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EBRCS Design Review

February 2008

East Bay Regional Communications System Design Review Report

Executive Summary

The Bay Area Super Urban Area Security Initiative (SUASI) Management Team asked the Interoperable Communications Technical Assistance Program (ICTAP), part of the U.S. Department of Homeland Security (DHS), Office of Emergency Communications (OEC), to provide an additional independent design review of the East Bay Regional Communications System (EBRCS) proposal submitted by Motorola and comments generated by CTA Communications, Inc. Motorola proposed a two-county, 800 MHz Project 25 (P25) digital trunked five cell simulcast system.

ICTAP initially began working on this review in August of 2007 but was directed by DHS in October to temporarily discontinue working on all technical assessments. This order was made so that ICTAP could apply 100% of their technical assistance efforts to the National Telecommunications and Information Administration (NTIA) Public Safety Interoperability Communications (PSIC) 1 billion dollar grant program. After completion of these efforts, ICTAP returned to the backlog of technical assistance requests, of which this EBRCS review was a priority. ICTAP is aware that this delay may cause undo stress on the administration of the EBRCS. Every attempt was made to get this review completed in a timely manner.

The Design Review Report addresses several identified concerns and questions that have come from the East Bay region, CTA Communications, and ICTAP engineers. On August 30, 2007, ICTAP met with East Bay and Motorola representatives to address these issues. On September 25, 2007 ICTAP had a follow on meeting with Motorola to obtain information regarding their RF coverage tool (Hydra) and to visualize the EBRCS coverage on a cell-by-cell basis. At this meeting, ICTAP was taken through the system design from a coverage standpoint. