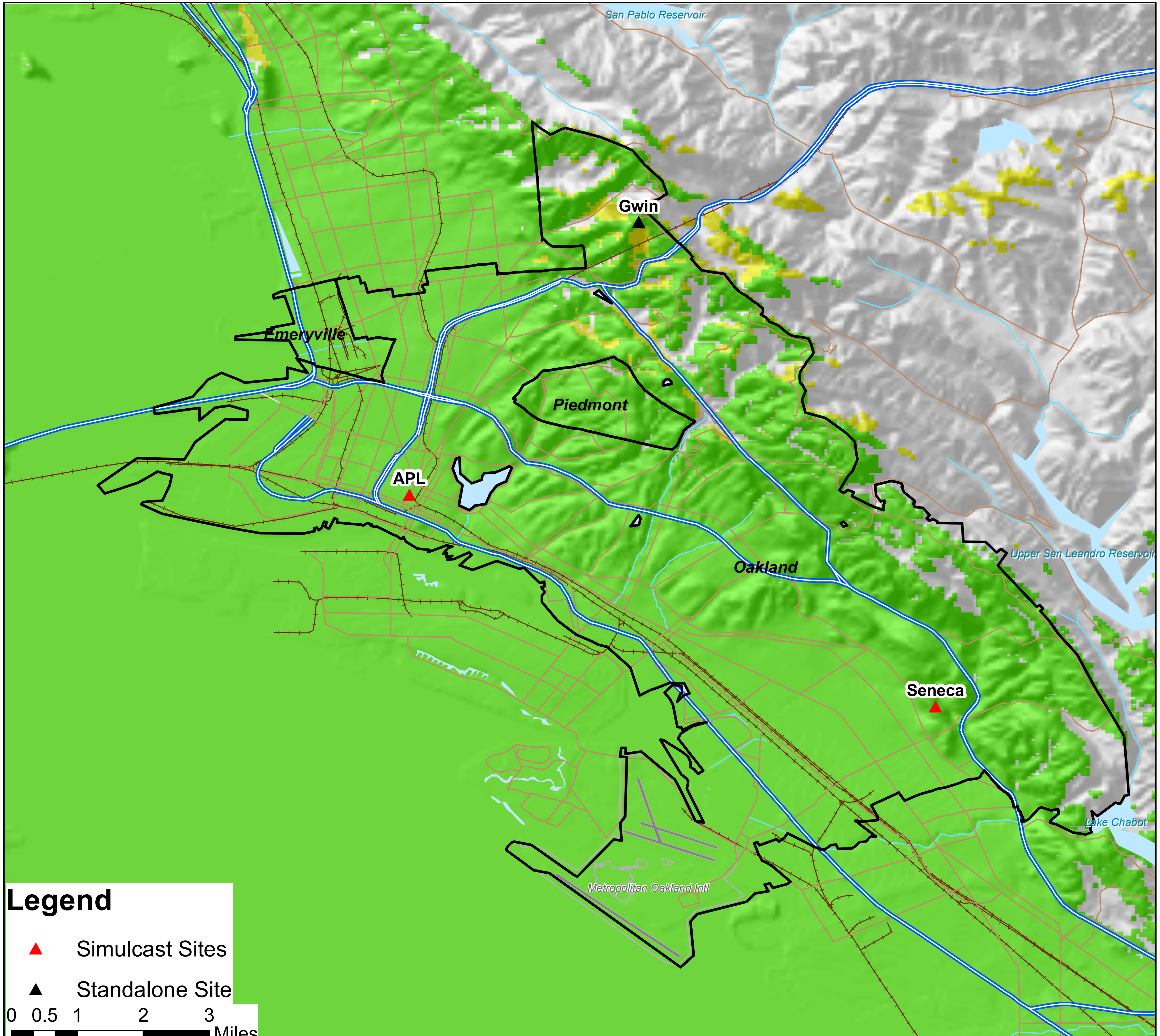

Figure 1-11
Predicted Oakland Simulcast Mobile 800MHz Coverage

Client: City of Oakland

Commission No. 20177A

Predicted Oakland Simulcast System
Mobile Coverage
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Seneca

Standalone Site: GWIN

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: WNC 15 December 2008

Drawn: TRM 28 January 2009

Checked: WNC 28 January 2009

Approved: WNC 28 January 2009

File Name:

M:\Projects\Radio Projects\60091365_20177 City of Oakland, CA\Phase A Needs Analysis\Job Files\Technical Data\CTA P-CALA\Arcview Maps\Figure 1-11 Predicted Oakland Simulcast Mobile 800MHz Coverage.pdf

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2.0 Spectrum Efficiency

2.1 Introduction

This section provides information and data pertaining to system operation that was gathered from the interview meetings, the site and dispatch facility surveys and the online survey. CTA used this system data to analyze the City's current communication system operation. This section also documents the advantages and disadvantage of a multi-site system configuration and provides recommendations for improved system operation and utilization.

The analysis in this section meets the requirements for SOW #2, Spectrum Efficiency. Although the SOW describes this task as Spectrum Efficiency, the description given for task #2 indicates that it could be called Multi-Site Operational Analysis. The results of this section will be included in the Final Study Report.

2.2 Multi-Site System

The City of Oakland Radio System is a two site EDACS 800 MHz radio system with transmit/receive sites at APL and Seneca. Oakland has installed an 800 MHz P25 site at Gwin that will eventually be used to fill in coverage for the Oakland Hills. The sites are tied together via microwave using a console switch at the dispatch center so that the dispatch operators can monitor radio traffic at all sites.

Each site in the Oakland system operates independently and automatic roaming between the sites is not supported at this time. The operational impact is that if a user from the northern portion of the City wants to communicate in the southern portion, they must manually change from an APL talkgroup to a Seneca talkgroup. This also holds true for users who need to use the Gwin site for coverage. The existing system consists of multiple repeater sites that are manually accessed by the radio user as **the user decides** which site will provide the best coverage for their location, and then the user must manually change the radio channel to that site.

The existing City of Oakland system is not a true "multi-site" system. In a true multi-site system, separate channels are assigned to each site, which presently is being done in the existing Oakland system. However, the major difference between the City of Oakland's system and a true multi-site system is that a true multi-site system supports roaming between the sites.

If the Oakland system was a true multi-site system, then as a user from APL's coverage area moved into an area with dual overlapping coverage (APL and Seneca), the subscriber unit would automatically recognize the additional control channel now also available from the Seneca site. The **radio would then decide** which site to affiliate with based on received signal strength. If the users from APL moved to an area where the Seneca site had superior signal strength, the radio would affiliate with the Seneca site. This process is called "hand-off" and is a major feature of cellular telephone networks. Hand-off gives the user the appearance of "seamless" operation when in fact multiple hand-offs are occurring as the user "roams" between different coverage areas.

The true Multi-Site system has the added benefit of automatic roaming over the existing system, but there is one important disadvantage. Because the coverage areas of each of the sites have significant overlap, many users from the same talkgroup could be affiliated to each of the two sites. It is not unlikely that half of the users on a talkgroup could be on one site, and the other half on another site, based on the location of each user. This would cause a significant increase in the number of channels needed to support the talkgroup and could cause a strain on radio capacity because channels are dedicated to the call from each site. CTA has analyzed the radio traffic for Oakland's current system and has found that many users (as many as 60%) are manually selecting sites that require a multi-site connection. In other words about

60% of the calls made must go through the IMC to make a connection between APL and Seneca. A large majority of these could be Dispatch initiated calls, but the numbers do indicate that additional strain is being placed on the system due to the current APL / Seneca configuration.

2.2.1 Multi-Site Advantages compared to Simulcast

This section also compares a true-multi site system with its counterpart, the simulcast system.

This comparison is provided in the next two sections:

- The primary advantage is cost.
  - Multi-Site systems require fewer repeaters. For example, a typical two-site simulcast system supporting 1000 users may require 7 shared channels total, while a two-site, multi-site system supporting the same 1000 users may require 5 channels per site—a total of 10 channels. The two-site simulcast system with the same 7 channels at each site would require 14 repeaters total—while the multi-site system with only 5 channels at each site would only require 10 repeaters total.
  - A multi-site system does not require the precise timing and equalization equipment, or the voters that a simulcast system needs. This translates to a reduction in cost.
- Ease of Implementation. Since each site operates independently on separate channels, each site can be configured individually without the need to account for the voters or signal comparators that are needed in simulcast systems.

2.2.2 Multi-Site Disadvantages compared to Simulcast

Despite the advantages offered by the Multi-Site system, there are several disadvantages when compared to its counterpart, the simulcast system.

These disadvantages are described below.

- Spectral efficiency is a disadvantage. In a multi-site system, different frequencies are required at each site, however, in a simulcast system, the same channels are reused at all sites. This requires additional frequencies for a multi-site system. For example, a typical two-site simulcast system supporting 1000 users may require 7 channels total, while a two-site multi-site system supporting the same 1000 users may require 5 channels per site—a total of 10 channels. Simulcast systems yield a higher capacity with an equivalent amount of spectrum, or an equivalent capacity with less spectrum.
- Network efficiency is also a disadvantage. If too many talk groups are operating on multiple sites, the system may require additional channels at each site to avoid the system becoming overloaded during the busy hour.
- Wide-area calls (calls between users on multiple sites but within the same talkgroup) can create the potential for lost or delayed communications. Wide-area call handling in a multi-site system can be programmed in one of two ways, but neither of these approaches is entirely satisfactory.
  1. The system can require that a channel be assigned to all sites associated with the talk group before the channel is granted (causing delays before communications can proceed); or
  2. The system can allow a call to proceed as soon as a channel is available on the site of the calling unit and units on other sites receive the call when channels are available at their sites (causing some units to miss part or all of the call).
- Roaming between multiple sites presents special problems to the programming and operation of the subscriber units in a multi-site system. As a unit travels through the coverage areas of multiple sites, it has to decide with which site to affiliate. This is done by periodically measuring the signal of all sites that it can receive and selecting what it considers to be the best one based on a predetermined algorithm. Terrain and other factors can cause

significant signal fades; signal levels can change by 20 or 30 dB within a distance of a couple feet. Because of these rapid fluctuations, the decision-making process is subject to potential error; a unit may not always affiliate with the best site and a user may not have communications when needed. In a Simulcast System, the all RF sites appear as one “site" to the mobile or portable. The voters in a simulcast system determine which RF site received the best signal, and provides this signal to the transmitters.

2.3 Improved System Operation

The real advantage to a true multisite system is the ability for users to roam between multiple sites without the need to make manual changes on the radio. In addition, the cost savings over a simulcast system can be significant depending on the number of channels. During the interview process, CTA was advised that the City of Oakland had purchased the equipment necessary to move from their current system to a true multisite system. Although the equipment is purchased, it has not been installed. Installation of the multisite system will provide the roaming feature many of the users requested during interviews.

A thorough study of the microwave back-haul capacity will also have to be conducted to ensure that the additional load placed on the backbone will not affect communications. In addition, traffic monitoring statistics available for the existing EDACS system can be used to verify that roaming will not add an additional burden on channel availability. After these studies are complete, the migration to a true roaming system can begin. In addition the installation of the roaming equipment can be coordinated with the current reprogramming that is occurring as a result of the 800 MHz rebanding effort. A final decision on the technical roadmap will be discussed after expressing the advantages and disadvantages of a simulcast system.

3.0 Coverage Redundancy

3.1 Introduction

This section analyzes the coverage overlap between the City's current 800 MHz radio system and the proposed EBRCS. The analysis in this section meets the requirements for SOW #3, Coverage Redundancy. The results of this section will be included in the Final Study Report.

3.2 Predicted Coverage Overlap

A preliminary look at the EBRCS and City of Oakland coverage overlap was presented in Section 1.2 of this report. The coverage maps presented in Section 1.2 will be used for the purpose of the comparison in this section. In Figure 1-8, the coverage provided in the City of Oakland's operational area by the EBRCS ALCO Northwest Cell is displayed. The coverage overlap for the City of Oakland is significant.

In the system design from Motorola in January 2009, the current ALCO Northwest and Southwest cells were merged into one cell. The cell was undersized for the city of Oakland, did not provide adequate coverage and did not meet the needs of the City of Oakland. Since the cell was split into a Northwest and Southwest and the sites were moved, the existing system design provides very good coverage for the City of Oakland. Even if the City does not decide to join EBRCSA, they should aggressively pursue keeping the sites in the existing Northwest Cell in order to provide very good coverage overlap for the entire City. A comparison of the coverage overlap can be clearly seen by comparing Figure 1-8 with Figure 1-9.

3.3 Site Consolidation Opportunities

In section 1.2.2, we summarized some of the site consolidation opportunities for EBRCS and the City of Oakland.

We examined three possible site consolidation opportunities:

1. Gwin and Lawrence Berkeley Lab
2. APL and Glen Dyer Jail
3. Seneca and Skyline Reservoir

The Gwin / Lawrence Berkeley site consolidation was determined not feasible for two reasons. First, the coverage provided by the Lawrence Berkeley site was not sufficient. Second, if EBRCS desired to move the Lawrence Berkeley Lab site to Gwin, there is not enough physical space to support additional equipment. Based on our evaluation of the Gwin site, the existing conditions of the site including grounding and maintenance all meet or exceed LMR standards. However, an additional tower and shelter would be needed to support additional channels for EBRCS. Due to the location of the Gwin site, there is not physical room for the new tower and larger shelter that would be needed to support a simulcast site. Because of the coverage differences and the lack of physical space, CTA recommends that these two sites remain separate.

The APL and Glen Dyer site combination provides a significant opportunity to consolidate two separate sites. In section 1.2, we provided an overview of several technical factors that should be considered if the two sites are to be consolidated. This analysis did not reveal any technical limitations that would prevent EBRCS from co-locating equipment at the APL site. A similar analysis was conducted for the Seneca and Skyline Reservoir site combination and again, nothing was revealed that would prevent EBRCS from collocating equipment at the Seneca site.

Even though a site consolidation may be technically feasible, it must also be cost effective and administratively achievable. A discussion of the various governance and administrative concerns is deferred to Section 14 of this report. The discussion of the cost savings of collocating equipment was discussed in Section 1.4. The costs included in Section 1.4 provide a guideline for making site consolidation decisions based on cost.

The major cost advantage is the fact that both APL and Seneca are existing LMR sites in excellent condition and both facilities have the physical space to accommodate additional equipment, towers and shelters.

4.0 Simulcast Technology

4.1 Introduction

This section evaluates the use of simulcast technology for use within the City of Oakland's radio system and provides an overview of the advantages and disadvantages of implementing a wide area simulcast radio system. In addition, CTA will include the information presented in this section to develop a potential technical roadmap if the City decides to implement a simulcast system.

The analysis in this section meets the requirements for SOW #4, Simulcast Technology. The results of this section will be included in the Final Study Report.

4.2 Simulcast Systems

The discussion of Simulcast Systems presented here assumes that the reader is familiar with trunked radio systems and that the multi-site description presented in Section 2 has been read. In a simulcast trunked radio system, all sites share the same set of frequencies. To avoid interference, timing among all transmitters must be precisely controlled to within fractions of a second and output power levels must be adjusted to avoid self interference. When a call is made, the best audio from the receivers is selected and routed to all transmitters. A Simulcast System enables users to roam anywhere in the system coverage area and continue to talk on their radio without making any adjustments based on location.

4.2.1 Simulcast Disadvantages compared to a Multi-site System

Overview of the disadvantages of simulcast compared to a multi-site system.

- The primary disadvantage is cost.
  - A simulcast system requires precise transmitter timing and equalization equipment. Receive systems must include voters (or signal comparators) to select the strongest receive signal and direct it to the console or repeater transmitters.
  - A simulcast system also requires additional repeaters compared to a multi-site system. For example, a typical two-site simulcast system supporting 1000 users may require 7 channels, while a two-site multi-site system supporting the same 1000 users may require 5 channels per site for a total of 10 channels. The two-site simulcast system with 7 channels at each site would require 14 repeaters total, while the multi-site system with only 5 channels at each site would only require 10 repeaters total.
- In a simulcast system, there is the potential for signal distortion in overlap areas between the simulcast sites. This can be minimized through proper system design and accurate system timing. Due to the technology used in P25 simulcast systems this problem is no longer of great concern.
- Current Simulcast P25 Technology limits the number of channels per system to 24 channels per controller for a Tyco Electronics system and 28 channels for a Motorola system. Other vendors may have similar channel limitations. Although this limitation does not affect the City of Oakland at this time (17 channels are currently used) it may have an impact on future upgrades or may affect channel limitations for EBRCS.
- Additional requirements are placed on the back-haul network that inter-connects the sites. Since additional traffic will likely occur between sites as a result of automatically routing all received signals to voter equipment and sending the best received signal out to all transmit sites, the back-haul network that connects the sites must be analyzed to ensure that it can support any additional traffic.

- Reduced coverage area is another disadvantage. In a simulcast system there is a limit to the number of sites, which effectively limits the coverage area. In the City of Oakland, this limitation will have no affect because the existing three sites are sufficient to cover the entire City.

4.2.2 Simulcast Advantages compared to multi-site system

Overview of the advantages of simulcast compared to multi-site system.

- The primary advantage of a simulcast radio system is spectral efficiency. Far fewer frequencies are needed for the same user capacity.
  - In a simulcast system, the same channels are reused at all sites; in a multi-site system, different frequencies are required at each site. For example, a typical two-site simulcast system supporting 1000 users may require 7 shared channels total, while a two-site multi-site system supporting the same 1000 users may require 5 channels per site—a total of 10 channels.
  - Another advantage is the reduction in the number of control channels from one per site, to one per system. In a multi-site system, one control channel is needed per site, while a simulcast system uses one control channel for the entire coverage area. The result is reduced equipment allocation for control channels, which results in more channels available for voice traffic.
- Simplicity of use is another advantage. All units are communicating on the same set of frequencies. No special procedures are required for wide-area calls among users on multiple sites.
  - Users do not have to “manually” select the site based on their location within the City of Oakland. With simulcast coverage, users can operate anywhere in the simulcast system’s coverage area without adjusting radio settings. In the City of Oakland this would enable seamless operation throughout the coverage area, including the cities of Oakland, Piedmont and Emeryville.
- The last advantage worth noting is improved redundancy. If one site totally fails, the remaining sites at least partially fill the gap. This is because of the existing coverage overlaps.

4.2.3 Simulcast in Oakland

Currently, with only 8 operational channels on the APL site and 5 channels on the Seneca site, the City has 11 channels available (7 on APL and 4 on Seneca) for voice traffic. If the City of Oakland should go simulcast, they would have 14 channels total, with 13 channels available for voice traffic.

Due to the spectrum efficiencies provided by Simulcast systems, as well as ease of use, CTA recommends that the City of Oakland begin to migrate to a Simulcast system. CTA completed an analysis of the radio traffic for the existing radio system and noted that about 60% of the calls were considered “multi-site” or wide area calls. Each of these calls ties up frequency resources on both sites. In some cases, these wide area calls have increased the queue time and have likely been the cause of degraded service. Despite the increased cost, the simulcast system is the best solution for the City of Oakland.

5.0 In-Building Coverage

5.1 Introduction

In this section, CTA provides an overview and analysis of the existing In-Building Coverage. CTA noted several problems that were reported during interviews and via the responses to CTASurveyorSM, the online survey tool, which are addressed in this section. An overview of possible solutions is provided and the section concludes with a recommended course of action to improve the City's in-building radio coverage.

The analysis in this section meets the requirements for SOW #5, In-Building Coverage. A brief excerpt from the Code of Federal Regulations, Title 47, Part 90 (47 CFR 90), which discusses the deployment of BDAs, is also included for the City of Oakland's convenience. The results of this section will be included in the Final Study Report.

5.2 Existing In-Building Coverage

Analysis of in-building system coverage began by first looking at existing radio in-building coverage within the City of Oakland's operational area. The in-building coverage maps shown at the end of this section reflect portable talk-In (the communication path from the portable to the tower) coverage for light, medium, and heavy buildings. Talk-in diagrams were selected due to the concern users consistently mentioned during interviews about not being able to talk back to dispatch.

The source of these in-building coverage estimates is a coverage prediction program that is part of CTA's proprietary Propagation, Coverage, and Loading Analyst (P-CALA℠) software. These in-building predictions are based on knowledge of radio signal propagation, and the factors which affect the signal as it travels through the air, over different terrain types, through different vegetation types, and into buildings. In-building coverage predictions are based on the version 1.2.2 Longley-Rice point-to-point model as implemented in the Terrain Analysis Package (TAP™) by SoftWright, LLC.

The three sites in the Oakland system operate independently, and automatic roaming between the sites is not supported at this time. If a user from the northern portion of the City travels to the southern portion, they must manually change from an APL talkgroup to a Seneca talkgroup. As a result, users typically have a primary site that they use for all communications. The in-building coverage diagrams reflect the in-building coverage that users are accustomed to as they operate from a single site.

5.2.1 Identified Problem areas

In-building problem areas were identified by the City of Oakland, Piedmont, and Emeryville users during initial interviews conducted by CTA. The specific buildings identified with poor in-building coverage during the interview process included 250 Frank H Ogawa Plaza (in the middle of the building), inside the Caldecott Tunnel, which connects Oakland with Contra Costa County, and inside the Highland General Hospital.

All three locations identified by the radio users are considered heavy buildings. GWIN talk-in portable radio coverage, show lack of coverage in and around the Caldecott Tunnel. The tunnel is blocked by terrain, and Hwy 24 leading into the tunnel from the west is located in a valley. The APL talk-in portable coverage for heavy buildings, it is clear that the Highland Hospital does not have coverage. It is well outside the heavy building coverage provided by the closest site. When reviewing the other heavy building coverage, it is clear they do not provide coverage at the hospital.

The “250 Frank Ogawa Plaza” location is actually a cluster of buildings. It was not clear during the interview process which building did not have coverage, though the City Hall building was discussed. The plaza is located just down the street from the APL site. Due to the close proximity to the APL site, it is expected that in-building coverage in the Frank Ogawa buildings would be achieved. In the middle of the building, where the problem was reported, the penetration loss through several walls of heavy construction can easily reach 50 dB or higher. CTA Communications calculates their heavy building coverage predictions at a 20 dB building penetration loss (i.e. one wall). It is typical to generate coverage predictions using a “one wall in” design approach. This would explain the discrepancy between the in-building coverage, and the radio user reported lack of coverage in the middle of the building. Table 5-1 shows typical attenuation values by construction material type measured in dB.

Table 5-1
UHF (300 MHz–3 Gigahertz) Building Materials Loss Measurements

Material	Attenuation (dB)
Ceiling duct	1–8
Small metal pole (6” in diameter)	3
Foil Insulation	3.9
Metal stairs	5
Concrete wall	8–15
Loss from one floor	13–33
Loss from two floors	18–50
Aluminum siding	20.4

*Rappaport, Theodore S., Wireless Communications Principles and Practice, Prentice-Hall, Inc., 1996

Older concrete construction, like that of the Frank Ogawa Plaza buildings, is notorious for causing in-building coverage issues. Sample link budgets showing street level, heavy building, and heavy building cluster signal levels are included in Table 5-3. The link budget shows the ability of a repeater site with a hypothetical receive sensitivity of -119 dB to receive a street level signal with a large margin available for further attenuation. This “fade margin” is calculated by subtracting the receiver sensitivity threshold from the received signal level. A negative value for fade margin indicates the repeater site would not be able to successfully receive the signal transmitted by the portable radio.

The values shown in the last column of the table, Heavy Cluster In-Building Talk-In, indicate increased losses through several walls of heavy construction, and illustrate why wireless networks that are able to provide adequate street level coverage often encounter difficulties operating inside buildings through multiple walls. This is an excellent example of why it is cost prohibitive to build a network that is specified to provide 100% in-building coverage due to the additional equipment required to achieve that goal.

In addition to the in-building coverage problems listed above, problems would likely exist in and around areas that lack outdoor coverage. Though relatively few in-building problems were reported, it is suspected that they could also be found near the areas where outdoor coverage problems were reported such as, Glen Alpine, La Salle Ave, Piedmont Ave, near the intersection of Oakland and Grand Ave, and so on.

5.2.2 Overview of Possible Solutions

Several options exist to improved in-building coverage. The following solutions can be used either as standalone solutions or together in various combinations as components of a system. They including simple bi-directional amplifier (BDA) installations, passive antennas, in-building repeaters paired with more complex distributed antenna systems, radiating cable, installation of new repeater sites, and mobile and portable coverage solutions.

5.2.2.1 Simple Bi-Directional Amplifier Installation

A simple BDA installation consists of a donor antenna usually located high on the exterior of the building to attain increased isolation and signal reception, feeding into the building (often through plenum rated coaxial cable) to a BDA. The amplifier then feeds the subscriber antenna, also called the coverage antenna, through a similar coaxial transmission line. The donor antenna receives the signal from the repeater site, routes the signal over the cable to the BDA which amplifies and retransmits over the coverage antennas located inside the building.

A BDA operates over a range of frequencies in a pass band and at lower power levels when compared with a repeater, and will not work on a simplex system. There are two types of Federal Communications Commission (FCC) accepted BDAs. Class A boosters amplify discrete, narrowband frequencies, while Class B boosters amplify a pass band of broadband frequencies. Typical donor antennas used in implementing in-building systems include Yagi antennas, corner reflectors, panels, and parabolics, while conventional antennas or radiating cable are used as coverage antennas inside the building.[1]

Typical BDA applications include underground parking structures, tunnels, sports stadiums, shopping malls, schools, casinos, convention centers, airports, museums, office buildings, factories, utility plants, hospitals, hotels, apartment complexes, government centers, courthouses, detention facilities, and other large buildings. The safety of first responders, tenants, and patrons of the facility being covered is the major benefit of a BDA. Common features of a BDA include isolation control, automatic gain control (AGC), and overload shutdown. More advanced features of a BDA are oscillation detection and suppression control feature to prevent network interference, dual band operation using two controllers which allows users to operate all functional capabilities independently, and local alarm contact closure points and interface for remote shutdown.

5.2.2.2 Passive Antennas

Passive antennas can also be installed externally and internally to a building to improve coverage. In order for this solution to be effective, very strong signals from the donor site are necessary, along with short coaxial cable runs when connecting the antennas. Also, the highest practical gain antennas should be used. The installation consists of a donor antenna and a coverage antenna connected via coaxial cable, and can be very cost effective under the right circumstances.

5.2.2.3 Distributed Antenna Systems (DAS)

For larger buildings, a distributed antenna system (DAS) can be used along with a repeater or BDA to radiate the signal throughout the building. A DAS consists of small antennas that are strategically located throughout a building where the coverage is limited. A DAS allows the

[1] Stoll, George R., Bi-Directional Amplifiers—Enhancing Radio Coverage in Shadowed Areas and Inside Buildings. February 11, 2002 (Stoll), Slide 8.

desired signal to be captured over the air from an external antenna, typically located on the roof, and then retransmitted through a network of small low power antennas inside the building. The antennas are usually small and inexpensive, and the factor limiting their deployment in a building is the cable required to connect them back to the main antenna on the roof. Fiber optic cables can carry the communications information over much greater distances than coaxial cable. For very large buildings, it may be necessary to use fiber optic cables to distribute signals rather than coaxial cables.

5.2.2.4 Radiating Cable

Radiating cable or “leaky coax” is a passive device that can be used to improve wireless communications coverage in confined areas. The cable functions like a continuous antenna. It is outfitted with controlled slots in the outer conductor that allow RF signals to be coupled between the coax cable and its surrounding environment uniformly along the entire length of cable. Furthermore, radiating cable helps to evenly distribute the power throughout a coverage area. Radiating cable is a viable option for communicating in buildings where the potential for RF blockage of point-source antennas due to obstructions is high and where public safety and emergency communications is essential.

5.2.2.5 New Repeater Sites

A new repeater site is another possible solution to resolving in building coverage. If a large number of buildings clustered together in a particular area do not have in-building coverage, and in-building coverage is deemed imperative, a new repeater site could be constructed. A careful cost-benefit analysis should be considered before making the decision to build a new repeater site versus covering each building with stand alone solution.

5.2.2.6 Mobile and Portable Coverage Solutions

While long term in-building solutions may be viable for heavily utilized buildings, such as the Highland Hospital, it is often more cost effective to implement a more portable solution. Mobile and portable repeaters provide portable grade coverage by acting as a coverage extender or by providing local coverage for disaster recovery operations. The primary distinction between the two is that a mobile repeater is usually mounted to a vehicle in a permanent installation, and the portable repeater is designed to be brought into a building or other enclosed areas away from the vehicle. Some mobile repeaters are designed for an in-vehicle installation but have quick release tabs for portable use.

There are several modes of operation to consider when investigating mobile and portable solutions. When mounted on a vehicle and integrated into the system, mobile repeaters extend system coverage for personnel operating with portable or mobile radios. Most repeaters can operate as a base repeater for localized operations and support operations in either trunked or conventional systems. Some portable repeaters operate in full duplex and are fully synthesized, field programmable, and flash upgradeable.

A mobile repeater configured in “system repeat mode” as a coverage extender allows portable radio use in areas with mobile coverage only. Installed on a car, fire apparatus, off-road vehicle or ATV the mobile repeater provides radio coverage when the user is away from the vehicle or in a nearby building. In full duplex mode a mobile repeater is configured as a true full duplex repeater, where it allows users at an incident to communicate with one another and also back to dispatch. End to end encryption and portable radio ID pass through between the companion portables and system users is normally supported.

In "local repeat mode" a mobile or portable repeater provides local coverage for companion portables working in analog or digital mode. Communication between local and portable radio users and mobile radio users is possible. The dispatcher and other system users are disconnected. This mode is designed for local radio use when the system-wide communications is not available or not desired. Typical applications include disaster recovery, fire ground communication, security detail operations or any remote-out of network coverage application.

A portable repeater configured as a "transportable tactical repeater" usually works as a portable base station. No mobile radio or vehicle is required. This configuration is ideal for ad hoc coverage where a single channel repeater is sufficient. Multiple portable repeaters can be added to the scene for additional capacity in most cases.

Some mobile or portable repeaters are flexible enough in their design to also be installed on the roof of a building to provide in-building and local area coverage for portable radio users with marginal or no system coverage.

Common features of mobile and portable repeaters to consider are as follows. Output power varies, typically from 1-10 Watts. Input power is normally provided by either plugging the repeater into an AC power outlet or by an external battery pack for portable units, or if it's a mobile unit, it is likely designed to run off of a vehicles 12v battery. It is a good idea to check accessibility of the connectors when considering the purchase of a mobile or portable repeater. Another feature to evaluate is whether or not the repeater allows for an Off Mode which disables the repeater for system communications while all other radio operational features remain. Some repeaters can be quickly activated either through the vehicle or remotely via a portable unit. Rugged, self contained, and water proof packaging is important.

It is also important to consider if the mobile, portable or vehicular repeater can support P25 features. Some key P25 features to consider are: group call (clear and encrypted), private call (clear and encrypted), emergency call (clear and encrypted), portable PTT ID pass-through, call alert paging, call back, "failsoft", out-of-range, site trunking, and talk permit/prohibit tone. Sometimes vehicular repeater modes can be selected from a mobile radio control head or from a portable when the mode is programmed as a talk group attribute. When some P25 vehicular repeaters work with a compatible P25 companion portable, the P25 trunking features are available to the portable radio user. In particular, a companion portable radio ID is passed across the system for group, private and emergency calls. End-to-end encryption is sometimes supported in all formats supported by the mobile radio. If programmed in a mixed mode, some P25 vehicular repeaters support both digital P25 and analog conventional portables operating on the same channel, providing a higher level of interoperability with legacy systems. Some vehicular repeaters use sophisticated algorithms that prevent multiple repeaters at the scene from transmitting on top of each other. In most cases, the algorithm can be fully transparent to the user or can be user controlled if deterministic selection of the master repeater is required.

5.2.3 Excerpt from FCC Title 47

The FCC rules address the deployment of BDAs. These rules rely primarily on the licensee to authorize and police any BDA use.

Following are the rules from 47 CFR, sections 90.7 and 90.219 that apply to public safety use of signal boosters:

Sec. 90.7 Definitions
Signal booster. A device at a fixed location which automatically receives, amplifies, and retransmits on a one-way or two-way basis, the signals received from base, fixed, mobile, and

portable stations, with no change in frequency or authorized bandwidth. A signal booster may be either narrowband (Class A), in which case the booster amplifies only those discrete frequencies intended to be retransmitted, or broadband (Class B), in which case all signals within the passband of the signal booster filter are amplified.

Sec. 90.219 Use of signal boosters
Licensees authorized to operate radio systems in the frequency bands above 150 MHz may employ signal boosters at fixed locations in accordance with the following criteria:

A. The amplified signal is retransmitted only on the exact frequency(ies) of the originating base, fixed, mobile, or portable station(s). The booster will fill in only weak signal areas and cannot extend the system's normal signal coverage area.
B. Class A narrowband signal boosters must be equipped with automatic gain control circuitry which will limit the total effective radiated power (ERP) of the unit to a maximum of 5 watts under all conditions. Class B broadband signal boosters are limited to 5 watts ERP for each authorized frequency that the booster is designed to amplify.
C. Class A narrowband boosters must meet the out-of-band emission limits of Sec. 90.209 for each narrowband channel that the booster is designed to amplify. Class B broadband signal boosters must meet the emission limits of Sec. 90.209 for frequencies outside of the booster's design passband.
D. Class B broadband signal boosters are permitted to be used only in confined or indoor areas such as buildings, tunnels, underground areas, etc., or in remote areas, i.e., areas where there is little or no risk of interference to other users.
E. The licensee is given authority to operate signal boosters without separate authorization from the Commission. Certificated equipment must be employed and the licensee must ensure that all applicable rule requirements are met.
F. Licensees employing either Class A narrowband or Class B broadband signal boosters as defined in Sec. 90.7 are responsible for correcting any harmful interference that the equipment may cause to other systems. Normal co-channel transmissions will not be considered as harmful interference. Licensees will be required to resolve interference problems pursuant to Sec. 90.173(b).

5.3 Recommended Solution

A detailed cost benefit study should be conducted prior to installing any in-building coverage solution. There are often several technical solutions to the same problem, but only one will prove to be the most cost effective. Radio user demand at the hospital is high. A permanent in-building repeater solution is recommended to improve in-building coverage at Highland General Hospital. For the Caldecott tunnel, a radiating coaxial cable installation would work well, but other solutions should also be considered. For the Frank Ogawa Plaza, the solution will depend on whether or not in-building coverage is required in all of the buildings or just one. An outdoor repeater on a rooftop is probably not the best option since outdoor coverage in this area is already strong and in-building coverage does not exist deep inside the buildings. A distributed antenna system or a simple BDA deployment would work best for a single building. Multiple building solutions become expensive and “cost-benefit” becomes a critical parameter to evaluate.

Portable and mobile solutions are recommended for buildings where in-building coverage is not needed on a frequent basis. Portable and Mobile solutions offer the advantage of being able to be used on a case-by-case basis as the incident dictates. Since coverage throughout the City of Oakland is provided for most heavy buildings, the portable and mobile solutions would be the most cost effective solution to cover any buildings that do not need frequent in-building coverage. These flexible solutions allow relatively small investments to be leveraged through repeaters that can be deployed when and where they are most needed. Recommended solutions for the City of Oakland are discussed further in the final report.

Table 5-2 has been omitted from this report.

Table 5-3
Heavy Building Link Budget

Parameter	Typical Street Level Talk-In Power Level (dBm)	CTA Heavy In-Building Talk-In Power Level (dBm)	Heavy Cluster In-Building Talk-In Power Level (dBm)
Portable Tx Power	34.8	34.8	34.8
Human Body Loss	-4	-4	-4
Antenna Gain	-2.2	-2.2	-2.2
ERP of Portable	30.8	30.8	30.8
Two Floor Penetration Loss	0	0	-30
Concrete Wall Penetration Loss	0	-10	-10
Other Losses (see Table 5-2)	0	-10	-10
Path Loss*	-108.6	-108.6	-108.6
Rx sensitivity**	-110	-110	-110
Rx Power at Radio Site	-77.8	-97.8	-127.8
Fade Margin***	32.2	12.2	-17.8

*Path Loss was calculated over 5 miles at 800 MHz
**This is a hypothetical minimum received signal level. Actual level may vary by manufacturer and other variables.
***A negative fade margin indicates the repeater site would not be able to successfully receive the signal.

6.0 P25 Migration

6.1 Introduction

This section provides an evaluation of the process of migrating to an APCO Project 25 (P25) standards based digital radio communications network. The evaluation takes a close look at the technical, operational and cost factors involved in implementing a P25 system.

The analysis in this section meets the requirements for SOW #6, P25 Migration. The results of this section will be included in the Final Study Report.

6.2 P25 Overview

As users throughout the City of Oakland consider the best technical and operational solutions to meet their current and future communications needs, they need to fully understand the advantages of a P25 standards based communication system.

The Association of Public-Safety Communications Officials International (APCO), in conjunction with the Telecommunications Industry Association (TIA) and others, initiated APCO Project 25 (P25) to promote a single non-proprietary set of standards for digital radio communications. The purpose of the standards was two-fold:

- To improve interoperability between public safety agencies; and
- To provide greater vendor competition and resultant cost savings in the procurement of radio equipment.

The TIA is responsible for overseeing and coordinating the ongoing development of the P25 standards. The P25 Standard is supported by a number of organizations, some of which are listed below, indicating widespread acceptance and a willingness for agencies throughout the nation to move toward P25:

- APCO
- Department of Homeland Security
- International Association of Chiefs of Police
- International Association of Fire Chiefs
- Department of Defense
- Department of Interior

The first phase of P25 implementation focused on providing a common air interface (CAI). The CAI defined a standard to provide one voice channel in a 12.5-kHz channel at a bit rate of 9.6 kbps using compatible four-level FM (C4FM) modulation. The CAI supports conventional and trunked operation. P25 also supports 9.6 kbps data with defined IP packets that are integrated with voice and control. P25 supports voice, data and control encryption and also supports over-the-air rekeying (OTAR).

Another advantage of P25 is backwards compatibility, which enables new digital P25 radios to communicate in analog mode with legacy analog radios and either digital or analog mode with current Project 25 radios. For the City of Oakland this means that the Harris P7200 portables received through rebanding have the ability to communicate with EDACS radio systems (BART for example), with Harris P25 radio systems, and with Motorola P25 radio systems. Connectivity to Motorola P25 systems may be limited without the use of an ISSI connection.

Impact of P25 Phase 2

P25 Phase 2 has several goals. One goal is to define technology standards that will provide one voice channel per 6.25 kHz of spectrum, doubling the spectral efficiency of Phase 1. The P25 committee is currently focusing its efforts on a TDMA standard based on a two-slot 12.5-kHz channel, which increases the number of voice paths in 12.5 kHz radio channels (2:1 for two-slot TDMA). This means that using P25 Phase 2 equipment will make it much easier to meet the capacity needs of the City of Oakland. The standard requires that any Phase 2 equipment must be backward-compatible to communicate in Project 25 Phase 1 mode.

Phase 2 P25 also provides for over-the-air programming (OTAP) and over-the-air rekeying (OTAR) offered by Phase 1.

P25 is becoming the technology of the future. Vendors have begun to accept contracts for Phase 2 equipment and at least three vendors now offer P25 multiband radios. Single-band P25 radios are available from many vendors.

There are two basic methods to ensure interoperability between geographically adjacent agencies that are using P25 compatible systems. The first method involves establishing talkgroups between the agencies that ensure each agency is using the same system when appropriate. This may not be the most desirable method because dispatcher monitoring can be lost if the radio user has switched to a talk-group on a different system. To resolve this issue, Phase 2 will also define IP-based interconnection ("inter-subsystem interface" or ISSI) standards for P25 radio systems from different manufacturers. This will allow seamless roaming and wide-area calling across multiple radio systems. The ISSI is an interface standard, not an actual device. System interface devices that are ISSI compliant are being developed and will be available on P25 systems in the near future. ISSI enables higher level interoperability opportunities which should be considered carefully.

P25 and Grant Funding

Although P25 is not the only technology being funded by the Department of Homeland Security, they prefer to support projects that look to the future and take advantage of the spectrum efficiency that P25 clearly offers. Proprietary, so-called "stovepipe" systems, which focus on older technology, are not likely to receive federal funding support in the future.

6.3 P25 Migration

The City of Oakland is currently operating on a system that is not compatible with P25 standards based systems. One of the significant differences is that P25 uses an IP based (or packet based) network while EDACS uses a circuit based network. This one difference will require the replacement of a significant portion of the existing equipment as the City of Oakland migrates to P25.

6.3.1 Technical Considerations

Rather than listing all of the equipment that must be replaced, CTA has provided the following list of equipment that can be used if the City of Oakland decides to migrate to a Harris P25 Phase II simulcast system. The list of existing equipment that can be re-used in a Harris P25 system includes:

- All Harris P7200 portables (These will likely need a Phase II software upgrade)
- Any existing antenna systems
- Most existing combiners
- Shelters, towers and other physical facilities
- Existing connectivity including some microwave and T1 circuits

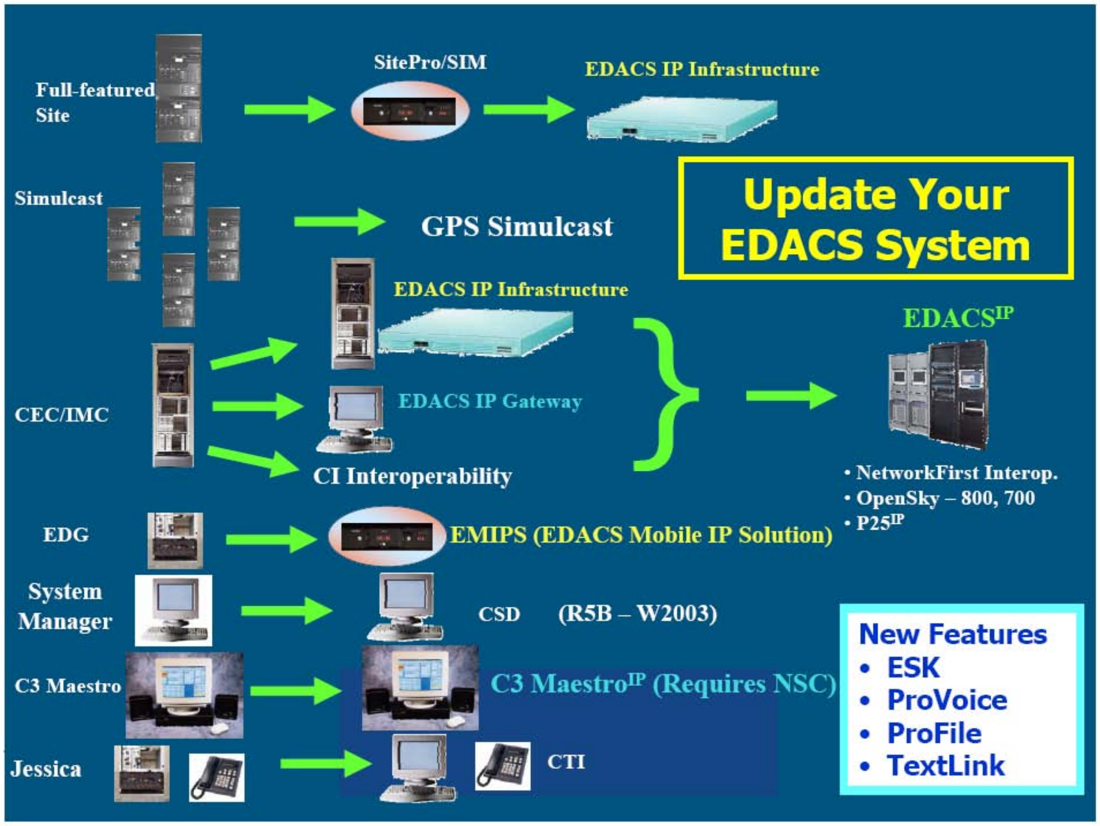
One important consideration that is often overlooked is the upgrade that will be required in the dispatch centers. The existing Maestro C3 consoles are not compatible with P25 technology.

According to information received from Harris, there are two primary options available for migration to P25. They are: a gradual migration to P25 via EDACS^{IP} or an immediate P25 transition.

The gradual P25 Migration via EDACS^{IP} will allow for a mixture of EDACS and P25 channels to be used at each site and will allow for continued use of non-P25 subscriber gear during the process. When subscriber radios are replaced, 7200's or above can be purchased to allow operation on EDACS and P25 channels. The steps involved are as follows:

- Upgrade desired repeaters to digital MASTR V with SitePro controllers
- Upgrade voting equipment
- Add a VIDA Network Switching Center (NSC), Router and Site Link
- Add EDACS IP Gateway between NSC and IMC (this will allow continued use of Maestro consoles and internetworking with P25 channels)

When ready to upgrade from EDACS^{IP} to P25, the infrastructure hardware (MASTR III, SitePro and NSC) will remain in place and will only require software upgrades.



Source: Harris Migrating Existing M/A-COM Customers Presentation.

The immediate transition to P25 will allow Oakland the quicker and seamless interoperability solution, but will not allow existing non-P25 subscribers or the Maestro consoles to work.

The steps for the immediate transition are as follows:

- Upgrade all repeaters to MASTR V with SitePro controllers
- Upgrade Voters
- Add VIDA NSC, Router and SiteLink
- Add P25 Maestro consoles

6.3.2 Subscriber Unit Considerations

During the rebanding process the City of Oakland agreed to pay the extra cost of replacing the subscriber units with P-25 capable MA/COM Subscriber units. It will be necessary to verify with the vendor what is required to upgrade these subscriber units for use on a P-25 Phase I system and what would be required to upgrade these subscriber units for use on a P-25 Phase II system. Our analysis indicates that the upgrades will be minimal, but this must be verified with the model numbers purchased from MA/COM.

6.3.3 Operational Considerations

The operational advantages offered by P25 are substantial. The main advantage is the increased interoperability with other P25 users. The recognized desire of the Bay Area UASI is to achieve “seamless interoperability” throughout the Bay Area. As the agencies, counties and municipalities throughout the Bay Area move toward P25 standards based systems, the City of Oakland must also move in this direction if they are to achieve truly interoperable communications with these agencies. If the City of Oakland stays with EDACS technology, they will not be able to directly communicate with surrounding agencies as they implement P25 systems.

Many users tend to focus on the technology that must be in place to enable “seamless interoperability”. Seamless interoperability however, requires that the technology, governance, and operational considerations are all in alignment. The coordination of the technology details is actually the most straight-forward of the three. The governance considerations are discussed in Section 14.

The operational planning needed to migrate to P25 must begin today. First, the City of Oakland needs to coordinate with EBRCSA to determine the interoperability needs between Oakland and the agencies within EBRCS. The goal would be to develop an interoperability talkgroup plan for the East Bay Area. A typical interoperable talkgroup plan would include a single interoperability **calling** talkgroup and possibly four interoperability **tactical** talkgroups, one for each of the major disciplines; Fire, Law, EMS and Emergency Operations. Additionally, users should be identified that have a reoccurring need to roam from Oakland into the surrounding areas while maintaining radio connectivity. Additional interoperability needs would have to be determined by conducting interviews which focus on interoperability needs, which is beyond the scope of the current CTA contract.

As the City of Oakland maps out their fleetmap of P25 talk group IDs and subscriber and console IDs, there should also be coordination with EBRCSA, such that each agency has its own range of IDs to use. This database planning and coordination may help minimize the challenges that Oakland had when trying to implement the Stargate with BART and the City of Richmond.

In conjunction with determining the required talkgroups, a channel capacity analysis should be conducted to determine the increased traffic on each of the systems. The interoperability traffic analysis inputs can be used to determine other needs that must be considered, such as backbone traffic and system configurations.

Second, the City of Oakland needs to sign Memorandums of Understanding (MOU) to allow the use of the frequencies used to support the interoperability talkgroups. Depending on how the interoperability talkgroups are defined, this could be all frequencies used for interoperability on each of the systems. Existing MOU’s could be modified to meet this requirement, but each agency would need to clearly define the rules of use.

Third, the current EBRCS plan is for a 700/800 simulcast P25 system. As the EBRCS is built, P25 will become an important standard between the two radio systems. In order for the two systems (City of Oakland and EBRCS) to become operationally effective, the important steps discussed here must be taken.

6.3.4 Cost Considerations

CTA has provided an opinion of probable cost to move to a MA/COM P25 Phase II standards based system in Section 1.

7.0 Subscriber Evaluation

7.1 Introduction

This section provides an analysis of the City's current inventory of Tyco Electronics (M/A-COM) EDACS subscriber radios. The evaluation also includes a comparison of the feature and function sets of the newly purchased Tyco P7200 Portables to the feature and function sets of other manufacturer's public safety grade subscriber units. Finally this section provides an overview of the backward compatibility of the newly purchased P25 portable radios and their ability to operate on BART's EDACS radio system.

The analysis in this section meets the requirements for SOW #7, Subscriber Evaluation. The results of this section will be included in the Final Study Report.

7.2 Current Subscriber Inventory

The City of Oakland's Department of Information Technology (DIT) is responsible for maintaining the City's Public Safety Radio system. The Radio/Wireless Division of DIT provides customer service, in the form of routine repair maintenance, for the Citywide Public Safety radio system. This department also provides radio repair services for a number of outside agencies whose radios utilize the City of Oakland radio system for their communication needs.

The Public Safety radio system supports the Oakland Police Department, Oakland Fire Department, Public Works Agency, Emeryville Fire Department, City of Piedmont Fire and Police Departments, and numerous other agencies within the City of Oakland. The radio shop and DIT support over 2,170 portables, 1,567 mobiles, and 54 base stations.

The current subscriber units are a mixture of three different makes and models of portable radios. The newer radios are Tyco Electronics P7200 series (either Tyco P7230 or P7270) portables and the older models are Ericsson GE MPA series portables. They are being replaced with Tyco P7200 radios that can support the current rebanding effort. A total of 2,987 replacement radios were subject to rebanding and a total of 3,471 subscriber units will be reprogrammed under the rebanding efforts.

7.2.1 Reported Radio Problems

In an effort to gather information on the City of Oakland's Radio System, CTA conducted interviews with each of the agencies supported by the radio system. In addition, CTA used our online survey tool, CTASurveyor^{SM}, to gather additional information on subscriber units.

Table 7-1 provides a list of problems reported by the City of Oakland Radio system users, dispatchers and technical points of contact that participated in the online survey. Table 7-1 indicates the problem, the agency that reported the problem, whether law, fire or PWA, and the level of severity of the perceived problems. Problems are listed in order of "overall" severity. Problem descriptions are described in Section 7.2.3.

Additional problems were also reported during the interviews conducted with each agency. The following list is a summary of the problems reported during the interviews:

- The 800 MHz portable radios are not trusted due to poor reliability and inadequate coverage related problems. Users reported that the 800MHz mobile radios appear to have much better coverage than the 800MHz portables.
- Training on the talk-around feature of the 800 MHz mobiles has not been implemented because contact with dispatch is lost when using this feature. This talk-around feature has been turned off in portables.

- Some agencies would like to control their own programming or at least have a say in how the programming is done.
- Poor radio issuing procedures; radios are dropped into a large wooden box through an opening in the top (2 feet off the ground) at the end of after hour shifts. Radios are then collected from the box. Officers are often issued different radio types and the programming between the radios is not consistent.
- The age of the existing equipment is becoming an issue because some agencies have not been able to migrate fully to the new 800 MHz equipment.
- The lead time on new equipment and turn-around time on repairs is too long.
- The prompt system does not work when arriving "on scene", nor does the system status update by push button. The prompt system was intended to update the status of the end user as they arrived on scene. The emergency button works but the user cannot be identified because in many agencies the radios are not permanently assigned to the same individual.
- A procedural problem exists when dispatch responds to an emergency button that has been pressed. The dispatcher asks "Is there any emergency?" which may not get answered if there really is an emergency. The result is the end users rely on a Mayday call and use the emergency button as a secondary measure. Consequently, the current emergency button feature is not trusted outside the City of Oakland.
- Buttons on the radios are difficult for firemen to use with gloves.
- There is a high incidence of volume controls and channel knob breakage on the 5200, 7100, and 7200 radios after only 4 months of use.
- Some agencies can hear Oakland Dispatch but can't respond on portables – response has to be made back at the mobile in the vehicle, adding unnecessary and potentially dangerous delay to the communications back to dispatch.
- In the City of Piedmont, some agencies have a difficult time knowing which emergencies to respond to, and in whose jurisdiction the emergency is. This is due to the oddly defined city limits of Piedmont.
- If the trunked system goes down, users do not know how to use the conventional channels that are also available in their radios.
- There is no training on how to use the State TAC channel for mutual aid. Also, the State Interoperability Channels cannot be monitored by the dispatch center.
- The National Mutual Aid channels, specifically the hail channel, are currently not routed into all agencies' consoles.
- Communication in the Caldecott Tunnel, which connects Oakland with Contra Costa County is challenging. The Oakland EDACS system will not work in the tunnel. The CalFire White channel is a VHF channel and does provide marginal coverage inside the tunnel. There is no 800 MHz coverage beyond the Caldecott Tunnel and in areas outside of the City which creates a problem when end users travel outside the coverage area and need to respond to an incident.
- Poor coverage typically exists where they have the greatest need for service. These areas exist along Glen Alpine, La Salle Ave and on St. James. In addition, coverage is poor along Piedmont Ave and in the area near the intersection of Oakland and Grand Ave., and in the "Golf Links near 580" area. The coverage in Highland Hospital is poor. Generally there is poor in-building coverage, especially within 250 Frank Ogawa, in the middle of the building.
- There is a coverage problem on Thornhill Dr. near Berkeley, on the "Hill" beats near Keller & Mountain, Monte Claire & Snake Rd, and sometimes at Diamond Park. Poor coverage in area of Chabot golf course, Thornhill Dr. and Elverton Drive as well as locations outside the City.
- Recently, some agencies are reporting that the problems do not seem to be area specific.
- Poor coverage exists in cement basements, underground, canyons, valleys, and hills.
- Nextel coverage is spotty and is poor within buildings and in the Oakland Hills. Coverage is good between I-880 and I-580 but poor elsewhere, especially north of Hwy 13 and near the I-

580 Hwy 13 intersection. The Oakland 800 MHz radio system seems to have better coverage than the Nextel system, but is still spotty in some of the same areas.

- There is concern over the Nextel tree site's impact on the City of Oakland's radio communications.
- The old GE radios seem to have better coverage than the new M/A-COM Jaguar radios. Some new portables purchased recently are not P25 compatible and will not work on the Gwin site.
- The BART Underground system is a high ambient noise environment and BART has the challenge to provide a clear intelligible voice channel in this high noise environment.
- There is no seamless roaming feature between sites. When a user roams out of the coverage areas for either of the main sites, they must manually change the talk group to access the new site.
- The existing microwave system is digital, but it is aging and may need to be replaced.
- The City has purchased and partially installed a StarGate for connectivity with BART and the City of Richmond, but the installation is not complete. The radio GID numbers were not programmed correctly so the Stargate did not solve the problems it was supposed to. Officers began losing transmissions just after the Stargate was deployed.
- Fire Station 22 is currently using "Port" radios for increased interoperability with the airport and with the Port authority.
- As the City of Oakland prepares to migrate to P25, some agencies have expressed concern over the possible vocoder issues in P25 compliant radios being deployed.
- The Motorola MW800 MDT's can be problematic due to inadequate infrastructure to service the heavy MDT demand which leads to frustration and lack of use. Server reliability appears to be another source of concern.
- The MDT's give an audible reminder to the officer of any updates, but the dispatchers only receive a visual cue. If they do not notice the visual display they miss the message.
The Motorola Printrak's closest engine dispatch feature only worked for about 1 week. Since then it has been intermittent and sporadic and is therefore not used.
- Printrak keystroke monitoring is delayed until the user submits the complete record. This delays communication with dispatch until user enters entire record.
- When communication is required over the ridge (north of Skyline Dr.) there is no radio coverage. In these cases, a vehicle is parked near the ridge and the traffic is relayed to dispatch via the vehicle's mobile radio.
- Some agencies are currently experiencing traffic congestion problems on the Seneca site and in and around the Oakland Coliseum.
- Officers can talk over each other disrupting communication. Officers can also hear each other, as well as dispatch, better than dispatch can hear the officers. The system is not balanced. Occasionally officers will hear static over the radio.
- Some radios are currently in the possession of other agencies and are unaccounted for.
- Some agency's consoles have no ergonomic accommodations. Books and Styrofoam are being used to raise equipment.
- Dispatch has a difficult time determining the officer's location and what is happening because radio coverage varies from block to block and communication is sometimes difficult.
- Some agencies whose personnel do not have portables cannot hear their mobiles when away from their vehicles. They need an external speaker. This feature would enable the crews to be contacted in the event of an emergency.
- Some agencies have no interoperability with outside agencies. The Park Rangers are part of OPD and there is no radio to radio communication with them. The appropriate channels may be programmed into some of the radios, but the agency's personnel have not received training on how to use them.

- There is a need to have direct communication between agencies' personnel and those that can provide the help they need when using the radio. Currently, there is none. For example, PWA would like to be able to report incidents directly to OPD.
- Some agencies find it difficult to contact the Oakland Police Department.
- Some agencies have not been trained on how to contact OPD and OFD over the radio, other than by using the emergency alarm button.

7.2.2 Radio Problem Descriptions

The problem areas summarized in Table 7-1 are defined below. In addition, the rating scale is provided.

Rating Scale:

0 - No problem identified.
1 - Identified problem, currently not of concern, may become a concern in the future.
2 - Occasionally a problem which affects some operations but is generally worked around.
3 - Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.
4 - Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill his mission.
5 - Critical concern, usually affects operations, likely compromise to safety of user or of citizen.

Capacity -- The system has insufficient capacity to support traffic associated with peak or emergency conditions.

Complex Operation -- The radio is too complicated to operate or the radio user does not know the characteristics of the system, which could cause difficulty if the user is in a high-pressure situation.

Dispatcher Access -- For unknown reasons, the dispatcher or the user cannot gain access to each other on a routine basis. Either the user must compete for the dispatcher's time, or the dispatcher has no way to contact the user.

Equipment Maintainability -- Maintenance is inadequate on user equipment (including consoles and desk top units); the user regularly needs to return the same equipment to get the same thing fixed.

Indoor Portable Operation -- Portable units are not reliable enough for use on the system, particularly indoors.

Interference -- Users from your own or other localities interfere and "step on" the local users. This either overrides critical communications or forces messages to be repeated.

Interoperability -- The system does not allow users the ability to communicate between agencies within the jurisdiction.

Limited Coverage – "Dead spots" regularly occur, particularly between a dispatcher and a user.

Outdoor Portable Operation -- Portable units are not reliable enough for use on the system, particularly outdoors.

Regional Interoperability -- The system does not allow users the ability to communicate between agencies outside of the jurisdiction.

System Busies – The user has to wait to gain access to the radio system, not because someone is using the talkgroup, but because a channel is not available.

System Reliability -- There are frequent breakdowns of old or poorly maintained infrastructure equipment.

Talk Group Congestion -- Too much unrelated chatter from other users is heard; user tends to turn volume down unless they specifically need to call someone, and thus cannot be reached.

7.3 Subscriber Features

Each of the radio vendors offers a slightly different set of features and functions for the subscriber units. In this section, CTA will briefly compare the feature set of the Tyco subscriber units that the City of Oakland has purchased with other third party vendors' radios.

Table 7-2 provides an overview of the subscriber features that CTA typically suggests for our clients. This list should be used as a baseline to determine the features that are required for subscriber units in the Oakland radio system. One important distinction to point out in Table 7-2 is the four levels or tiers of radios: High, Mid, Basic and Agency. These tiers are described below:

- High-Tier Units are full featured, public safety grade portable or mobile radios. These units typically provide features such as automatic telephone interconnect, private or single unit calling, and access to groups or subgroups necessary for administrative functions. This normally entails a free form DTMF keypad. High-Tier Units are typically assigned to administrative, command, or management personnel.
- Mid-Tier Units are public safety grade portable or mobile radios, which include those features necessary for fulfilling the particular mission of the public safety agency. These units typically provide features such as automatic telephone interconnect or private or single unit calling through list selection rather than free form dialing, and access to talk groups necessary for administrative functions.
- Basic – Tier Units have the same features of mid-tier radios with fewer talk groups accessible. Reliability is equivalent to the other Tier units. These units are limited to very basic features yet retain the public safety grade of reliability.
- Agency-Tier Units are economically priced, limited feature mobile or portable radios. The emphasis is on cost control through reduction in features. These units may be limited in the groups and subgroups available, and ruggedness. Agency-Tier Units are typically assigned to public service personnel, who are mainly interested in communicating with each other or with their office.

During the rebanding process the City of Oakland agreed to pay the extra cost of replacing the subscriber units with P-25 capable MA/COM Subscriber units. It will be necessary to verify with the vendor what is required to upgrade these subscriber units for use on a P-25 Phase I system and what would be required to upgrade these subscriber units for use on a P-25 Phase II system. Our analysis indicates that the upgrades will be minimal, but this must be verified with the model numbers purchased from MA/COM.

7.3.1 Technical Specifications and P25 Function Set

As the City of Oakland moves toward a P25 standards based radio system, additional subscriber unit choices become available. CTA remains vendor neutral and is not attempting to recommend one vendor over another and is providing this analysis in support of the task in the statement of work. Rather than completing a complex feature comparison for various vendor P25 portables, we have chosen to highlight the technical characteristics and then provide the functions that are available under P25. The technical analysis of five different P25 800 MHz portable radios is contained in Table 7-3.

Figures 7-1 and 7-2 provide an overview of the available P25 features. Each vendor will implement these features in a slightly different way and may call them by slightly different names; however the basic features remain consistent. The City of Oakland should decide upon the tier of radio that is required to support each agency and then weigh the cost, interoperability and features provided by each vendor prior to making a purchasing decision. CTA is able to assist the City through a competitive bid process upon request.

7.3.2 Maintaining Interoperability with BART

CTA conducted an interview with BART and BART has no plans to upgrade to P25 until the useful life of their current system diminishes. BART estimates that they will not have any need for system upgrades within the next 5 years and that they will continue to use their existing analog trunked EDACS system.

The impact of BART's decision to remain with their current EDACS system must be taken into consideration as the City of Oakland migrates to a P25 standard based system. If Oakland desires to continue its current level of interoperability with BART, the City must take into account the need for subscriber units to be able to talk on both an EDACS system and a P25 system. If the City of Oakland continues to purchase subscriber units that are both P25 and EDACS capable, the City will continue to have its current level of interoperability with BART due to the backwards compatibility of the Tyco P25 subscriber unit, specifically the P7200 series of portables.

If, however, the City decides to purchase third party radios, they will not be able to talk on the BART EDACS talkgroups. In this case, the City of Oakland would have to rely on the same interoperability that BART provides for non-EDACS users. When there is an incident, the Incident Command System (ICS) is established and the non-EDACS users are sent a BART representative to serve as a liaison. During an incident response, BART focuses on providing coverage in the underground and has provided 200 portables for interoperability use with surrounding jurisdictions that do not use an EDACS radio system.

7.4 Desired System Features

The City of Oakland radio system users, dispatchers, and technical points of contact were asked to participate in an online survey that captured their needs for the new radio system. Table 7-4 summarizes the results of the survey. Needs are listed in order of "overall" importance and are also ranked by discipline: fire, law enforcement, PWA and all others. The needs descriptions (Ref column) are found in Section 7.4.2.

7.4.1 Needs Reported during Interviews

CTA conducted interviews with representatives from many of the agencies that use the City of Oakland radio system. During these interviews, the users discussed the system features that they would like to see in a future radio system.

These features and needs are reported below.

- Some agencies would like a say in how their radios are programmed or would like control over their own programming. Many agencies have also requested a dedicated talk group for coordination within their own section.

- Some agencies that currently rely on experienced personnel to locate buildings within the City would like Mobile Data Terminals (MDT's) and GIS based software.
- Some agencies would like interoperability with the Coast Guard, ambulances, and the City of Berkeley on VHF channels.
- Most agencies feel that tactical communications between field personnel and command functions must be of optimal quality and reliability. Anything less compromises end user safety, operational coordination, and accountability. Communication problems are routinely cited in "after action" reports of end user near-miss and fatality cases.
- Most agencies would like portable radios for every individual in combination with improved accountability and training for the radio, specifically radio to radio communications.
- Some agencies would like quicker response on repairs and new equipment orders.
- Most agencies would like procedural improvements established. A quick reference card that identified other agencies and the talk group(s) used to communicate with them would be useful.
- There is a need to train the field personnel on radio procedures. Some agencies have a training system in place already, but it needs to be enhanced. Other agencies do not have any training system in place or are unaware of the training that is available to them.
- Some agencies requested implementation of procedures on how to contact OPD for coordination during an incident. In addition, radio procedures for most agencies need to be documented.
- Most agencies would like State mutual aid channels that can be used regionally. A set of common interoperability channels that will facilitate mutual aid and multi-jurisdictional pursuits is necessary.
- Some agencies have an immediate need for interoperability within Alameda County, Contra Costa County, and the cities of Richmond, Fremont, Livermore / Pleasanton, Hayward Hills, Moraga, Orinda and occasionally East Bay Regional Parks.
- Most fire agencies would like the ability for dispatch to monitor the VHF interoperability channels for fire.
- Most agencies would like end user training on use of conventional and interoperability channels. Some protocols have been developed, but dedicated interoperability talk groups have not been established.
- Most agencies would like direct console to console communications for the dispatch centers, perhaps even a TAC line (ring down line).
- Piedmont would like a microwave backup to their current T1 line.
- Most agencies have requested the ability to roam from site to site seamlessly based on signal strength without having to make a manual change on the radio.
- Some agencies have the BART channels, but need training and standard procedures for interoperability with BART.
- PPD needs improved interoperability with Oakland PD due to frequent contact.
- Most agencies need vehicle chargers for the portable radios.
- Most agencies have requested hardened radios to handle the difficult environment in which they are used.
- BART would like interoperability with San Francisco PD, FD, and San Mateo FD, and 700 MHz capability in the underground for mutual aid.
- If the City of Oakland decides to migrate away from Tyco equipment, BART would need an interoperability solution to communicate with Oakland personnel.
- BART Police would need dual band P25 radios if the City of Oakland migrates to a P25 system.
- Some agencies recognize the need for an improved maintenance program for the region, possibly modeled after the City of Oakland IT Department's program.

- Many agencies have requested a technical road map for migration to P25 and Simulcast systems.
- Many agencies have requested improved coverage in and around the area of the planned SCAT site. All agencies have requested improved and more reliable voice coverage for 800 MHz equipment, and removal of "dead" spots, which would alleviate the dependency on commercial radio networks.
- Many agencies agree that the focus should be on voice communications. Future radios need to be simple to operate and only include the features and functions needed for the users. Additional complexity of the radio only adds complication and does not facilitate improved communications. A reasonable physical size of the radio is also important.
- Most agencies have requested "Panic button" roaming on portables, better reliability for this feature, and a well thought out procedural plan for its use. This button has also been referred to as the "Emergency Button".
- Some agencies would like a GPS location feature.
- Some agencies would like the use of portable BDA's that can be deployed in a high-rise or on a wild land fire researched.
- Oakland Fire Department would like a more reliable server for their MDT's, improved dispatch center ergonomics, improved AVL system reliability, software upgrades for GPS and records management systems, talking sirens for dispatch, and a 311 system to reduce non-emergency calls.
- Some agencies have requested the ability to interoperate with other agencies without patches, specifically through the deployment of P25.
- Many agencies have requested improved subterranean communications, including through Caldecott and Posey tunnels, and down in the sewer system.
- More ergonomic console furniture in the dispatch centers is necessary.
- Motorola Printrak keystroke monitoring without "submit to update" delay feature would speed up a critical communications path between the field and dispatch.
- Within the Oakland PWA Department, it would be nice to integrate the radio system with the reporting system. This would enable employees to report incidents, graffiti problems or other issues that need to be addressed by PWA personnel in a more direct manner.
- Oakland PWA is about to spend $1M to implement a work management system called Cityworks. They would like to integrate the MDT that will be installed in the PWA vehicles with the Oakland Radio System.
- Text messaging on the new P25 radios has been requested.
- Some agencies have requested better incorporation of the "Citizens of Oakland Respond to Emergencies (CORE)" into the radio system.
- External speakers on the radios would help some agencies' workers to hear radio communications when outside the vehicle, especially those agencies that do not use portables.

7.4.2 System Feature Descriptions.

The attributes summarized in Table 7-4 are defined below. In addition, the rating scale is included:

Rating Scale:
0 - Attribute is NOT IMPORTANT to the user.
1 - Attribute is MINIMALLY IMPORTANT to the user.
2 - Attribute is NICE TO HAVE, could enhance operations.
3 - Attribute is USEFUL, will promote more efficient day to day operation.
4 - QUITE IMPORTANT, lack of attribute could result in degradation of mission, injury, or loss of property.

5 - CRITICAL, lack of attribute will generally result in injury, loss of property, or degradation of mission.

Ref Column Descriptions:

Improved Voice Radio Coverage: The system shall provide a signal availability of 95 percent to/from mobile radios, with coverage evenly distributed over the service area for all operational functions.

In-Building Coverage: The system shall provide a signal availability of 95 percent to/from portables in building.

Minimize Interference: The system should minimize or eliminate interference.

Increased Channel Capacity: The system design shall include additional channels for current and future capacity. Additional channels are important to alleviate congestion on the dispatch and incident channels.

On-Scene Fireground/Tactical Communications Channels: Direct radio-to-radio frequencies (firegrounds) enable local incident communications in-building, below grade, and in other situations where repeated channels do not offer solid coverage.

Monitored Firegrounds: Fireground communications must be available to be monitored by dispatch, command personnel, or recording.

Emergency Alerting: The radios and system shall provide an emergency function for alerting dispatch and supervisors to the need for assistance.

Workgroup Oriented Operation: The system shall be organized with sufficient channels or talk-groups to allow departmental workgroups to have their own channel or talk group.

Voice Security: The system shall provide encrypted communications for users that need to prevent unauthorized interception of sensitive information.

Operational Boundary Transparency: System operation will be logical, with the focus on whom the user wants to call rather than where they are located. Changes in the user agencies' operational boundaries shall be transparent to radio users. The radio system shall allow any group or department to operate with full communications capability within the service area.

One System Serves All Agencies: Convenient, same-radio communications is important between all Public Safety agencies within the locality.

Interoperability through Dispatch: The radio system shall provide a connection between all dispatch operations allowing dispatchers to facilitate information flow between agencies through dispatch and incident command, rather than at the user level.

Interoperability with Adjacent Localities: The radio system design shall emphasize compatibility with radio systems in the adjacent localities to enable public safety users to assist in adjacent counties (and vice versa) and communicate with users from other Public Safety agencies using their assigned radios.

Interoperability with State Agencies: The radio system design should emphasize compatibility with radio systems in use by the State to facilitate communications with State agencies.

Interoperability with Federal Agencies: While local agencies cannot operate radios on Federal channels, compatible equipment would facilitate Federal/local cooperative efforts if Federal users could communicate over the local infrastructure.

Person Location: Dispatch can determine the location of a user (to his portable or mobile radio), useful for example when sending assistance.

System Control: The locality is significantly more comfortable with the high level of system control that comes with exclusive use and system ownership.

Text Messaging: The mobiles and portable radios shall be capable of text messaging.

Dual Band Operation: The user radios need to operate on VHF and 700 / 800 MHz.

Recorder Operations: Logged audio is important for all dispatch and incident communications.

Future Expansion: The system shall be capable of future expansion in the number of channels and the number of users. System design shall incorporate expansion to the level of usage predicted for the next 15 years with only the addition of minor equipment.

Owner-Controlled Connectivity Network: The system shall be interconnected using a dedicated interconnecting backbone network, such as microwave or fiber. The goal is to maximize reliability, minimize use of leased carriers and associated costs, and maintain control of the network. Additionally, a dedicated, highly reliable network interconnecting all major radio locations is highly desired. This can be via microwave or fiber.

Microwave Additional Capacity: The network design shall include extra capacity, over and above the radio and mobile data needs, for other Locality uses.

Regional Connectivity: The system design shall provide infrastructure connectivity to adjacent areas.

OTAP: The system shall provide for Over-the-Air-Programming of radios.

OTAR: The system shall provide for Over-the-Air-Rekeying of encrypted radios.

Over-the-Air-Reflash: The system shall provide for over-the-air upgrades to operating software or new software versions for mobiles and portables.

Survivability: The system shall be designed to survive in severe weather or emergency conditions. If dispatch points are shifted from their primary to a backup location, radio control shall be available at the backup location to the same degree it was available at primary dispatch.

Reliability/Failure Hierarchy: The radio system and equipment must be designed such that single-mode failures do not perceptibly impact the routine operations of the system.

The following requirements shall apply to failure conditions:

- Channel failure: no operating impact due to failed voice channel.
- Site failure: no operating impact except reduced coverage area.
- Primary power failure: UPS backup shall be supplied for all communications equipment, and generator backup for the radio equipment.

- Console failures: Single console failure: use reserve console. Console common equipment failure: dispatchers operate co-located radio control station.
- Communications Center failure: Dispatch using radio control stations at a backup dispatch center.

Single Points of Failure: The system shall, as much as practical, minimize single points of failure. This is accomplished through redundant equipment, multi-node network design, distributed processing, backup equipment, etc.

Power Backup: All fixed radio equipment shall require backup power with automatic transfer, capable of handling 100 percent loading of radio equipment. An uninterruptible power system (UPS) shall be required for all communications equipment.

Staffing and Training: The system vendor shall provide formal training for system administrators, supervisors, dispatchers, radio users, and maintenance technicians.

Centralized Maintenance: The locality / agency prefer to centrally maintain and administer the radio system, dispatch systems, and user radios, either in-house or using a service shop. Centralized maintenance provides consistent and coordinated services for all user departments.

Competitive Procurement Process: The overall system concept shall be available from more than one vendor allowing a competitive procurement process. Equipment shall be procured using open non-restrictive, competitive specifications. Award to be based on the most cost-effective system meeting the specified operational and functional requirements.

Commonality of Equipment: A single vendor shall install and supply all required equipment; as much as possible, user equipment shall be similar in operation and maintenance requirements. The goal is to minimize spare parts inventory and multiple vendor training requirements.

Multiple Sources: Compatible user equipment shall be available from multiple vendors. Competitive procurement of user equipment is more important than equipment commonality.

Phased Implementation: As much as possible, system procurement and implementation shall occur on a phased basis, allowing costs to be spread over several years. The radio system shall be designed to add user groups to the system over time.

Tiered Subscriber Cost: High-tier, mid-tier, and low-tier radio equipment with feature sets and costs matched to the user group shall be provided.

Table 7-1
City of Oakland
Trunked Radio Problems

Problems	Overall	Fire	Law Enforcement	PWA
Limited Coverage	3.7	3.8	4.3	1.0
Regional Interoperability	3.4	3.5	4.0	1.0
Indoor Portable Operation	2.8	3.2	2.8	0.0
Interoperability	2.7	3.2	2.6	1.0
Interference	2.6	2.7	3.3	1.0
Equipment Maintainability	1.9	2.2	2.0	0.0
Outdoor Portable Operation	1.9	2.2	2.0	0.0
System Busies	1.8	1.8	2.4	0.0
System Reliability	1.8	1.9	2.3	0.0
Talk Group Congestion	1.3	1.5	1.2	0.0
Capacity	1.1	0.9	2.0	0.0
Dispatcher Access	1.1	1.0	1.4	0.0
Complex Operation	0.9	1.0	1.1	0.0

0 : No problem identified.
1 : Identified problem, currently not of concern. May become a concern in the future.
2 : Occasionally a problem, affects some operations but is generally worked around.
3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.
4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill his mission.
5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Table 7-2
SUBSCRIBER FEATURES

Feature	Configuration											
	Mobile, Trunk- or Dash-Mounted				Portable				Control Station			
	High	Mid	Basic	Agency	High	Mid	Basic	Agency	High	Mid	Basic	Agency
Trunked Talk Groups or Conventional Channels	128	128	48	16	128	128	48	16	128	128	48	16
Time-Out Timer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dynamic Regroup Capable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Out-of-Range Signal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Group Call Capable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Emergency Call Button	Yes	Yes	Yes		Yes	Yes	Yes					
Talkaround Operation	Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes	
Private Call Receive	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Private Call Initiate	Yes	Menu			Yes	Menu			Yes	Menu		
Vehicular Charger					Yes	Yes	Yes					
Touch Pad	Yes	Limited			Yes	Limited			Yes	Limited		
Auto Phone Interconnect	Yes	Menu			Yes	Menu			Yes	Menu		
Priority Group Scan	Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes	
All Call Receive	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
All Call Initiate	Yes				Yes				Yes			
Status Message	Yes	Yes			Yes	Yes						
Encryption Capable	Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes	
Call Alert	Yes	Menu			Yes	Menu			Yes	Menu		
Radio/Data Interface Port	Yes	Yes	Yes									
Selective Radio Inhibit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ON/OFF Switch	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Touch Pad	Yes	Limited			Yes	Limited			Yes	Limited		
Volume Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Eight-Character Alphanumeric Display	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	
Transmit Indicator	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
System Busy Indicator	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTES:
1. "N/A" indicates that the specification or feature is not applicable to the unit configuration.
2. The lack of a "Yes" beside a feature indicates that the feature is not required.
3. Only for channels as specified.

Table 7-3
Subscriber Technical Characteristics

		Brand and Model Number				
		Tyco P7200 Series	Tait TP9100 Series	Motorola Astro XTS 5000 Series	Kenwood TK-5400	EFJohnson 5100 ES Series
	Frequency Range(s)	764-776, 794-825, 851-869 MHz	VHF UHF 762-776, 792-825, 851-870 MHz	VHF UHF 764-777, 792-824, 851-870 MHz	806-825, 851-870 MHz	VHF UHF 762-806, 806-870 MHz
Transmitter	RF Power Output	0.5 - 3 W	5W, 3W, 2W, 1W (VHF) 4W, 2.5W, 2W, 1W (UHF) 3W, 2.5W, 2W, 1W (700/800)	6/1 W (VHF) 5/1 W (UHF) 2.5/1 W (700) 3/1 W (800)	1 - 3 W	2.5/1 W (700) 3/1 W (800)
	Frequency Stability	±1.5 ppm	±1.5 ppm	±2.0 ppm (VHF/UHF) ±1.5 ppm (700/800)	±1.5 ppm	±1.5 ppm
	Modulation Limiting	± 5 kHz	± 5 kHz (25 kHz Channel) ± 2.5 kHz (12.5 kHz Channel)	± 5 kHz (25 kHz Channel) ± 2.5 kHz (12.5 kHz Channel)	Unknown	± 5 kHz (25 kHz Channel) ± 2.5 kHz (12.5 kHz Channel)
	Audio Response	+1, -3dB	+1, -3dB	+1, -3dB	Unknown	+1, -3dB
	FM Hum and Noise	-49 dB (non-NPSPAC) -38 dB (NPSPAC)	-42dB (VHF) -37dB (UHF) -34dB (700/800)	-42 dB (VHF) 12.5 kHz -40 dB (UHF/700/800) 12.5 kHz	-45 dB	-35 dB 12.5 kHz -40 dB 25 kHz
	Audio Distortion	<2% at 1kHz, 3 kHz Deviation	< 5% at 1kHz, 60% Modulation	1% (VHF) 1.5 % (UHF/700/800)	2%	2%
Receiver Specifications	Rated Audio Output Power	500 mW	500 mW	500 mW	500 mW	500 mW
	Channel Spacing (kHz)	12.5/25kHz/PLL Step	12.5/15/20/25/30 kHz	12.5 / 25 kHz	12.5 / 20 / 25 kHz	12.5 / 25 kHz
	Frequency Stability	± 1.5 ppm	± 1.5 ppm	±2.0 ppm (VHF/UHF) ±1.5 ppm (700/800)	± 1.5 ppm	± 1.5 ppm
	Analog Sensitivity (12 dB SINAD)	0.25 uV (-119 dBm)	0.28 uV (-118 dBm)	0.20 uV (-121 dBm) (VHF/UHF) 0.25 uV (-119 dBm) (700/800)	0.30 uV	0.25 uV (-119 dBm)
	P25 Reference Sensitivity (5% BER)	0.25 uV (-119 dBm)			0.30 uV	
	Digital Sensitivity (5% BER)	0.20 uV (-121 dBm)	0.20 uV (-121 dBm)	0.20 uV (-121 dBm) (VHF/UHF) 0.25 uV (-119 dBm) (700/800)	0.30 uV	0.25 uV (-119 dBm)
	Adj. Channel Selectivity 700/800 MHz	-60 dB (12.5 kHz) -72 dB (25 kHz)	-60 dB (12.5 kHz) -70 dB (25 kHz)	-63 dB (12.5 kHz) -72 dB (25 kHz)	-72dB (25 kHz) -63dB (12.5 kHz) -60dB (P25)	-63 dB (12.5 kHz) -75 dB (25 kHz)
	Intermodulation Rejection	-70 dB	-78 dB	-75 dB	-70dB (25 kHz) -63dB (12.5 kHz) -60dB (P25)	-75 dB
	Spurious Response Rejection	-70 dB	-75 dB (VHF/UHF) -70 dB (700/800)	-80dB (VHF) -85dB (UHF) -75dB (700/800)	-73 dB	-75 dB
	FM Hum and Noise	-37 dB (non-NPSPAC) -35 dB (NPSPAC)	-42dB (VHF) -37dB (UHF) -34dB (700/800)	-40dB (12.5 kHz) -48dB (25 kHz)	-45 dB	-35dB (12.5 kHz) -40dB (25 kHz)
	Audio Distortion	2.5 %	< 3%	1% (VHF/UHF) 1.5 % (700/800)	< 2%	2%
	Weight (w/ Battery)	22.9 ounces with NiCd 23.9 ounces with NiMH	19.7 ounces	23.6 ounces with NiCd 22 ounces with NiMH	20.64 ounces	23.96 ounces with NiMH
	Dimensions (HxWxD)	6.75" x 2.58" x 1.79"	6.6" x 2.6" x 1.9"	6.58" x 2.44" x 1.83"	6.09" x 2.31" x 1.5"	6.7" x 2.52" x 1.8"
	Operational Temperature Range	-30ºC to 60ºC with NiCd -20ºC to 50ºC with NiMH	-30ºC to 60ºC	-30ºC to 60ºC	-30ºC to 60ºC	-30ºC to 60ºC

Table 7-4
City of Oakland
System Attribute Ranking

Ref	Attributes	Overall	Fire	Law Enforcement	PWA	Other
a	Improved Voice Radio Coverage	4.9	4.8	5.0	5.0	4.7
b	In-Building Coverage	4.8	4.9	4.8	4.3	5.0
g	Emergency Alerting	4.7	4.7	4.9	4.0	4.7
bb	Survivability	4.7	4.8	4.3	4.3	5.0
cc	Reliability/Failure Hierarchy	4.7	4.7	4.7	4.5	5.0
ff	Staffing and Training	4.6	4.6	4.8	4.0	4.7
c	Minimize Interference	4.6	4.7	4.4	4.0	5.0
dd	Single Points of Failure	4.6	4.5	4.8	4.0	5.0
ee	Power Backup	4.5	4.5	4.8	3.7	5.0
j	Operational Boundary Transparency	4.3	4.3	4.4	4.0	4.7
gg	Centralized Maintenance	4.3	4.3	4.4	3.7	5.0
m	Interoperability with Adjacent Localities	4.2	4.3	4.4	2.7	3.7
e	On-Scene Fireground / Tactical Communications Channels	4.1	4.3	3.8		3.7
v	Owner-Controlled Connectivity Network	4.1	3.7	4.2		5.0
f	Monitored Firegrounds	4.0	4.0	3.7		4.0
l	Interoperability through Dispatch	3.9	3.9	4.0	3.0	4.7
u	Future Expansion	3.9	3.7	4.3	3.0	5.0
x	Regional Connectivity	3.8	3.9	3.8	2.5	4.3
n	Interoperability with State Agencies	3.8	3.9	3.9	2.7	3.7
ii	Commonality of Equipment	3.7	4.0	3.7	3.5	2.0
hh	Competitive Procurement Process	3.6	3.5	3.5	5.0	4.0
t	Recorder Operations	3.6	3.3	4.2	0.0	5.0
w	Microwave Additional Capacity	3.5	2.8	4.0		5.0
s	Dual Band Operation	3.5	3.4	3.6	3.0	4.7
y	OTAP	3.5	3.2	3.6		4.7
h	Workgroup Oriented Operation	3.5	3.1	4.2	4.0	4.0
p	Person Location	3.4	3.3	3.6	2.0	4.3
z	OTAR	3.4	3.1	3.7		4.3
aa	Over-the-Air-Reflash	3.3	3.2	3.3	3.0	4.0
k	One System Serves All Agencies	3.3	3.1	3.8	4.5	3.0
q	System Control	3.1	2.9	3.1		5.0
d	Increased Channel Capacity	3.1	3.0	3.4	3.0	3.3
ll	Tiered Subscriber Cost	3.1	3.0	2.6	3.5	4.0
o	Interoperability with Federal Agencies	3.0	2.9	3.3	2.5	3.3
kk	Phased Implementation	3.0	2.6	2.9	3.3	4.7
jj	Multiple Sources	2.9	2.8	2.8	2.0	4.7
i	Voice Security	2.8	2.3	3.9	1.3	5.0
r	Text Messaging	2.1	2.1	2.1	2.3	2.7

Ratings
0 - Attribute is NOT IMPORTANT to the user.
1 - Attribute is MINIMALLY IMPORTANT to the user.
2 - Attribute is NICE TO HAVE, could enhance operations.
3 - Attribute is USEFUL, will promote more efficient day to day operation.
4 - QUITE IMPORTANT, lack could result in degradation of mission, injury, or loss of property.
5 - CRITICAL, lack generally will result in injury, loss of property, or degradation of mission.

Note: To identify further information about an attribute, look up the Ref column in Section 7-4-2.

Figure 7-1
P25 Trunked Features Matrix

Trunked P25 Features Matrix
User List
- 7/25/2008 -

M = Mandatory
SO-R = Standard Option Required
SO = Standard Option

Feature Name	Requirement Level	Standards Documents	Comments
Voice Calls			
Group Voice Call	M	102A, AABC-B, AABD	May also be referred to as Unit to Group Call
Individual Voice Call	M	102A, AABC-B, AABD	May also be referred to as Unit to Unit Call
Broadcast Voice Call	M	102A, AABD	
Discreet Listening	SO	102A	
Call Interrupt	M	102A	
Announcement Group Call	SO	AABC-B, AABD	
System Call	SO	AABC-B, AABD, CABA, BAAD	May also be referred to as (ALL) System Call, System Wide TG Call
Mobility Management			
Roaming	M	102A, AABC-B, AABD	
Intra-System Roaming	M	102A, AABC-B, AABD	May also be referred to as Roaming
Inter-System Roaming (Manual)	M	102A, AABC-B, AABD	May also be referred to as Intra-WACN Roaming
Inter-System Roaming (Automatic)	SO	102A, AABC-B, AABD	May also be referred to as Intra-WACN Roaming
Inter-WACN Roaming	SO	102A, AABC-B, AABD, AABF-A-2	May also be referred to as Roaming
Registration	M	102A, AABC-B, AABD	
Link Layer Authentication	SO	AACE	
Affiliation	M	102A, AABC-B, AABD	May also be referred to as Group Affiliation
De-Registration	M	AABC-B	
Encryption			
Block Encryption	SO	AAAD, AACA	May also be referred to as Encryption or Encrypted Audio
DES-OFB Encryption of Voice	SO	102A, AAAD	For Backward compatibility only. Not encouraged for new systems
DES-OFB Encryption of Packet Data	SO	102A, AAAD	For Backward compatibility only. Not encouraged for new systems
AES Encryption of Voice	SO-R	AAAD	
AES Encryption of Packet Data	SO-R	AAAD	
Type 1 Encryption	SO	102A, NSA Spec DN618551, DN618536	
Multiple Encryption Algorithms	SO	AAAD, AACA	
Multiple Encryption Keys	SO	AAAD	
Encryption Key Update	SO	102A	May also be referred to as Encryption Update
Over The Air Rekeying (OTAR)	SO	102A, AACA, AACB, AACD	Contains 23 sub-options listed in AACA
Manual Rekeying Features	SO	102A, AACD	12 sub-options listed in AACD. Also referred to as Physical Key Management
Supplementary Services			
Call Alerting	SO	102A, AABC-B, AABD, AABG, BACD	May also be referred to as Call Alert, Unit Page
Pre-programmed Data Messaging / Short Message	SO	102A, AABD, AABC-B, AABF-A, AABG, AABA-A, BACD	May also be referred to as Short Message, Short Data Message, Message
Silent Emergency	SO	102A, CABA	
Radio Unit Monitoring	SO	102A, AABG, AABC-B, BACD	May also be referred to as Radio Unit Monitor
Emergency Alarm	SO	102A, AABC-B, AABD, AABG, BACD	May also be referred to as Emergency Alert, Emergency Indications, Emergency
Emergency Call	SO	BAAD, AABF-A	May also be referred to as Emergency Group Call
Extended Functions			
Radio Unit Inhibit* / Disable	SO	102A, AABC-B, AABD, AABG	
Radio Unit Uninhibit* / Re-enable	SO	102A, AABC-B, AABD, AABG	
Radio Check	SO	AABD, AABC-B, AABG	
System Services			
Network Status	M	AABC-B, AABD	
System Status	M	AABC-B, AABD	
Channel Identifier	M	AABC-B, AABD	
System Service	SO	AABC-B, AABD	
Adjacent Site Status	SO	AABC-B, AABD	
Secondary Control Channel	SO	AABC-B, AABD	
Composite Control Channel	SO	AABA-A, AABB-A, AABC-B, AABD	Also referred to as Single Station Sites or Traffic on Control
Backup Control Channel	SO	AABC-B, AABD	
Miscellaneous			
Talking Party Identification	SO	102A	May also be referred to as Caller Identification or Caller ID
Call Restriction	SO	102A, AABC-B	
Priority Call	SO	102A, AABC-B, AABD	May also be referred to as Priority
Preemptive Priority Call	SO	102A	
Queuing	M	AABC-B, AABD	May also be referred to as Queue
Call Routing (Efficient)	SO	102A	May also be referred to as "Efficient use of RF resources"
Message Trunking	SO	AABA-A	
Transmission Trunking	SO	AABA-A	
SU Electronic Serial Number (ESN)	M	102A, AABD	
Common Air Interface (U_m)			
CAI	M	102A, BAAA-A	
Phase 1			
Enhanced Full Rate Vocoder	M	102A, BABA	Also referred to as P25 Defined Vocoder: Enhanced Version required in new products
12.5 kHz Channel Bandwidth	M	102A, BAAA-A	
Frequency Division Multiple Access (FDMA)	M	102A, BAAA-A, AABA-A	
C4FM and CQPSK Modulation	M	102A, BAAA-A	Older products may have only C4FM
9.6 kbps Gross Bit Rate	M	102A, BAAA-A	
Backwards Compatibility (Analog FM Operation)	M	102A, ANSI/TIA/EIA-603 Compliance	
Inter RF Sub-System Interface (G)			
ISSI	SO	102A, BACA, BACA-1, BACA-3, BACD	
Voice Services			
Group Voice Service	SO-R	BACA, BACA-1	
SU-to-SU Voice Service	SO-R	BACA, BACA-1	
Mobility Management Functions			
SU Registration	SO-R	BACA, BACA-1	
SU Tracking	SO-R	BACA, BACA-1	
Group Affiliation	SO-R	BACA, BACA-1	
Group Tracking	SO-R	BACA, BACA-1	
Authentication Credential Distribution	SO-R	BACA, BACA-1	
Supplementary Data Services (include)			May also be referred to as Supplementary Services
Emergency Alarm	SO-R	BACD-A	Also referred to as Emergency Alert
Emergency Alarm Cancellation	SO-R	BACD-A	
Group Emergency Cancellation	SO-R	BACD-A	
Call Alert	SO-R	102A, BACD-A	
Short Message / Pre-programmed Data Messaging	SO-R	102A, BACD-A	
Status Query	SO-R	BACD-A	
Status Update	SO-R	BACD-A	
Radio Unit Monitor	SO-R	102A BACD-A	
Radio Check	SO-R	BACD-A	
Radio Inhibit	SO-R	102A, BACD-A	
Radio Uninhibit	SO-R	102A, BACD-A	
Data Interfaces (A and E_d) and Services			
Data Interfaces (A and E_d)	SO	102A	
Data Configuration - Radio to FNE	SO	BAEB-A	May also be referred to as Mobile to Fixed Host Service (FNE Data)
Data Configuration - Radio to Radio (Direct)	SO	BAEB-A	May also be referred to as Mobile to Mobile Service (Direct)
Data Configuration - Radio to Radio (Repeated)	SO	BAEB-A	May also be referred to as Mobile to Mobile Service (Repeated Data)
Packet Switched Confirmed Delivery Data	SO	BAEB-A	
Packet Data Registration	SO	BAAD-1, BAEB-A	
SU Registration	SO	BAAD-1, BAEB-A	
SU Deregistration	SO	BAAD-1, BAEB-A	
SU Location Tracking	SO	BAAD-1, BAEB-A	
Packet Data Scan Mode	SO	BAAD-1, BAEB-A	
Packet Switched Data Network Access	SO	BAEB-A	
RCP (Radio Control Protocol)	SO	BAEE-A, BAEB-A	Used for Radio Management Protocol
SNMP (Simple Network Management Protocol)	SO	BAEE-A, BAEB-A	Used for Radio Management Protocol
SCEP (Simple CAI Encapsulation Protocol)	SO	BAEB-A	
SNDCP (Subnetwork Dependent Convergence Protocol)	SO	BAEB-A	
Link Layer and Physical Layer Protocols	SO	BAEA-A, BAEB-A	
Telephone Interconnect Interface (E_t)			
Telephone Interconnect	SO	102A, BADA	Contains 33 sub-options listed in BADA. May also be referred to as Voice Telephone
Fixed Station Interface (E_f)			
TBD			
Console Sub-System Interface (E_c)			
Console Sub-System Interface	SO	102A, BACA-2	
Voice Services	SO-R	BACA-2	
Mobility Management Functions	SO-R	BACA-2	
Supplementary Data Services (See ISSI)	SO-R	BACD, BACA-3	May also be referred to as Supplementary Services
Console Priority	SO-R	BACA-2	Includes Dispatcher Audio Takeover and Call Interrupt
Network Management Interface (E_n)			
TBD			

Figure 7-2
P25 Conventional Features Matrix

Conventional P25 Features Matrix User List
- 7/31/2008 -

M = Mandatory
SO-R = Standard Option Required
SO = Standard Option

Feature Name	Requirement Level	Standards Documents	Comments
Voice Calls			
Unaddressed Voice Call	M	102A	
Group Voice Call	SO	102A, AABC-B, AABD	May also be referred to as Unit to Group Call
Individual Voice Call	SO	102A, AABC-B, AABD	May also be referred to as Unit to Unit Call
Discreet Listening	SO	102A	
Call Interrupt	M	102A	
Monitor Squelch	M	102A, BAAD, CABA	May also be known as Digital Carrier Squelch
Normal Squelch	M	102A, BAAD, CABA	May also be referred to as Unaddressed Voice Call
Selective Squelch	SO	102A, BAAD, CABA	
System Call	SO	AABC-B, AABD, CABA, BAAD	May also be referred to as (ALL) System Call, System Wide TG Call
Mobility Management			
TBD			
Encryption			
Block Encryption	SO	AAAD, AACA	May also be referred to as Encryption or Encrypted Audio
DES-OFB Encryption of Voice	SO	102A, AAAD	For Backward compatibility only. Not encouraged for new systems
DES-OFB Encryption of Packet Data	SO	102A, AAAD	For Backward compatibility only. Not encouraged for new systems
AES Encryption of Voice	SO-R	AAAD	
AES Encryption of Packet Data	SO-R	AAAD	
Type 1 Encryption	SO	102A, NSA Spec 0N618551, 0N618536	
Multiple Encryption Algorithms	SO	AAAD, AACA	
Multiple Encryption Keys	SO	AAAD	
Encryption Key Update	SO	102A	May also be referred to as Encryption Update
Over The Air Rekeying (OTAR)	SO	102A, AACA, AACB, AACD	Contains 23 sub-options listed in AACA
Manual Rekeying Features	SO	102A, AACD	12 sub-options listed in AACD. Also referred to as Physical Key Management.
Supplementary Services			
Call Alerting	SO	102A, AABC-B, AABD, AABG, BACD	May also be referred to as Call Alert, Unit Page
Pre-programmed Data Messaging / Short Message	SO	102A, AABD, AABC-B, AABF-A, AABG, AABA-A, BACD	May also be referred to as Short Message, Short Data Message, Message
Silent Emergency	SO	102A, CABA	
Radio Unit Monitoring	SO	102A, AABG, AABC-B, BACD	May also be referred to as Radio Unit Monitor
Emergency Alarm	SO	102A, AABC-B, AABD, AABG, BACD	May also be referred to as Emergency Alert, Emergency Indications, Emergency
Emergency Call	SO	BAAD, AABF-A	May also be referred to as Emergency Group Call
Extended Functions			
Radio Unit Inhibit* / Disable	SO	102A, AABC-B, AABD, AABG	
Radio Unit Uninhibit* / Re-enable	SO	102A, AABC-B, AABD, AABG	
Radio Check	SO	AABD, AABC-B, AABG	
Miscellaneous			
Talking Party Identification	SO	102A	May also be referred to as Caller Identification or Caller-ID
SU Electronic Serial Number (ESN)	M	102A, AABD	
Common Air Interface (U_m)			
CAI	M	102A, BAAA-A	
Phase 1			
Enhanced Full Rate Vocoder	M	102A, BABA	Also referred to as P25 Defined Vocoder: Enhanced Version required in new products
12.5 kHz Channel Bandwidth	M	102A, BAAA-A	
Frequency Division Multiple Access (FDMA)	M	102A, BAAA-A, AABA-A	
C4FM and CQPSK Modulation	M	102A, BAAA-A	Older products may have only C4FM
9.6 kbps Gross Bit Rate	M	102A, BAAA-A	
Backwards Compatibility (Analog FM Operation)	M	102A, ANSI/TIA/EIA-603 Compliance	
Inter RF Sub-System Interface (G)			
TBD			
Data Interfaces (A and E_d) and Services			
Data Interfaces (A and E_d)	SO	102A	
Data Configuration - Radio to FNE	SO	BAEB-A	May also be referred to as Mobile to Fixed Host Service (FNE Data)
Data Configuration - Radio to Radio (Direct)	SO	BAEB-A	May also be referred to as Mobile to Mobile Service (Direct)
Data Configuration - Radio to Radio (Repeated)	SO	BAEB-A	May also be referred to as Mobile to Mobile Service (Repeated Data)
Packet Switched Confirmed Delivery Data	SO	BAEB-A	
Packet Data Registration	SO	BAAD-1. BAEB-A	
SU Registration	SO	BAAD-1. BAEB-A	
SU Deregistration	SO	BAAD-1. BAEB-A	
SU Location Tracking	SO	BAAD-1. BAEB-A	
Packet Data Scan Mode	SO	BAAD-1. BAEB-A	
Packet Switched Data Network Access	SO	BAEB-A	
RCP (Radio Control Protocol)	SO	BAEE-A, BAEB-A	Used for Radio Management Protocol
SNMP (Simple Network Management Protocol)	SO	BAEE-A, BAEB-A	Used for Radio Management Protocol
SCEP (Simple CAI Encapsulation Protocol)	SO	BAEB-A	
SNDCP (Subnetwork Dependent Convergence Protocol)	SO	BAEB-A	
Link Layer and Physical Layer Protocols	SO	BAEA-A, BAEB-A	
Telephone Interconnect Interface (E_t)			
Telephone Interconnec	SO	102A, BADA	Contains 33 sub-options listed in BADA. May also be referred to as Voice Telephon
Fixed Station Interface (E_f)			
FSI	SO	102A, BAHA, CADA	
Analog			
Transport of Clear Audio	SO	BAHA, CADA	
Tone Remote Control (TRC)	SO	BAHA, CADA	
Intercom	SO	BAHA, CADA	
E&M Signaling	SO	BAHA, CADA	
Digital			
IP Capabilities	SO-R	BAHA, CADA	
Block Encryption	SO-R	BAHA, CADA	May also be referred to as Encryption, Encrypted Audio
Talking Party Identification	SO-R	BAHA, CADA	May also be referred to as Caller Identification, Caller-ID
Talkgroup Information	SO-R	BAHA, CADA	
NAC Information	SO-R	BAHA, CADA	
Emergency Alert	SO-R	BAHA, CADA	May also be referred to as Emergency Alarm
Emergency Indications	SO-R	BAHA, CADA	May also be referred to as Emergency Alarm
Frequency of Operation Control	SO-R	BAHA, CADA	
Repeating Voice Control	SO-R	BAHA, CADA	
Receiver Squelch Control	SO-R	BAHA, CADA	
Ethernet 100 Base-T with RJ-45 connector	SO	BAHA	
Received Voter Information	SO	BAHA, CADA	
Intercom	SO	BAHA, CADA	
Console Sub-System Interface (E_c)			
TBD			
Network Management Interface (E_n)			
TBD			

8.0 Interoperability with BART

8.1 Current State of Interoperability

Maintaining interoperability with the Bay Area Rapid Transit System (BART) radio network is of extreme importance to the City of Oakland and its public safety first responders. Utilizing information gathered from the interviews, questionnaires, and applicable interoperability plans supplied to CTA by the participating agencies, this section will provide an evaluation of the current state of interoperability between the City of Oakland and BART. It will also provide an evaluation of the impact of the City of Oakland's migration to a P25 radio communication network on interoperability with BART. CTA Communications' BART interoperability analysis results and recommendations will be included in the Final Study Report.

This report contains two major sections, the current state of interoperability and the impact of the City of Oakland's migration to P25. The information contained in this section meets the contractual obligations outlined in SOW Task #8.

8.1.1 Current BART System

BART provides rapid transportation for the bay area. The BART system contains 110 miles of track and 43 BART stations in a system that spans four counties and includes the City of Oakland. The track is segmented into 5 segments, and 30 miles of the track is underground. The trains are dispatched from a centralized control center. About 3/5 of the underground segments of the track are in the City of Oakland.

The BART police have 240 sworn officers and have an authority similar to the State Police, since their jurisdiction crosses county and city borders. The BART Police have their own dispatch center and Public Safety Answering Point (PSAP).

The BART radio system is an analog EDACS trunked simulcast radio system. The system consists of a 10 site, 10 channel simulcast system. The sites are linked together using a fiber Sonet backbone. In addition, they have a regional high level system that consists of 4 sites, with one conventional 800 MHz channel on each site.

The underground portion of the BART system is a high ambient noise environment and BART has the challenge to provide a clear intelligible voice channel in this high noise environment. The 30 miles of underground track are covered using Radiax and a distributed amplifier system. In tunnels that are longer than 2000 feet, BART feeds source RF signals into the Radiax from both directions. The channels used underground include the National Public Safety Telecommunications Council (NPSTC) channels, which are used for BART communications. They also have two conventional 800 MHz mutual aid channels repeated underground for the use of Fire/EMS and Law enforcement.

The BART radio system supports 3300 subscriber units of which 600 are mobiles and 2700 are portables. They currently have about 35,000 PTT/day with the busiest hour experiencing a volume of 2,500 PTT/hr. Radio coverage is provided to a 1 ½ miles distance on each side of the track at 95% coverage. About 40-45 units have CDPD mobile data using commercial air cards. The life expectancy of the radio and mobile data equipment is still within limits and there are no present capacity issues. Although there is a planned rail expansion, radio capacity limitations are not anticipated due to the geographical expansion. BART personnel have no plans to review updating the system within the next 5 years.

The BART communications/dispatch center has the capability to communicate directly with every train and can access the in-train intercom system. The dispatch center has 2 consoles and plans to add 6 more in the near future. They have no backup center for their dispatch facility. A single T1 line is active between the BART radio control point and the City of Oakland Dispatch facility.

8.1.2 Existing Interoperability

Interoperability with BART is provided on 2 levels. The first is with other EDACS users including the cities of Richmond and Oakland. A Stargate has been purchased by Oakland to increase the functionality of the network, but it is not fully operational. The logical identifiers (LIDS) have been coordinated between BART and the City of Oakland, but group identifiers (GIDS) will be fully implemented after the completion of re-banding.

The second level of interoperability is with all non-EDACS users. When there is an incident, the Incident Command System (ICS) is established and the non-EDACS users are sent a BART representative to serve as a liaison. BART focuses on providing coverage in the underground and has given out 200 portables for interoperability use with surrounding jurisdictions that do not use an EDACS radio system. Occasionally, emergency responders will use Nextel handsets to communicate with BART personnel.

8.1.3 Interoperability Needs

The City of Oakland has future interoperability needs relating to BART. The primary concern among local agencies is the reliability of the BART channels underground, and the lack of training received on how to use the BART channels. Several Oakland agencies are aware that BART channels are programmed into the radios they use every day, but still believe there is no interoperability with BART, and don't understand how it works. This perception indicates the clear need for training on the use of the BART interoperability channels.

Piedmont Fire Department (PFD) for example, would like to be able to talk with BART since they respond to Oakland Station 10. They have the BART channels programmed in their radios, but standard procedures for interoperability with BART need to be established.

Other agencies have a more thorough understanding of how interoperability works with BART. Oakland Fire Department (OFD) interoperability with BART takes place on the BART channels which are programmed into their 800 MHz radios. OFD dispatch has a dedicated BART radio using BART channels 3 and 5. VHF is used as a backup to the BART channels. OFD also utilizes the BART house lines (red, yellow, and blue phones) when necessary. Each OFD Battalion Chief has a yellow BART phone at their disposal. OFD dispatchers communicate through a direct connect phone line to BART personnel.

It is possible that once the training needs are met and standard procedures have been established, the perceived reliability of the BART underground channels will improve.

BART has future interoperability needs as follows. Radio communications between BART and the San Francisco Police Department in talk around mode is desirable. There is a need for interoperability with San Francisco Fire Department and San Mateo Fire Department. There is a possible need for dual band P25 radios for the BART Police. There is a need for 700 MHz capability in the underground for mutual aid. A backup plan for the BART dispatch facility is also needed in the event that their existing facility becomes inoperable.

BART personnel have researched the advantages of increased channel capacity offered by P25, but at this time their present capacity demand is being met. Therefore, migration of the BART network to P25 capability is not one of BART's critical short-term needs.

8.2 Oakland's Upgrade/Migration to P25

The City of Oakland has begun its upgrade to a P25 standards based system. All non-fixed P25 subscriber equipment has been procured and some of the equipment has been deployed. In addition, P25 infrastructure upgrades have also begun. The new site being developed at Gwin will be a 3 channel 800 MHz site with P25 capability. P25 capable handsets will be strategically distributed after the site is fully operational.

8.2.1 Impact of Upgrade on Interoperability

The impact of the P25 upgrade on the City of Oakland's interoperability with BART will be minimal, provided that the City of Oakland continues to purchase subscriber units that are both P25 and EDACS capable. If the City of Oakland end user has a Tyco EDACS compatible radio with a properly programmed BART channel, they will be able to communicate with BART personnel on the BART network. The key is that P25 radios manufactured by Tyco will be backwards compatible on a non-P25 EDACS network.

After the upgrade, however, BART will not be able to talk on the City of Oakland channels because BART does not have P25 compatible radios. As the P25 standard is more widely implemented in the counties and cities that BART services, BART could begin to purchase P25/EDACS compatible portables and mobiles which would enable them to talk to any P25 network within the BART area of operation.

As the City of Oakland migrates to P25 and continues to reprogram radios due to rebanding, the City has the opportunity to implement a well thought out plan for communicating with BART personnel in the event of an emergency. A well developed technical solution can then be paired with proper training and a set of standard procedures for using P25 radios on the BART system. The result will be reliable interoperability between the two agencies.

Section 9 has been purposely omitted from this report.

10.0 Channel Capacity

10.1 Introduction

System Availability includes two aspects: Coverage, which was addressed in Section 1 and Channel Capacity. Coverage indicates that sufficient radio signal is available at the location where the user needs to talk. Capacity means that the radio channel is available when the user needs to talk. In this section, CTA evaluates existing channel capacity of the City of Oakland Radio System. In addition, future system requirements are addressed as well as the advantages that a P25 Phase II system would provide.

The analysis in this section meets the requirements for SOW #10, Channel Capacity. The results of this section will be included in the Final Study Report.

10.2 Existing EDACS channels

The City of Oakland Radio System utilizes available capacity from two main sites, APL and Seneca. Because the system is set up in a multi-site topology, each site must have its own control channel. The APL site has nine channels provisioned, including a control channel for overhead traffic. The channel numbers assigned to this site are channels 2, 3, 4, 6, 8, 9, 11, 12, and 13. Channel 3 is currently out of service and not repairable and one channel is always used for overhead. This leaves seven channels available for voice or data traffic. The Seneca site has five channels including a control channel for overhead. They are defined in the site as channels 1 through 5. This leaves four channels available for voice or data traffic.
Two additional future sites are planned, Gwin and a SCAT site at Fire Station 28. The Gwin site will be a P25 capable site located in the foothills near the Caldecott Tunnel. Although this site is not yet activated for all users, it has been allocated three channels, one for overhead and two for voice traffic. The SCAT site will require, by definition, a single channel that will be used for both control and voice traffic.

There are in excess of 4,000 users on the City of Oakland Radio System, with 4,093 LIDS, or logical identifiers, programmed into the system. The City of Oakland maintains a database of radio resources which indicates that the City of Oakland Radio system has 2,170 portable radios and 1,567 mobile radios and an additional 54 desktop control stations. CTA has recommended that every Oakland Police Department (OPD) Officer be equipped with a portable radio. As a result, we have added an additional 400 portable radios to account for these additional radios.

The total number of subscriber units used for channel capacity is:

Mobiles:	2,170
Portables:	1,567
Additional OPD Portables:	400
Desktop Control Stations:	54
Total Subscriber Units:	4,191

10.3 Future Channel Requirements

A key element in the overall system design is the determination of the number of channels required to handle the expected load due to voice calls. The mathematical model used to perform this calculation is “Erlang C”, and involves a set of parameters estimated through a statistical analysis. It is important to understand that the system design is assumed to be a two-site P-25 simulcast system. The analysis is based on trunked channels, all of which are available on a per call basis, and a probability distribution for the random nature in which calls are placed, call duration, number of calls per unit per hour, etc. For these calculations, we need the total number of users or radio units in the inventory as a starting point.

The current non-fixed radio equipment (mobiles, portables, etc.) inventory estimates for the City were provided by the DIT from the amounts reported in the current radio system management tables, which are shown above. We also projected radio quantity growth estimates for the next 20 years to use in this traffic analysis. This estimate is based on data obtained from the US Census Bureau's 2006 population estimates indicating an average city-wide growth rate of 1.3% per year, which we have used as a growth estimate per year for the next 15 years. In addition, we have included an additional 400 portable radios to ensure that adequate portables are available to equip every sworn Oakland Police Department Officer with a portable radio.

There is a well developed database of trunked radio system metrics obtainable from the System Manager that is included in almost all fielded systems. The System Manager records traffic flow, push-to-talks (PTTs), length of calls, channel usage, etc. We have analyzed this data for the City of Oakland and from other projects, and have developed our traffic loading models based on this data and our experience. Armed with this statistical data, the number of subscriber units at present and projected out 20 years, we are ready to perform a traffic loading analysis for the trunked system. Assuming that calls are placed in a random order, the system traffic can be approximated with a statistical model. The Erlang C model is the most appropriate for estimating the traffic flow and loading on a two-way radio trunked system.

We have taken the approach that the minimum number of channels will be the most economical solution. The key parameter to measure is the "Delayed Call Grade-of-Service" shown in the bottom of Table 10-2. We have used a maximum acceptable call delay of 1 second – this is the length of time that a user would have to wait to gain access to an available channel after initiating a push-to-talk (PTT). For public safety, we recommend a "delayed call" grade-of-service to be no greater than 1%, (i.e. less than 1% of all calls placed during the busy hour are forced to wait more than 1 second to gain access to the system). The busy hour is defined as the hour of the day during which a radio system carries the most traffic.

In most localities, the busy hour occurs during weekday late afternoons between 3:00 pm and 7:00 pm. Often a shift change, causing higher radio traffic, occurs during this time. CTA analyzed the data for the City of Oakland's existing radio system and determined that the busy hour normally occurs from 6:00 pm to 7:00 pm with about 3,900 calls granted by APL and Seneca on average.

When sizing systems the busy hour calculation is an important number. In order to calculate a busy hour, it is preferable to have access to system data that corresponds to an incident. During the course of this project, CTA was also provided with data from the recent demonstrations that occurred on January 7, 2009. On this day the number of calls for the busiest hour increased from the average of 3,900 to over 5,800 calls on January 7, 2009. This hour occurred from 5:00 pm to 6:00 pm on this day. For traffic loading purposes it is important to insure that busy hour calculations can handle this increased traffic.

Our definition produces a conservative traffic loading design because it assumes the same busy hour for all user agencies, an unlikely situation. Peak and disaster situations produce higher traffic loading as was indicated by the recent incident in the City of Oakland. System capacity is managed during these periods using prioritized calling. Calls that are queued are processed according to user priority.

In Table 10-2, we have summarized the results for the traffic loading study using "message trunking" for the City of Oakland and other agencies. We have made some assumptions, which are indicated below:

1. The system will be a two-site P25 simulcast trunked radio system.
2. The system is sized for a 1.3% growth rate each year over the next 15 years. As a result we have used 5087 subscriber units to size the system based on growth predictions.
3. Message trunking was chosen in order to provide a more conservative estimate. The impact is that rather than the 3.27 call length for the existing Oakland system, an average call length of 4.1 seconds was used.
4. The total number of radios used to size the system was 4,191.

5. A delay or call overhead of 1.0% was added for the call setup and digital to analog conversion needed in a P25 system.
6. The busy hour calculation should be such that the system is sized to handle the voice traffic during an incident.
7. The assumption on the number of calls per hour per unit is 1.3, which is based on industry standards.

The data in Table 10-2 indicates that the City of Oakland will need **16 voice talkpaths** to support voice requirements through the year 2024. P25 and most public safety trunked systems employ a "control channel"– this is a dedicated channel that performs command and control functions 100% of the time. In a trunked system implementation employing this approach, one of the channels would be assigned this function and would not be unavailable as a voice channel. In our modeling, we have assumed that there is a control channel, so the number of voice channels is equal to 16 plus one additional channel that is allocated for the control channel, for a total of 17 radio channels.

Finally, we should note that our analysis here is based on our professional opinion concerning the number of channels required to handle the expected traffic. The FCC has rules that are more liberal in terms of the number of channels that can be justified. Typically, the FCC requires a trunked voice system for public safety to justify 1 channel for every 100 users. In the beginning, the rule can be relaxed to 1 channel for every 70 users with the expectation of increasing traffic load in the future. Using these rules, Oakland could justifiably apply for several additional trunked channels. The problem, however, is that additional frequency assets are likely not available in the 800 MHz band.

10.3.1 P25 Phase II TDMA

One of the significant improvements to Phase II is the increased channel capacity that will be available. Utilizing Time Division Multiple Access (TDMA) on the voice channels, Phase II essentially doubles the channel capacity for Phase II systems. The P25 Phase I 12.5 kHz voice channel will be split into two time slots and will give the system the FCC spectral-efficiency requirements of 6.25 kHz *equivalency*.

A P25 Phase II TDMA working channel is essentially 2 talkpaths. In the channel loading description provided in Table 10-2, the City of Oakland would need 16 voice talkpaths for voice communication and 1 control channel. In a P25 Phase II system, the City of Oakland would need 9 radio channels, 8 working channels with 2 talkpaths each for a total of 16 voice talkpaths and 1 control channel.

A P25 Phase II solution for the City of Oakland will help remove any need for the City to obtain additional 800 MHz (or 700 MHz) licenses to support future growth expectations. The City of Oakland currently has 17 licensed 800 MHz channel, which will meet the City's frequency needs long into the future if a P25 Phase II simulcast solution is chosen.

10.3.2 P25 Phase I FDMA

If the City were to choose a P25 Phase I solution, the working channels will use Frequency Division Multiple Access (FDMA) voice channels which have a single talkpath. Because of this fact, there is a one to one correlation between voice talkpaths and channel requirements. The result is that the City of Oakland would need 17 radio channels, 16 channels for voice requirements and 1 channel for overhead. Again, the City of Oakland has the frequency assets to support a Phase 1 solution.

10.3.3 Joining the EBRC System

After determining how many channels the City of Oakland will require for their own needs, we were then able to evaluate how many channels would need to be allocated for the EBRCS ALCO

West simulcast cell to support the City of Oakland users and the remaining Alameda County users that are also in the ALCO West cell. In recent months EBRCSA has made the decision to move toward a P25 Phase II solution for the EBRCS, which dramatically impacts the number of radio channels needed to support the subscriber units on the system. In addition, EBRCS has updated the number of Oakland users in the ALCO Northwest cell from 2,231 in the Motorola report, to 4,191, which is an accurate representation of the number of users in the City of Oakland.

Since CTA's analysis of the channel capacity needed for the ALCO Northwest cell is based upon the updated City of Oakland inventory numbers, the ALCO Northwest cell will have sufficient capacity to support the City of Oakland.

Table 10-1 has purposely been omitted from this report.

TABLE 10-2
TRAFFIC LOADING RESULTS SUMMARY

	2024	Notes
Number of Radios on System	5,087	1
Trunked Voice Channels	16	2
P25 Phase II Working Channels	8	2,3
Mean Call Duration (Seconds)	5.1	
Voice Calls/Hour	6,613	
Offered Load (Erlangs)	7.97	3
Delayed Call Grade-of-Service (%)	**0.940**	5

Note 1: Quantities to determing number of users during the busy hour, based on 1.3% growth per year for 15 years.

Note 2: P25 systems utilize one additional channel for control functions.

Note 3: P25 Phase II utilizes TDMA to assign 2 talkpaths per Working Channel.

Note 4: The Erlang is the dimensionless unit of measure for traffic. It is calculated as the product of calls/second times mean call duration.

Note 5: Delayed Call Grade-of-Service (1% design target) is the odds that a caller will have to wait more than the maximum acceptable call delay (1 second).

11.0 Return on Investment Evaluation

11.1 Introduction

This section provides a review and analysis of the City of Oakland's investment in the current EDACS radio system. The analysis will include a Return on Investment (ROI) timeline assessment and document suggestions / recommendations on how the City's current radio communications system investment could be leveraged into the EBRCSA.

The analysis in this section meets the requirements for SOW #11, Return on Investment Evaluation. The results of this section will be included in the Final Study Report.

11.2 Current Radio System Investment

The City of Oakland Radio System is a Tyco Electronics EDACS system that utilizes two main sites, APL and Seneca. The APL site has nine channels provisioned, including a control channel for overhead traffic. The Seneca site has five channels including a control channel for overhead. The sites are configured in a multi-site configuration and roaming is not supported at this time. The equipment to support roaming has been purchased but has not been installed. A third site is located at the Corpyard Shack. This site is connected via Microwave links to the two main sites and provides connectivity to the Oakland Police Communication Center (Dispatch). The communication center has an Integrated Multi-site and Console Controller (IMC) that allows the dispatch operators to dispatch from both Seneca and APL, and also allows users on Seneca to talk to users on APL.

Two additional future sites are planned, Gwin and a SCAT site at Fire Station 28. The Gwin site has been built and is a P25 capable site located in the foothills near the Caldecott Tunnel. Although this site is not yet activated for all users, it has been allocated three channels and has been fully installed. The channels / talkgroups allocated for the Gwin site have been programmed into some of the subscriber units, but full activation will be completed in conjunction with the reprogramming that is currently in progress for rebanding.

The SCAT site will require, by definition, a single channel that will be used for both control and voice traffic. The SCAT site was not installed at the time of this report and no investment calculation was made for this site.

The Public Safety radio system supports the Oakland Police Department, Oakland Fire Department, Public Works Agency, Oakland Unified School District, Emeryville Fire Department, City of Piedmont Fire and Police Departments and numerous other agencies within the City of Oakland.

The current subscriber units are a mixture of three different makes and models of portable radios. The newer radios are Tyco Electronics P7200 series (either Tyco P7230 or P7270) portables, which make up about 80% of the total radio count. The older models are Ericsson GE MPA series portables. The City of Oakland has 4000 subscriber units.

There are three dispatch centers that serve the Oakland area, Oakland PD Dispatch, Oakland FD Dispatch and the Piedmont Dispatch. The current investment figures were based on 17 console positions in the Oakland PD and FD Dispatch centers and 2 console positions in the Piedmont Dispatch Center. There are 20 additional call-taker positions in the OPD Dispatch.

11.3 ROI Timeline Assessment

The current radio system was installed in the mid 1990's. Some of the equipment has been upgraded since the original installation. These upgrades included a Harris Microwave digital backbone in the late 1990's and the current rebanding effort which has replaced 80% of the subscriber units (mobiles and portables) and has upgraded the repeaters from Master II to Master III. We have taken these upgrades into consideration for our Return on Investment calculations. Since this ROI calculation focuses on the radio system, we have not included the 20 call taker positions at the Oakland Police Dispatch in our calculations. It should be noted that the Master III cannot be re-programmed as a P25 Phase 2 repeater and must be replaced with the Master V.

Table 11-1 shows three columns. The first column reflects the cost if the City of Oakland was to purchase the entire system today. This cost includes towers, shelters, and all infrastructure, microwave, and subscriber units. The second column reflects the value of the system. The current value subtracts out the costs associated with installation ("Vendor Service" in Table 11-1), spares and contingency, which the City of Oakland does not have. The third column is the depreciated value due to the age of the current system. We have depreciated 20% of the subscriber equipment by 2/3. We have depreciated all of the Radio Infrastructure, Microwave, Physical Facilities, and Dispatch Equipment by 2/3.

11.4 Investment Recommendations

The City of Oakland has made a significant investment in its current radio system. The City has several opportunities to leverage this investment. First, the City has several well established and well maintained radio sites. These sites provide benefit far beyond the dollar amounts shown in Table 11-1. Several of the benefits include, approved zoning, FCC licensed sites, known good microwave path profiles, and site development and grounding. The City should leverage these site advantages by working with the EBRCSA to co-locate sites at APL and Seneca.

Another notable investment is the P25 capable subscriber units. These subscriber units represent almost 90% of the current dollar value of the City of Oakland radio system. They also position the City to move toward a P25 system without incurring a large subscriber unit cost. The subscriber units also have the added advantage in that they are compatible with any P25 standards based infrastructure, including Tyco and Motorola.

Finally, the P25 Gwin site can continue to be used in a multi-site configuration that will provide increased coverage in the Oakland Hills area. It should be noted that Gwin should continue to be used as a standalone multisite that provides additional coverage in the foothills. As our analysis in Section 1 of this report indicated, the Gwin site does not have the physical space to place a larger shelter and antenna that would be needed in a simulcast configuration, but does provide significant coverage that no site in the EBRCS provides.

The existing EDACS radio system is nearing its end of life. It is possible that with continued maintenance and some upgrades to the microwave backbone the system may be used for the next few years, but capacity on the existing system is nearing the point where officer safety could be jeopardized. In addition, interoperability needs throughout the region will continue to be strained since most surrounding agencies do not have the ability to interoperate with an EDACS system.

Table 11-1
RETURN ON INVESTMENT
CITY OF OAKLAND, CALIFORNIA

COST ELEMENT	COST IF THE SYSTEM PURCHASED TODAY	VALUE IF THE SYSTEM PURCHASED TODAY	DEPRECIATED CURRENT VALUE
RADIO INFRASTRUCTURE	$ 1,411,600	$ 1,411,600	$ 470,533
MICROWAVE	$ 1,081,200	$ 1,081,200	$ 360,400
NON-FIXED EQUIPMENT	$ 9,085,000	$ 9,085,000	$ 7,527,571
PHYSICAL FACILITIES	$ 317,400	$ 317,400	$ 105,800
DISPATCH EQUIPMENT	$ 797,100	$ 797,100	$ 265,700
VENDOR SERVICES	$ 592,200	$ -	$ -
SPARES - NON FIXED	$ 181,700	$ -	$ -
SPARES - FIXED	$ 32,900	$ -	$ -
CONTINGENCY	$ 329,000	$ -	$ -
TOTAL	**$ 13,828,100**	**$ 12,692,300**	**$ 8,730,005**

12.0 Maintenance Costs

12.1 Introduction

This section provides an analysis of maintenance / replacement costs for the City of Oakland. The analysis includes a comparison of the City's maintenance costs of its current radio communications system versus the buy-in, maintenance and ongoing system/equipment costs (monthly subscriber fees) of joining the EBRCSA. In addition, CTA has included an estimate of the ongoing maintenance costs associated with installing a new P25 simulcast system relative to the costs already allocated for the existing EDACS radio system.

The analysis in this section meets the requirements for SOW #12, Maintenance Costs. The results of this section will be included in the Final Study Report.

12.2 Current Maintenance Costs

The City's radio shop (Radio/Wireless Division) has a staff of 5 personnel who are responsible for the routine repair and maintenance of the citywide public safety radio system. This division provides radio repair services for a number of outside agencies whose radios utilize the City of Oakland radio system for their communication needs. The Electronic Technician staff provides assistance and engineering to City agencies for their over the air communication needs for both voice and data. Radio Shop staff maintain a variety of electronic equipment including wireless networks, camera security systems, satellite systems, cable TV, cellular services, audio video systems, and public address systems.

The yearly budget for the Radio Shop is $1.2M with 4.2 percent of this allocated for replacement parts and other equipment needed to maintain the City of Oakland radio system. Roughly 72 percent is allocated for labor and the remaining budget supports other operational expenses. Labor costs include the time needed to maintain the subscriber units and the radio system infrastructure as well as the maintenance of the towers, backup power, electric bills for radio sites, administrative overhead, T1 connectivity, and radio site maintenance.

The City of Oakland estimates that less than 20 percent of the radio shop's time is spent maintaining the City of Oakland infrastructure and 40 percent of the radio shop's time is spent maintaining the subscriber units, with the remaining 40 percent spent on other types of equipment used by other City agencies. Using the budget figures above the chart below summarizes the existing annual maintenance costs:

Replacement parts	$ 50,400	
Labor Costs 72% of Budget	$ 864,000	
Infrastructure Labor 20%		$ 172,800
Subscriber Labor 40%		$ 345,600
Additional Labor 40%		$ 345,600
Additional Operational Expenses	$ 285,600	
Total Radio Shop Budget	$1,200,000	

Total Infrastructure Budget Costs used for Cost Comparison $ 172,800

If the City of Oakland decides to continue to maintain and upgrade the current system, these costs would remain relatively unchanged, aside from the normal yearly increases to reflect yearly cost of living increases.

12.3 Estimated P25 Simulcast System Maintenance Costs

If the City of Oakland decides to build a 2 site, P25 simulcast radio system, the budget allocation and costs outlined above could be redirected to maintaining the new system. Since the same subscriber units will continue to be used, the costs associated with the subscriber units would remain unchanged. Since the number of sites in the new system would be the same as the number of sites in the old system, the infrastructure labor costs would remain relatively unchanged. In fact, the City of Oakland may even see a slight decrease in the hours needed to maintain a new system, versus the number of labor hours needed to maintain the infrastructure of the old system. Typically a 10 year old system will require 10% more maintenance time than a new system would. However, for the purposes of this analysis, we are making the assumption that the current labor budget for infrastructure maintenance would remain unchanged.

In addition the costs outlined above, the City of Oakland will have several additional maintenance costs associated with the new radio system. First there is the maintenance cost that is paid to the vendor, called vendor maintenance, to support the new radio system. Typically this cost is used to pay for return and repair, software services, technical support and potentially remote monitoring and would be about $100,000 annually. When combined with the existing budget allocated for infrastructure maintenance costs, the City of Oakland could expect to pay $314,000 annually for system maintenance and infrastructure labor.

In addition to vendor maintenance there is a cost associated with replacing the system as the system nears its end of life. With today's P25 radio systems, this would likely occur between 15-20 years after the installation of the new system. The cost to replace the system as it nears its end of life should be considered in the estimation of the maintenance costs of a new P25 simulcast radio system. CTA estimates that the City of Oakland will have to set aside $495,760 annually for an infrastructure replacement fee. The table below summarizes these costs.

City of Oakland Annual Maintenance Fee	$172,800
Software Support Services	$100,000
City of Oakland Annual Replacement Fee	$495,760
Additional City of Oakland Radio Shop Budget	$1,027,200
Annual Total	$1,795,760

In addition to the above maintenance costs, the City of Oakland would have to find a funding source for the purchase of a new P25 Phase II radio system. Grant funding sources and other funding opportunities exist for the initial purchase, but if these costs fall on the City, then they should be factored into the decision making process.

12.4 Estimated EBRCSA System Costs

The business model for EBRCSA is still under development, but the current plan is to charge each participating agency a fee that will cover the costs of operating and maintaining the infrastructure (microwave and radio sites) and a replacement fee. The replacement fee is intended to be used to generate a funding source to replace the infrastructure in 15 years.

Under the planned business model, the City would still be required to maintain their subscriber units, if they were to join EBRCSA. In addition, the City would also have to continue to maintain the dispatch centers and the Gwin P25 fill in site. It is unlikely, based on the percentage of time (20%) allocated to maintain the current infrastructure compared to the time required to maintain subscriber units, that any reduction of staff would be justified by joining EBRCSA. The City of Oakland radio shop could potentially see, as a result of joining EBRCSA, a 20 percent savings in labor requirements, or about $172,800 dollars from the annual budget that is currently being used to maintain the radio system infrastructure.

System costs for EBRCSA are still in development and exact numbers will depend on the number of subscriber units that sign an agreement with EBRCSA. Current estimates are based on the numbers provided in the Motorola contract that have been adjusted by CTA, working closely with EBRCSA.
The number that is most important to the City of Oakland is the monthly reoccurring cost per subscriber unit that EBRCSA will charge the City of Oakland. The fee, sometimes called a subscriber unit fee, is based on the number of subscriber units that the City of Oakland will have on the EBRCS. The fee covers the costs of maintaining the infrastructure as well as an infrastructure replacement fee. The current business model does not include any buy-in costs.

Current figures break this fee into two parts, a maintenance fee and a replacement fee. Currently the maintenance fee will be about $15.25 per month. The replacement fee is still being discussed but will likely be between $14.75 and $16.75. For the purposes of this report we will use the lower of these two numbers. The City of Oakland will have 4,191 subscriber units on EBRCS, which means the monthly fee will be as follows:

EBRCSA Monthly Maintenance Fee	4191 times $15.25 = $63,912.60
EBRCSA Monthly Replacement Fee	4191 times $14.75 = $61,817.30

EBRCSA Annual Maintenance Fee	$766,953
EBRCSA Annual Replacement Fee	$741,807
Estimated City of Oakland Radio Shop Budget	$1,027,200
Annual Total	$2,535,960

One significant challenge to the City of Oakland is the fact that the $766,953 in annual maintenance fees alone almost exceeds the entire City of Oakland Radio Shop budget. Keep in mind the existing budget would not significantly change if the City of Oakland were to join East Bay and as a result we have used the current radio shop budget minus current infrastructure labor costs in our calculation above.

12.5 Maintenance Cost Conclusions

If the City of Oakland were required to pay both the Maintenance Fee and the Replacement fee, the annual fee for joining EBRCSA, 1,508,760 far exceeds the current budget for the entire City of Oakland radio shop. From a purely maintenance cost perspective, it is difficult to justify paying up to $1.5M in yearly infrastructure maintenance and replacement fees, when an entire replacement P25 system could be paid for in under four years.

It is possible that the City of Oakland could work out an agreement with EBRCSA to be the maintenance provider for the infrastructure and the subscriber units in the ALCO Northwest Cell, but the details and business plan for this model are beyond the scope of this project. The idea would be for the City of Oakland to leverage the existing radio maintenance capabilities of the City and offer these services to other agencies in areas surrounding Oakland. The significant barrier to this model may be the fact that the City of Oakland's radio shop is a MA/COM shop, while those agencies in EBRCSA will primarily be Motorola based.

13.0 Continuity of Operations

13.1 Introduction

The City's radio shop is one of the keys to providing continuity of operations and customer service assurances. CTA interviewed the radio shop personnel and surveyed the radio shop facilities during the week of interviews conducted in the City. This section provides an overview of the Oakland Radio Shop and an assessment of the radio shop's ability to provide the level of maintenance required to maintain the continuity of operations needed to support public safety communication.

The analysis in this section meets the requirements for SOW #13, Continuity of Operations. The results of this section will be included in the Final Study Report.

13.2 Oakland Radio Shop Overview

The City's radio shop (Radio/Wireless Division) has a staff of 5 personnel who are responsible for the routine repair and maintenance of the citywide public safety radio system. This division provides radio repair services for a number of outside agencies whose radios utilize the City of Oakland radio system for their communication needs. The Electronic Technician staff provides assistance and engineering to City agencies for their over the air communication needs for both voice and data. Radio Shop staff maintain a variety of electronic equipment including wireless networks, camera security systems, satellite systems, cable TV, cellular services, audio video systems, and public address systems.

The City's radio shop is primarily a MA/COM service provider and a majority (95%) of the radio equipment serviced and maintained is MA/COM equipment. In addition the radio shop does service Harris microwave equipment. The primary service line is 700 / 880 MHz subscriber units (mobiles and portables) from MA/COM. The secondary service line includes Kenwood VHF radios.

The five personnel who staff the radio shop include the supervisor and four journeyman technicians, each with a variety of certifications and training that fully qualify them to perform the essential duties of a the radio shop. Two of the journeyman technicians are assigned as full time radio equipment installers.

The test equipment at the facility includes power supplies, soldering stations, 100 MHz scope, RF voltmeters, Digital VOM, Wattmeter, signal generators, spectrum analyzers, RD counter and other installation and maintenance equipment.

13.3 Oakland Radio Shop Assessment

At the time of CTA's visit to the City of Oakland Radio shop, they were in the middle of the rebanding process. They had received a total of 2,987 replacement radios as a result of the rebanding effort. In addition, they were in the process of reprogramming a total of 3,471 subscriber units based on the rebanding requirements.

The rebanding effort also required the replacement of several of the radio repeaters at Seneca and APL. Despite the fact that the radio shop was midway through this intrusive and complicated process, the facility was well organized and regular maintenance and installation operations were continuing unhindered.
The scope of work for this task asked CTA to assess the radio shops' service capability, maintenance/installation operations and the staff's technical expertise. The overview provided in Section 13.2 clearly indicates that the radio shop's facilities meet or exceed the necessary facility requirements. In addition, during interviews and discussions with several of the radio shop staff, CTA was able to

determine that level of technical expertise was commendable. In particular, CTA worked very closely with Gregg Tanner, whose knowledge of the microwave connectivity and the radio site configurations was extremely helpful in completing many sections of this report. He was able to run several channel static, channel utilization and system summary reports on the EDACS system that were used to determine channel utilization statistics.

CTA also conducted a site survey of the dispatch facilities and each of the sites located in the City of Oakland. The summary of these sites surveys is located in Section 9 of this report. In addition, the site survey worksheets are contained in Appendix B. The survey's results clearly indicated that the sites were well maintained, clean and neatly organized, which is a direct indication of the maintenance and installation operations proficiency of the radio shop. CTA feels confident that the City of Oakland Radio Shop is able to provide the level of service needed to support the emergency responders who rely upon the City of Oakland Radio System for their communication needs.

14.0 Governance

14.1 Introduction

The statement of work requires CTA to complete a technical, financial and implementation evaluation of the current EBRCSA JPA Agreement and document concerns we find that are related to the technical, financial and implementation (timeline) aspects of the regional agreement.

The analysis in this section meets the requirements for SOW #14, Governance. The results of this section will be included in the Final Study Report.

14.2 Overview of the EBRCSA JPA

CTA reviewed the current Joint Exercise of Powers Agreement for the East Bay Regional Communications System Authority (EBRCSA) final agreement dated : August 14, 2007 for this section of the report. The EBRCS Joint Exercise of Powers Agreement (JPA) is available for download from the EBRCSA website.

14.3 Technical Evaluation

The EBRCSA JPA identifies the technical solution for the two county area (Alameda and Contra Costa County) as a "P25 digital trunking system operating in the 800Mhz/700Mhz frequency spectrum. The system solution is a wide area, two county, IP-based architecture communications system that is compliant with the ANSI/EIA/TIA-102 suite of standards. The EBRCS Project will utilize sites strategically located throughout, but not limited to, Member jurisdictions. The EBRCS Project is also expected to meet typical public safety requirements of a Grade of Service of two percent busies during the busy hour with an estimated 90 percent of busy calls queued within 2.5 seconds. "

The technical solution identified in the EBRCSA JPA will meet the needs of the City of Oakland, however this report includes many documented City of Oakland user needs that should be addressed by any specific technical solution that is put into place to support public safety radio needs in the City of Oakland.

14.4 Financial Evaluation

The EBRCSA JPA has put procedures in place for an adequate fiscal management, which are outlined in Section 6.d. The JPA outlines the responsibilities of the treasurer and auditor and established a fiscal years from July 1st of each year to and including the following June 30th. Budget adoption and approval requirements are also outlined. It should be noted, however, that only voting members on the Board have input into the budgetary process.

Section 4.b. contains an important limitation of the imposition of powers. This section states that the "Board of Directors shall have no power to impose taxes, assessments, fees or charges within any Member's jurisdiction unless the Member's governing body adopts a resolution approving the tax, assessment, fee or charge."

The JPA does not include any other details on any specific financial information.

14.5 Implementation Evaluation

The EBRCSA JPA makes a provision to develop a Capital Plan; however the current JPA does not include the details of the plan. Section 5.d of the EBRCSA JPA states that the Board will "use its best efforts to develop and adopt within six (6) months of execution of this Agreement:

(i) a Capital Plan specifying a means or formula for determining the timing and sequencing of construction of the EBRCS Project consistent with the Functional Specifications referenced in Section 1 of this Agreement and

(ii) a funding plan specifying a means or formula for funding the Authority's operations and any EBRCS Project phases that are the responsibility of the Authority (the "Funding Plan"), which Funding Plan will include an allocation of costs among the Members, Subscribers to the EBRCS Project and other funding sources.

At the time of this report the results of these tasks were not available.

In addition Section 5.h of the EBRCSA JPA states that the Board will "establish system participation pricing including start-up costs, and ongoing Subscriber/Member unit pricing to cover system operations, technical upgrades, and system replacement reserves."

At the time of this report the results of these tasks were not available.

Finally section Section 5.i of the EBRCSA JPA states that the Board will "establish policies and procedures for the voluntary transfer and/or lease of assets from Member jurisdictions including but not limited to frequencies, transmitter sites and associated equipment. "

At the time of this report the results of these tasks were not available.

When this data is made available, the evaluation can be completed.

15.0 Recommendations

15.1 Introduction

This section makes recommendations on a technical roadmap for a radio system that will meet the needs of the City of Oakland and that will provide seamless interoperability with BayRICS. The scope of work for the project required CTA to:

1. Review and evaluate existing technology owned and operated by the City.
2. Establish a technical roadmap for full and seamless interoperability with BayRICS.
3. Provide a cost benefit analysis of the EBRCS JPA proposal.
4. Review the City's spectrum efficiencies (simulcast) and the leveraging of the city's equipment and investments as part of the EBRCS.
5. Provide recommendations for an interim solution for an Oakland EBRCS MOU.

Because, the City of Oakland is part of the Bay Area Super Urban Area Security Initiative (UASI), the goals and vision of the UASI must be incorporated into the technical roadmap that is developed for the City. This section keeps the vision of BayRICS and the UASI in view, namely "the ability for any public safety radio in the region to communicate with any other public safety radio regardless of location, radio system, or frequency band and to seamlessly roam throughout all 10 Counties in the Bay Area." In addition, this section also addresses the critical needs of the emergency responders in the City of Oakland.

The recommendations in this section are substantiated by the analysis and documentation provided in the other 14 sections of this report. The statement of work also requires CTA to explore the cost savings to the City if it were to join the EBRCSA and recommendations concerning interim MOU, terms and conditions for joining the EBRCSA.

15.2 Technical Roadmap Recommendation

As the City of Oakland prepares for the future needs of radio users throughout the City of Oakland, CTA has several key steps that should be taken to ensure the needs of the emergency responders supported by the City of Oakland radio system are met, while keeping in mind the objectives of the Bay Area UASI and the California SCIP objectives.

We recommend the following steps be taken:

1. Complete the current 800 MHz rebanding effort.
2. Re-license the rebanded 800 MHz frequencies for a simulcast system, with at least 100 Watts at each site. The key is to increase the ERP at AP from 19 Watts to as much as 300 Watts.
3. Purchase an additional 500 portables to be issued to Oakland PD so that each officer has his own radio.
4. After increased power levels and upgraded sites following the rebanding effort, verify the coverage meets the needs of the users.
5. Research the cost of upgrading the existing EDACS system to a simulcast system. This research will be used to determine if current system needs exceed capacity, this might be a viable short term solution as the City of Oakland decides if they should build out their own system, or join EBRCSA.
6. The existing Microwave upgrades should continue. Even if the City of Oakland joins EBRCS, the existing microwave loop could be incorporated into the EBRCS design. If the City builds its own system, the existing microwave system will need to be upgraded as planned.
7. Aggressively look for grant funding opportunities to pay for a City of Oakland P25 radio system. If these grant funding sources can be found, then the City should move in this direction.

8. Aggressively work with EBRCSA to ensure the current site selections are those that are used in the final design for the EBRCSA ALCO Northwest Cell. Work closely with EBRCSA and negotiate site sharing details for Seneca and APL.
9. Work with EBRCSA to determine if a maintenance agreement can be put in place for the City of Oakland to provide all maintenance infrastructure and subscriber support for the agencies in the ALCO Northwest Cell. If an agreement can be made, it may be possible for the City of Oakland to defer most of the costs of joining EBRCSA.
10. The final decision will depend on the answers to number 7, 8, and 9 above, since either solution is equally viable from an operational and interoperability perspective.

15.3 Major Findings

This final section is a comparison of the two options based on each of the major attributes of the solutions. Option 1 is the choice to build out a MA/COM (Harris) P25 simulcast system for the City of Oakland. Option 2 is the choice to join the EBRCS ALCO Northwest Cell.

Operability: Both options provide the same level of operability. The needs of the radio users on the City of Oakland System could be met by both options. It is possible, that due to the additional tower sites in Option 2, that better in-building coverage would be achieved with Option 2.

Interoperability: Both options meet the interoperability goals outlined by the Bay Area UASI and by the California SCIP. If the City chooses Option 1, then EBRCS would need to define Interoperability Talkgroups that can be used on the EBRCS by City of Oakland Users.

Initial Cost: The City of Oakland would have to find a funding source to fund the build out of the $5.67M dollar system for Option 1. At this time there is no initial cost with joining EBRCSA.

Maintenance Costs: The clear advantage is Option 1. Option 1 is about $740K less per year than Option 2. If the annual replacement costs are removed, then this difference is even greater. Option 2 can make up some of this difference if the City of Oakland is able to provide maintenance support to the users in the ALCO Northwest cell as described above.

Coverage: Option 2 provides the best coverage, provided the current ALCO Northwest design with sites at UC Berkeley, APL, Seneca and Skyline is installed. In addition, in-building coverage should be better with Option 2. Option 1 will provide increased coverage over the current system and will meet the needs of the City of Oakland users.

Redundancy and Reliability: Option 1 provides increased redundancy and reliability over Option 2. Option 1 provides an additional layer of coverage and is a completely separate radio system form EBRCSA. Provided interoperability talkgroups are defined on each system, Option 1 can provide redundancy for users on EBRCSA and EBRCSA can provide redundancy for City of Oakland Users.

System Capacity: Both options provide adequate capacity for the City of Oakland. However, it should be noted that if the multi-cell users (those that place calls from ALCO Northwest to other cells) significantly increases, then Option 2 could begin to see in increase in traffic. If Option 1 is chosen, this would not be an issue.

Governance: Option 1 is much less complicated from a governance perspective. The challenges with Option 2 are not significant, but will require more effort than Option 1.

Interoperability with BART: Option 1 provides an advantage in this category. If Option 2 is chosen, then BART users cannot talk on the system unless they purchase P25 Phase II radios and they are defined on the Motorola system that is being built out for Option 2.

Appendix C – Surveyor Results

In order to identify current problems and the future radio system needs of the City of Oakland, an online survey was used to obtain this critical information. This appendix summarizes the results of the On-line Survey. The trends reported in the online survey align with the information that was reported during user interviews and provide a snap shot of the existing problems with the City of Oakland radio system. A list of the survey questions is provided in SECTION C.4.

C.1 Survey Reported Radio Problems

Oakland users, dispatchers and technical points of contact were asked to participate in an online survey that captured some information about their current communication systems. TABLE C-1 summarizes the problems for trunked radio systems for Oakland. The tables indicate the level or seriousness of the perceived problems. Problems are listed in order of "overall" severity and are also ranked by discipline: fire, law enforcement, public safety, and all others.

C.2 Radio Problem Descriptions

The problem areas summarized in TABLE C-1 are defined below. The headings listed below correspond to the "Problem" Column of TABLE C-1.

Problem Descriptions for Trunked Radio System (Table C-1):

Capacity -- The system has insufficient capacity to support traffic associated with peak or emergency conditions.

Complex Operation -- The radio is complicated to operate or the radio user needs to know the characteristics of the system, which could cause difficulty if the user is in a high-pressure situation.

Dispatcher Access -- For whatever reason, the dispatcher or the user cannot gain access to each other on a routine basis. Either the user must compete for the dispatcher's time, or the dispatcher has no way to contact the user.

Equipment Maintainability -- Maintenance is inadequate on user equipment (including consoles and desk top units); the user regularly needs to return to get the same thing fixed.

Indoor Portable Operation -- Portable units cannot reliably be used in the system, particularly indoors.

Interference -- Users from your own or other localities interfere and step on the local users. This either overrides critical communications or forces messages to be repeated.

Interoperability -- The system does not allow users the ability to communicate between agencies within the jurisdiction.

Limited Coverage -- Dead spots regularly occur, particularly between dispatcher and user.

Outdoor Portable Operation -- Portable units cannot reliably be used in the system, particularly outdoors.

Regional Interoperability -- The system does not allow users the ability to communicate between agencies outside of the jurisdiction.
System Busies – The user has to wait to gain access to the radio system, not because someone is using the talkgroup, but because a channel is not available.

System Reliability -- There are frequent breakdowns of old or poorly maintained infrastructure equipment.

Talk Group Congestion -- On your radio system, too much unrelated chatter from other users is heard; user tends to turn volume down unless they specifically need to call someone, and thus cannot be reached.

Rating Scale:

0. No problem identified.
1. Identified problem, currently not of concern. May become a concern in the future.
2. Occasionally a problem which affects some operations but is generally worked around.
3. Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.
4. Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill his mission.
5. Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

C.3 System Attribute Descriptions

The attributes summarized in TABLE C-2 are defined below. The headings listed below correspond to the “Ref” Column in TABLE C-2.

Reference Column Descriptions:

Improved Voice Radio Coverage: The system shall provide a signal availability of 95 percent to/from mobile radios, with coverage evenly distributed over the service area for all operational functions.

In-Building Coverage: The system shall provide a signal availability of 95 percent to/from portables in building.

Minimize Interference: The system should minimize or eliminate interference.

Increased Channel Capacity: The system design shall include additional channels for current and future capacity. Additional channels are important to alleviate congestion on the dispatch and incident channels.

On-Scene Fireground/Tactical Communications Channels: Direct radio-to-radio frequencies (firegrounds) enable local incident communications in-building, below grade, and in other situations where repeated channels do not offer solid coverage.

Monitored Firegrounds: Fireground communications must be available to be monitored by dispatch, command personnel, or recording.

Emergency Alerting: The radios and system shall provide an emergency function for alerting dispatch and supervisors to the need for assistance.

Workgroup Oriented Operation: The system shall be organized with sufficient channels or talk-groups to allow departmental workgroups to have their own channel or talk group.

Voice Security: The system shall provide encrypted communications for users that need to prevent unauthorized interception of sensitive information.

Operational Boundary Transparency: System operation will be logical, with the focus on whom the user wants to call rather than where they are located. Changes in the user agencies' operational boundaries shall be transparent to radio users. The radio system shall allow any group or department to operate with full communications capability within the service area.

One System Serves All Agencies: Convenient, same-radio communications is important between all Public Safety agencies within the locality.

Interoperability through Dispatch: The radio system shall provide a connection between all dispatch operations allowing dispatchers to facilitate information flow between agencies through dispatch and incident command, rather than at the user level.

Interoperability with Adjacent Localities: The radio system design shall emphasize compatibility with radio systems in the adjacent localities to enable public safety users to assist in adjacent counties (and vice versa) and communicate with users from other Public Safety agencies using their assigned radios.

Interoperability with State Agencies: The radio system design should emphasize compatibility with radio systems in use by the State to facilitate communications with State agencies.

Interoperability with Federal Agencies: While local agencies cannot operate radio on Federal channels, compatible equipment would facilitate Federal/local cooperative efforts if Federal users could communicate over the locality infrastructure.

Person Location: Dispatch can determine the location of a user (to his portable or mobile radio), useful for example when sending assistance.

System Control: The Locality is significantly more comfortable with the high level of system control that comes with exclusive use and system ownership.

Text Messaging: The mobiles and portable radios shall be capable of text messaging.

Dual Band Operation: The user radios need to operate on VHF and 700 / 800 MHz.

Recorder Operations: Logged audio is important for all dispatch and incident communications.

Future Expansion: The system shall be capable of future expansion in the number of channels and the number of users. System design shall incorporate expansion to the level of usage predicted for the next 15 years with only the addition of equipment.

Owner-Controlled Connectivity Network: The system shall be interconnected using a dedicated interconnecting backbone network, such as microwave or fiber. The goal is to maximize reliability, minimize use of leased carriers and associated costs, and maintain control of the network. Additionally, a dedicated, highly reliable network interconnecting all major radio locations is highly desired. This can be via microwave or fiber.

Microwave Additional Capacity: The network design shall include extra capacity, over and above the radio and mobile data needs, for other Locality uses.

Regional Connectivity: The system design shall provide infrastructure connectivity to adjacent areas.

OTAP: The system shall provide for Over-the-Air-Programming of radios.

OTAR: The system shall provide for Over-the-Air-Rekeying of encrypted radios.

Over-the-Air-Reflash: The system shall provide for over-the-air upgrades to operating software or new software versions for mobiles and portables.

Survivability: The system shall be designed to survive in severe weather or emergency conditions. If dispatch points are shifted from their primary to a backup location, radio control shall be available at the backup location to the same degree it was available at primary dispatch.

Reliability/Failure Hierarchy: The radio system and equipment must be designed such that single-mode failures do not perceptibly impact the routine operations of the system.

The following requirements shall apply to failure conditions:
- Channel failure: no operating impact due to failed voice channel.
- Site failure: no operating impact except reduced coverage area.
- Primary power failure: UPS backup shall be supplied for all communications equipment, and generator backup for the radio equipment.
- Console failures: Single console failure: use reserve console. Console common equipment failure: dispatchers operate co-located radio control station.
- Communications Center failure: Dispatch using radio control stations at a backup dispatch center.

Single Points of Failure: The system shall, as much as practical, minimize single points of failure. This is accomplished through redundant equipment, multi-node network design, distributed processing, backup equipment, etc.

Power Backup: All fixed radio equipment shall require backup power with automatic transfer, capable of handling 100 percent loading of radio equipment. An uninterruptible power system (UPS) shall be required for all communications equipment.

Staffing and Training: The system vendor shall provide formal training for system administrators, supervisors, dispatchers, radio users, and maintenance technicians.

Centralized Maintenance: The Locality / Agency prefers to centrally maintain and administer the radio system, dispatch systems, and user radios, either in-house or using a service shop. Centralized maintenance provides consistent and coordinated services for all user departments.

Competitive Procurement Process: The overall system concept shall be available from more than one vendor allowing a competitive procurement process. Equipment shall be procured using open non-restrictive, competitive specifications. Award to be based on the most cost-effective system meeting the specified operational and functional requirements.

Commonality of Equipment: A single vendor shall install and supply all required equipment; as much as possible, user equipment shall be similar in operation and maintenance requirements. The goal is to minimize spare parts inventory and multiple vendor training requirements.

Multiple Sources: Compatible user equipment shall be available from multiple vendors. Competitive procurement of user equipment is more important than equipment commonality.

Phased Implementation: As much as possible, system procurement and implementation shall occur on a phased basis, allowing costs to be spread over several years. The radio system shall be designed to add user groups to the system over time.

Tiered Subscriber Cost: High-, mid-, and low-tier radio equipment with feature sets and costs matched to the user group shall be provided.

Users ranked the attributes utilizing the following scale:

Rating Scale:

Attribute is NOT IMPORTANT to the user.

Attribute is MINIMALLY IMPORTANT to the user.

Attribute is NICE TO HAVE, could enhance operations.

Attribute is USEFUL, will promote more efficient day to day operation.

QUITE IMPORTANT, lack could result in degradation of mission, injury, or loss of property.

CRITICAL, lack generally will result in injury, loss of property, or degradation of mission.

C.4 Survey Questions

This section presents the CTA Surveyor questions used for the Oakland survey. Each section contains a group of related questions.

User Information - Initial Questions

Note: These questions gather information about the survey participant.

Is your radio system Trunked or Conventional?
Trunked
Conventional

Your radio system is trunked if you use talk groups. Trunked systems are typically at 700, 800 or 900 MHz. Your radio system is conventional if you use channels or frequencies. Conventional radio systems are typically at high band, VHF or UHF frequencies.

Are you a manager or administrator of the radio system?
Yes
No

You manage or administer the radio system.
Yes
No

D o you currently use or do you plan to use Mobile Data?
Yes
No

Current Conventional Voice Radio System Assessment

This section will only be presented if the survey participant answers “Conventional” to the question “Is your radio system Trunked or Conventional?

Rating Scale and Problem Descriptions are shown in Section C-2

Current Trunked Voice Radio System Assessment

This section will only be presented if the survey participant answers “Trunked” to the question “Is your radio system Trunked or Conventional?

Rating Scale and Problem Descriptions are shown in Section C-2

Mobile Data

The Mobile Data sections will only be presented if the survey participant answers “Yes” to the question “Do you use mobile data in your work?”

Mobile Data Information

Current Mobile Data Operations

Do you use mobile data on a radio system, a commercial (cellular) data service provider or both?

Your radio system may provide the ability to have mobile data. Mobile data may be provided by a commercial data services provider or cellular provider via an "air card."

Radio System
Commercial Data Service Provider
Both

If your mobile data is on a radio system, what is the frequency band?
- Low Band
- VHF
- UHF
- 700 MHz
- 800 MHz
- 900 MHz
- Other

What Type of Mobile Data Equipment Do You Use?
- Laptops
- Mobile Data Computers or Terminals
- Other

If you selected "Other," please describe.

Mobile Data Applications

Does your mobile data system support GPS or Automatic Vehicle Location (AVL)?

Does your mobile data system support sending fingerprints?

Does your mobile data system support sending maps or geo-files?

Does your mobile data system support sending images?

Does your mobile data system support video?

Possible Answers for Ratings Questions:

0. No problem identified.
1. Identified problem, currently not of concern.
2. Occasionally a problem.
3. Regularly a problem.
4. Frequently a problem.
5. Critical concern.
6. Don't Know.

Limited Data Coverage: When you use mobile data, do you experience areas of limited data coverage?
Limited Data Coverage Area -- Dead spots regularly occur,

Access: Can you gain access to the mobile data system when you need to?
Access -- User cannot gain access when the situation requires data communications.

Capacity: Does the system have sufficient capacity to support mobile data during peak or emergency conditions?
Capacity -- The system has insufficient capacity to support traffic associated with peak or emergency conditions.

System Reliability: Are there frequent problems; does the equipment breakdown?
System Reliability -- Frequent breakdowns of old or poorly maintained equipment, including infrastructure equipment.

Complex Operation: How easy is it to operate the laptop, MDC or the mobile data application?
Complex Operation -- The mobile data application is complicated to use, which could cause difficulty if the user is in a high-pressure situation.

Dispatcher Access: Can you gain access to the dispatcher via the mobile data system?
Dispatcher Access -- For whatever reason, the dispatcher or the user cannot gain access to each other via the data system on a routine basis.

Equipment Maintainability: Is maintenance on your laptop or MDC adequate, or do you regularly need to get the same thing fixed?
Equipment Maintainability -- Maintenance is inadequate on user equipment; the user regularly needs to return to get the same thing fixed.

Data Speed: Does it take a long time to send or receive a message?
Data Speed—It takes a long time to send and / or receive a message, or the message has to be resent.

Equipment Quantities Assessment

The Radio Equipment sections will only be presented if the survey participant answers "Yes" to the question "Are you a manager or administrator of the radio system?"

Current Subscriber Equipment Quantities

For each equipment category, enter the total number of units you operate (not including spares) for each frequency band.

Equipment Type	Low Band	UHF	Dual Band 700 / 800 MHz	800 MHz	900 MHz
Mobiles					
Portables					
Desktop or Control Stations					

Current Spare Radios in Inventory

For each equipment category, enter the total number of spare units you have in inventory for each frequency band.

Equipment Type	Low Band	Dual Band 700 / 800 MHz	800 MHz	900 MHz
Mobiles				
Portables				
Desktop or Control Stations				

Immediate Radio Equipment Needs

This section will only be presented if the survey participant answers “Yes” to the previous question.

For each equipment category, enter the total number of units you need today for each frequency band.

Equipment Type	Low Band	Dual Band 700 / 800 MHz	800 MHz	900 MHz
Mobiles				
Spare Mobiles				
Portables				
Spare Portables				
Desktop or Control Stations				
Spare Desktop or Control Stations				

Radio Equipment – Future Subscriber Quantities

Enter the percentage increase in the quantities of user equipment estimated to be needed 5, 10 and 15 years from now. For example, if you currently have 500 mobiles, 300 portables, and 20 desktop stations, and you enter 10 (percent), this means you would need 50 more mobiles, 30 more portables, and 2 more Desktop stations in 5 years. This is a rough estimate, and so will be applied across each radio type (mobiles, portables, control stations). Note that the range is 0% to 1000%, allowing for no increase to up to 10 times as many radios as currently in place. It would be unusual for increases over 50%, unless you are expecting significant growth, or planning consolidation with other Agencies on a shared system, for example

	5 Years	10 Years	15 Years
What percentage increase in equipment do you forecast for 5, 10, and 15 years out?			

Current Mobile Data Equipment Quantities

The Mobiles Data Equipment sections will only be presented if the survey participant answers "Yes" to the questions "Are you a manager or administrator of the radio system?" and "Do you have Mobile Data on your system?

Current Equipment in Operation (Not Including Spares)

Please enter the number of current laptops or MDCs you have in operation (not including spares).

Current Spare Equipment in Inventory

Please enter the number of spare laptops or MDCs you have in inventory.

Immediate Mobile Data Needs

Are the equipment quantities you entered in the previous section sufficient for your current staffing needs?

Additional Mobile Data Needs

Additional Laptops or MDCs: Please enter the number of additional laptops or MDCs you need today but do not have (not including spares).

Additional Spare Laptops or MDCs: Please enter the number of additional laptops or MDCs you need in inventory but do not have today.

Future Mobile Data Quantities

Enter the percentage increase in the quantities of equipment estimated to be needed 5, 10 and 15 years from now.

	5 Years	10 Years	15 Years
What percentage increase in equipment do you forecast for 5, 10, and 15 years out?			

Interoperability Information SAFECOM Continuum

The Interoperability sections will only be presented if the survey participant answers "Yes" to the question "Are you a manager or administrator of the radio system?"

Governance

A common governing structure for solving interoperability issues will improve the policies, processes, and procedures of any major project by enhancing communication, coordination, and cooperation, establishing guidelines and principles, and reducing any internal jurisdictional conflicts. This group should consist of local, tribal, state, and federal entities as well as representatives from all pertinent public safety disciplines within the identified region. A formal governance structure is critical to the success of interoperability planning.

Possible Answers for Ratings Questions:

1. Individual Agencies Working Independently
2. Informal Coordination Between Agencies
3. Key Multi-Discipline Staff Collaboration on a Regular Basis
4. Regional Committee Working with a Statewide Communications Interoperability Plan Framework
5. Don't Know

Please select the response that best describes your interoperability governance structure with other disciplines within your own jurisdiction or locality.

Please select the response that best describes your interoperability governance structure with other agencies outside your jurisdiction or locality.

Please select the response that best describes your interoperability governance structure between state and local government.

Please select the response that best describes your interoperability governance structure between federal and local government.

Standard Operating Procedures

Standard Operating Procedures (SOPs) are formal written guidelines or instructions for incident response. SOPs typically have both operational and technical components. Established SOPs enable emergency responders to successfully coordinate an incident response across disciplines and jurisdictions. Clear and effective SOPs are essential in the development and deployment of any interoperable communications system.

Possible Answers for Ratings Questions:

1- Individual Agency SOPs
2- Joint SOPs for Planned Events
3- Joint SOPs for Emergencies
4- Regional Set of Communications SOPs
5- National Incident Management (NIMS) Integrated SOPs
6- Don't Know

Please select the response that best describes your Standard Operating Procedures for interoperability with other disciplines within your own jurisdiction or locality.

Please select the response that best describes your Standard Operating Procedures for interoperability with agencies outside your jurisdiction or locality.

Please select the response that best describes your Standard Operating Procedures for interoperability between state and local government.

Please select the response that best describes your Standard Operating Procedures for interoperability between federal and local government.

Technology - Voice

Although technology is a critical tool for improving Interoperability, it is not the sole driver of an optimal solution. Success in each of the other elements is essential to its proper use an implementation, and should drive technology procurement. Technology is highly dependent upon existing infrastructure within a region. Multiple technology solutions may be required to support large events.

Possible Answers for Ratings Questions:
1- Swap Radios
2- Gateway
3- Shared Channels
4- Proprietary Shared Systems
5- Standards-based Shared Systems
6- Don't Know

Please select the response that best describes the technology or your means of interoperability with other disciplines within your own jurisdiction or locality.

Please select the response that best describes the technology or your means of interoperability with other agencies outside your own jurisdiction or locality.

Please select the response that best describes the technology or your means of interoperability between state and local government.

Please select the response that best describes your interoperability governance structure between federal and local government.

Technology - Data

Although technology is a critical tool for improving Interoperability, it is not the sole driver of an optimal solution. Success in each of the other elements is essential to its proper use an implementation, and should drive technology procurement. Technology is highly dependent upon existing infrastructure within a region. Multiple technology solutions may be required to support large events.

Possible Answers for Ratings Questions:
1- Swap Files
2- Common Applications
3- Custom-Interfaced Applications
4- One-Way Standards-based Sharing
5- Two-Way Standards-based Sharing
6- Don't Know

Please select the response that best describes the technology or your means of data interoperability with other disciplines within your own jurisdiction or locality.

Please select the response that best describes the technology or your means of data interoperability with other agencies outside your own jurisdiction or locality.

Please select the response that best describes the technology or your means of data interoperability between state and local government.

Please select the response that best describes the technology or your means of data interoperability between federal and local government.

Training & Exercises

Proper training and regular exercises are critical to the implementation and maintenance of a successful interoperability solution. Implementing effective training and exercise programs to practice communications interoperability is essential for ensuring that the technology works and responders are able to effectively communicate during emergencies.

Possible Answers for Ratings Questions:
1- General Orientation on Equipment
2- Single Agency Tabletop Exercises for Key Field and Support Staff
3- Multi-agency Tabletop Exercises for Key Field and Support Staff
4- Multi-agency Full Functional Exercises Involving All Staff
5- Regular Comprehensive Regional Training and Exercises
6- Don't Know

Please select the response that best describes your interoperability training and exercises with other disciplines within your own jurisdiction or locality.

Please select the response that best describes your training and exercises for interoperability with agencies outside of jurisdiction.

Please select the response that best describes your training and exercises for interoperability between state and local government.
Please select the response that best describes your training and exercises for interoperability between federal and local government.

Usage

Usage refers to how often interoperable communications technologies are used. Success in this element is contingent upon progress and interplay among the other four elements on the Interoperability Continuum.

Possible Answers for Ratings Questions:
1- Planned Events
2- Localized Emergency Incidents
3- Regional Incident Management
4- Daily Use throughout Region
5- Don't Know

Please select the response that best describes how often you use interoperability with other disciplines within your own jurisdiction or locality.

Please select the response that best describes how often you use interoperability with other agencies outside your jurisdiction.

Please select the response that best describes how often you use interoperability between state and local government.

Please select the response that best describes how often you use interoperability between federal and local government.

Voice Systems Interoperability Assessment

In this Voice Interoperability Assessment section, you will be asked to describe how your interoperability, using voice radio, with other Agencies. There are four groups of questions - interoperable communications within your jurisdiction, between jurisdictions, with State agencies, and with Federal agencies.

Please answer all questions to the best of your ability.

Clicking on any Question will provide "Help" in this screen. Click in the response field to the right of the Question to provide your response.

You can change any response.

Current Interoperability

The section asks who you have interoperability with currently, within your jurisdiction or locality, outside your jurisdiction or locality, with state agencies and with federal agencies.

What disciplines within your jurisdiction do you currently have interoperability with?
Select all that apply – Disciplines within your jurisdiction that your Agency currently has interoperability with. If you do not have interoperability with any other disciplines, check "None".

Law Enforcement - Sheriff
Law Enforcement - Police
Law Enforcement - Tribal
Fire
EMS
Emergency Management
Hospitals
Correctional Facilities
Local Public Works
Other Local Government
Other Tribal Government
Other
None

What disciplines outside your jurisdiction do you currently have interoperability with?
Select all that apply – Disciplines outside your jurisdiction that your Agency currently has interoperability with. If you do not have interoperability with any other disciplines, check "None".

Law Enforcement - Sheriff
Law Enforcement - Police
Law Enforcement - Tribal
Fire
EMS
Emergency Management
Hospitals
Correctional Facilities
Local Public Works
Other Local Government
Other Tribal Government
Other
None

What State Agencies are you currently able to communicate with? (List must be customized for applicable state)
Select all that apply - State Agencies that your Agency communicates with. If you do not communicate with any State Agencies, check "None".

State Police
Fish and Game

Homeland Security
Dept. of Agriculture
Dept. of Commerce
Corrections
Health
Emergency Management
Human Services
Information Technologies
National Guard
Transportation Dept.
Other
None

What Federal Agencies are you currently able to communicate with?
Select all that apply - Federal Agencies that your agency communicates with. If you do not communicate with any Federal Agencies, check "None".

Alcohol, Tobacco, and Firearms
Bureau of Land Management
Drug Enforcement Administration
Dept of Interior
Dept of Homeland Security
Environmental Protection Agency
Federal Bureau of Investigation
National Parks Service
Natural Resource Conservation Service
Secret Service
Transportation Security Agency
US Dept of Agriculture
US Forest Service
US Fish and Wildlife Service
US Marshals
US Postal Service
Other
None

If you selected "Other" for having interoperability with any local, state or federal disciplines or agencies, please enter the agencies here.

List the specific disciplines that you have interoperability with that are not listed above.

Interoperability Need

What disciplines in your jurisdiction do you need to communicate with, but cannot?
Select all that apply – Disciplines that your Agency is not currently able to interoperate with. If you do not communicate with any other disciplines, check "None".

Law Enforcement - Sheriff
Law Enforcement - Police
Law Enforcement - Tribal
Fire
EMS
Emergency Management

Hospitals
Correctional Facilities
Local Public Works
Other Local Government
Other Tribal Government
Other
None

What disciplines outside of your jurisdiction do you need to communicate with, but cannot?
Select all that apply – Disciplines that your Agency is not currently able to interoperate with. If you do not communicate with any other disciplines, check "None".

Law Enforcement - Sheriff
Law Enforcement - Police
Law Enforcement - Tribal
Fire
EMS
Emergency Management
Hospitals
Correctional Facilities
Local Public Works
Other Local Government
Other Tribal Government
Other
None

What State Agencies or disciplines do you need to communicate with, but cannot? (List must be customized for applicable state)

Select all that apply - State Agencies that your Agency is not currently able to interoperate with. If you do not communicate with any other disciplines, check "None".

State Police
Fish and Game
Homeland Security
Dept. of Agriculture
Dept. of Commerce
Corrections
Health
Emergency Management
Human Services
Information Technologies
National Guard
Transportation Dept.
Other
None

What Federal Agencies or disciplines do you need to communicate with, but cannot? (List must be customized for applicable state)

Select all that apply – Federal Agencies that your Agency is not currently able to interoperate with. If you do not communicate with any other disciplines, check "None".

Alcohol, Tobacco, and Firearms
Bureau of Land Management
Drug Enforcement Administration
Dept of Interior
Dept of Homeland Security
Environmental Protection Agency
Federal Bureau of Investigation
National Parks Service
Natural Resource Conservation Service
Secret Service
Transportation Security Agency
US Dept of Agriculture
US Forest Service
US Fish and Wildlife Service
US Marshals
US Postal Service
Other
None

If you selected "Other" for needing interoperability with any local, state or federal disciplines or agencies, please enter the agencies here.

List the specific Agencies that you communicate with (interoperations) that have not been selected above.

Future Systems Information

This section contains features and functionality desired in a Radio Communications System. Please rate the importance of the following system attributes to your Agency for a future radio system.

These system attributes are characteristics that COULD be emphasized in a new system design.

Please rate each attribute according to importance for your operation using the rating scale defined below. "Click" on the button to select your desired response. Please answer all questions to the best of your ability. You can change any response.

Possible Answers for Ratings Questions:

0. Attribute is NOT IMPORTANT to the user.
1. Attribute is MINIMALLY IMPORTANT to the user.
2. Attribute is NICE TO HAVE, could enhance operations.
3. Attribute is USEFUL, will promote more efficient day to day operation.
4. QUITE IMPORTANT, lack could result in degradation of mission, injury, or loss of property.
5. CRITICAL, lack generally will result in injury, loss of property, or degradation of mission.
6. Don't Know, insufficient information available to answer this question.

Radio Coverage

Improved Voice Radio Coverage: The system should provide radio coverage evenly distributed over the service area for all operational functions. The goal is for there to be no dead spots.
The system shall provide a signal availability of 95 percent to/from mobile radios, with coverage evenly distributed over the service area for all operational functions.

In-Building Coverage: The radio system should provide in-building coverage in the metropolitan areas and in other areas where appropriate.
The system shall provide a signal availability of 95 percent to/from portables in building.

Minimize Interference: The system should minimize or eliminate interference.

Radio Voice Operations

Increased Channel Capacity: The system design shall include additional channels for current and future capacity. Additional channels are important to alleviate congestion on the dispatch and incident channels.

On-Scene Fireground/Tactical Communications Channels: The system design should include licensed simplex frequencies for use by fire departments on-scene.
Direct radio-to-radio frequencies (firegrounds) enable local incident communications in-building, below grade, and in other situations where repeated channels do not offer solid coverage.

Monitored Firegrounds: The system design should provide a means or routing fireground channels to dispatch. *Fireground communications must be available to be monitored by dispatch, command personnel, or recording.*

Emergency Alerting: The radios and system shall provide an emergency function for alerting dispatch and supervisors to the need for assistance.

Workgroup Oriented Operation: The system shall be organized with sufficient channels or talk groups to allow departmental workgroups to have their own channel or talk group.
Voice Security: The system shall provide encrypted communications for users that need to prevent unauthorized interception of sensitive information.

Operational Boundary Transparency: The radio system design shall utilize multiple tower sites, and to the extent possible, automatically switch to the correct site, transparent to the radio user.
System operation will be logical, with the focus on whom the user wants to call rather than where they are located. Changes in the user Agencies' operational boundaries shall be transparent to radio users. The radio system shall allow any group or department to operate with full communications capability within the service area.

One System Serves All Agencies: One radio system shall support all Public Safety agencies including all Law Enforcement, Fire agencies and Emergency Medical Service agencies. It may also support Public Service agencies.
Convenient, same-radio communications is important between all Public Safety agencies within the Locality.

Interoperability through Dispatch: The radio system shall provide a connection between all dispatch operations allowing dispatchers to facilitate information flow between agencies through dispatch and incident command, rather than at the user level.

Interoperability with Adjacent Localities: The radio system design shall emphasize compatibility with radio systems in the adjacent localities to enable public safety users to assist in adjacent counties (and visa versa) and communicate with users from other Public Safety agencies using their assigned radios.

Interoperability with State Agencies: The radio system design should emphasize compatibility with radio systems in use by the State to facilitate communications with State agencies.

Interoperability with Federal Agencies: The radio system design shall emphasize compatibility with radio systems in use by the Federal agencies operating in the locality.

While local agencies cannot operate radio on Federal channels, compatible equipment would facilitate Federal/local cooperative efforts if Federal users could communicate over the locality infrastructure.

Person Location: The radio system shall include radio location technology to map the location of user radios.
Dispatch can determine the location of a user (to his portable or mobile radio), useful for example when sending assistance.

System Control: The Locality is significantly more comfortable with the high level of system control that comes with exclusive use and system ownership.

Text Messaging: The mobiles and portable radios shall be capable of text messaging.

Dual Band Operation: The user radios need to operate on both VHF and 700 / 800 MHz.

Recorder Operations: The system design shall provide the capability of recording audio for all Public Safety agencies using the system.
Logged audio is important for all dispatch and incident communications.

Infrastructure Capabilities

Future Expansion: The system shall be capable of future expansion in the number of channels and the number of users.
System design shall incorporate expansion to the level of usage predicted for the next 15 years with only the addition of equipment.

Owner-Controlled Connectivity Network: The system shall be interconnected using a dedicated interconnecting backbone network, such as microwave or fiber.
The goal is to maximize reliability, minimize use of leased carriers and associated costs, and maintain control of the network. Additionally, a dedicated, highly reliable network interconnecting all major radio locations is highly desired. This can be via microwave or fiber

Microwave Additional Capacity: The network design shall include extra capacity, over and above the radio and mobile data needs, for other Locality uses.

Regional Connectivity: The system design shall provide infrastructure connectivity to adjacent areas.

OTAP: The system shall provide for Over-the-Air-Programming of radios.
The radios shall be capable of being reprogrammed over-the-air.

OTAR: The system shall provide for Over-the-Air-Rekeying of encrypted radios.

Over-the-Air-Reflash: The system shall provide for over-the-air upgrades to operating software or new software versions for mobiles and portables.

Reliability and Availability

Survivability: The system shall be designed to survive in severe weather or emergency conditions.
If dispatch points are shifted from their primary to a backup location, radio control shall be available at the backup location to the same degree it was available at primary dispatch.

Reliability/Failure Hierarchy: The radio system and equipment must be designed such that single-mode failures do not perceptibly impact the routine operations of the system.

The following requirements shall apply to failure conditions:

- Channel failure: no operating impact due to failed voice channel.
- Site failure: no operating impact except reduced coverage area.
- Primary power failure: UPS backup shall be supplied for all communications equipment, and generator backup for the radio equipment.
- Console failures: Single console failure: use reserve console. Console common equipment failure: dispatchers operate co-located radio control station. Communications Center failure: Dispatch using radio control stations at a backup dispatch center.

Single Points of Failure: The system shall, as much as practical, minimize single points of failure. *This is accomplished through redundant equipment, multi-node network design, distributed processing, backup equipment, etc.*

Power Backup: All fixed radio equipment shall require backup power with automatic transfer, capable of handling 100 percent loading of radio equipment. An uninterruptible power system (UPS) shall be required for all communications equipment.

Training and Maintenance

Staffing and Training: The system vendor shall provide formal training for system administrators, supervisors, dispatchers, radio users, and maintenance technicians.

Centralized Maintenance: The Locality / Agency prefers to centrally maintain and administer the radio system, dispatch systems, and user radios, either in-house or using a service shop.
Centralized maintenance provides consistent and coordinated services for all user departments.

Cost and Procurement

Competitive Procurement Process: The overall system concept shall be available from more than one vendor allowing a competitive procurement process.
Equipment shall be procured using open non-restrictive, competitive specifications. Award to be based on the most cost-effective system meeting the specified operational and functional requirements.

Commonality of Equipment: A single vendor shall install and supply all required equipment; as much as possible, user equipment shall be similar in operation and maintenance requirements.
The goal is to minimize spare parts inventory and multiple vendor training requirements.

Multiple Sources: Compatible user equipment shall be available from multiple vendors. Competitive procurement of user equipment is more important than equipment commonality.

Phased Implementation: As much as possible, system procurement and implementation shall occur on a phased basis, allowing costs to be spread over several years. The radio system shall be designed to add user groups to the system over time.

Tiered Subscriber Cost: High-, mid-, and low-tier radio equipment with feature sets and costs matched to the user group shall be provided.
The initial cost of user radios is a prime concern in the evaluation of proposed alternatives.

Mobile Data Operations

Possible Answers for Ratings Questions:

0. Attribute is NOT IMPORTANT to the user.
1. Attribute is MINIMALLY IMPORTANT to the user.
2. Attribute is NICE TO HAVE, could enhance operations.
3. Attribute is USEFUL, will promote more efficient day to day operation.
4. QUITE IMPORTANT, lack could result in degradation of mission, injury, or loss of property.
5. CRITICAL, lack generally will result in injury, loss of property, or degradation of mission.
6. Don't Know, insufficient information available to answer this question.

One Mobile Data Network Serves All Agencies: One mobile data system shall support all Public Safety agencies.
A common system is important for compatibility and to avoid duplication of equipment, operation, and maintenance.

Cross CAD Interconnection: The system design shall include a means of exchanging information across different CAD systems.
CAD information exchange is important for information database sharing.

Mobile Data Criticality: The mobile data system is equally important to public safety communication as the voice radio system.
The mobile data system will be designed to meet the same critical communications standards as the voice radio system.

Vehicle Location: Automatic vehicle location (AVL) shall allow vehicles to be located by dispatch.
Unit location information can assist dispatch in selecting units for incident response and by incident commanders for checking location status of assigned units.

EMS Telemetry: The mobile data radio network shall support telemetry of EMS patient data.
This function is needed in the vehicle while en route and patient-side in the field.

High-Speed Broadband Service: The system design shall include locations with access to wireless broadband service. *High bandwidth service is important for advanced surveillance applications, exchange of bulky files, access to bandwidth intensive Locality information, and laptop maintenance.*

Mobile Applications: The mobile data system shall be designed around an application set suitable for routine law enforcement and fire operations.
These capabilities typically include:

- CAD dispatch
- Records access
- Unit status
- Sheriff civil process
- In-car mapping
- Messaging
- Email
- State and National Queries
- Access to electronically stored reference materials
- Other law, fire, public service specific applications
- Fingerprints

- Image Files (Mug Shots)

Advanced Mobile Applications: The mobile data system shall include capacity and capability for advanced applications for law enforcement and fire operations.
Advanced capabilities include:

- Video Surveillance
- Field biometrics
- Mobile access to many types of Locality information
- Larger photos
- Field citations
- Field reports

Access Locality / Agency Information: The mobile data radio network shall provide access to Locality GIS information.
Transfer of this type information tends to require significant bandwidth and may be offered over wireless broadband or be provided as local MDC or laptop files.

Value Added Comments

In this Additional Comments section of the survey, please provide any additional comments by typing them in the answer field to the right of the question. Your answers will be helpful in the overall communication system study. After completing this section, please proceed by clicking the Next button.

Voice Radio System

What radio system Features or Technologies do you need that you don't have today?

What is working well today?
Describe the aspects of the Communications System which are working well today.

Which areas need the most improvement?
Describe the areas which need the most improvement.

Additional related comments
Please provide any additional related comments.

Mobile Data System

What mobile data Features or Technologies do you need that you don't have today?

What is working well today?
Describe the aspects of the Communications System which are working well today.

Which areas need the most improvement?
Describe the areas which need the most improvement.

Additional related comments
Please provide any additional related comments.

Table C-1
City of Oakland
Trunked Radio Problems

Problems	Overall	Fire	Law Enforcement	PWA
Limited Coverage	3.7	3.8	4.3	1.0
Regional Interoperability	3.4	3.5	4.0	1.0
Indoor Portable Operation	2.8	3.2	2.8	0.0
Interoperability	2.7	3.2	2.6	1.0
Interference	2.6	2.7	3.3	1.0
Equipment Maintainability	1.9	2.2	2.0	0.0
Outdoor Portable Operation	1.9	2.2	2.0	0.0
System Busies	1.8	1.8	2.4	0.0
System Reliability	1.8	1.9	2.3	0.0
Talk Group Congestion	1.3	1.5	1.2	0.0
Capacity	1.1	0.9	2.0	0.0
Dispatcher Access	1.1	1.0	1.4	0.0
Complex Operation	0.9	1.0	1.1	0.0

0 : No problem identified.
1 : Identified problem, currently not of concern. May become a concern in the future.
2 : Occasionally a problem, affects some operations but is generally worked around.
3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.
4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill his mission.
5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Table C-2
City of Oakland
System Attribute Ranking

Ref	Attributes	Overall	Fire	Law Enforcement	PWA	Other
a	Improved Voice Radio Coverage	4.9	4.8	5.0	5.0	4.7
b	In-Building Coverage	4.8	4.9	4.8	4.3	5.0
g	Emergency Alerting	4.7	4.7	4.9	4.0	4.7
bb	Survivability	4.7	4.8	4.3	4.3	5.0
cc	Reliability/Failure Hierarchy	4.7	4.7	4.7	4.5	5.0
ff	Staffing and Training	4.6	4.6	4.8	4.0	4.7
c	Minimize Interference	4.6	4.7	4.4	4.0	5.0
dd	Single Points of Failure	4.6	4.5	4.8	4.0	5.0
ee	Power Backup	4.5	4.5	4.8	3.7	5.0
j	Operational Boundary Transparency	4.3	4.3	4.4	4.0	4.7
gg	Centralized Maintenance	4.3	4.3	4.4	3.7	5.0
m	Interoperability with Adjacent Localities	4.2	4.3	4.4	2.7	3.7
e	On-Scene Fireground / Tactical Communications Channels	4.1	4.3	3.8		3.7
v	Owner-Controlled Connectivity Network	4.1	3.7	4.2		5.0
f	Monitored Firegrounds	4.0	4.0	3.7		4.0
l	Interoperability through Dispatch	3.9	3.9	4.0	3.0	4.7
u	Future Expansion	3.9	3.7	4.3	3.0	5.0
x	Regional Connectivity	3.8	3.9	3.8	2.5	4.3
n	Interoperability with State Agencies	3.8	3.9	3.9	2.7	3.7

Ratings
0 - Attribute is NOT IMPORTANT to the user.
1 - Attribute is MINIMALLY IMPORTANT to the user.
2 - Attribute is NICE TO HAVE, could enhance operations.
3 - Attribute is USEFUL, will promote more efficient day to day operation.
4 - QUITE IMPORTANT, lack could result in degradation of mission, injury, or loss of property.
5 - CRITICAL, lack generally will result in injury, loss of property, or degradation of mission.

Note: To identify further information about an attribute, look up the Ref column in Section C.2

Table C-2 (cont.)
City of Oakland
System Attribute Ranking

Ref	Attributes	Overall	Fire	Law Enforcement	PWA	Other
ii	Commonality of Equipment	3.7	4.0	3.7	3.5	2.0
hh	Competitive Procurement Process	3.6	3.5	3.5	5.0	4.0
t	Recorder Operations	3.6	3.3	4.2	0.0	5.0
w	Microwave Additional Capacity	3.5	2.8	4.0		5.0
s	Dual Band Operation	3.5	3.4	3.6	3.0	4.7
y	OTAP	3.5	3.2	3.6		4.7
h	Workgroup Oriented Operation	3.5	3.1	4.2	4.0	4.0
p	Person Location	3.4	3.3	3.6	2.0	4.3
z	OTAR	3.4	3.1	3.7		4.3
aa	Over-the-Air-Reflash	3.3	3.2	3.3	3.0	4.0
k	One System Serves All Agencies	3.3	3.1	3.8	4.5	3.0
q	System Control	3.1	2.9	3.1		5.0
d	Increased Channel Capacity	3.1	3.0	3.4	3.0	3.3
ll	Tiered Subscriber Cost	3.1	3.0	2.6	3.5	4.0
o	Interoperability with Federal Agencies	3.0	2.9	3.3	2.5	3.3
kk	Phased Implementation	3.0	2.6	2.9	3.3	4.7
jj	Multiple Sources	2.9	2.8	2.8	2.0	4.7
i	Voice Security	2.8	2.3	3.9	1.3	5.0
r	Text Messaging	2.1	2.1	2.1	2.3	2.7

Ratings
0 - Attribute is NOT IMPORTANT to the user.
1 - Attribute is MINIMALLY IMPORTANT to the user.
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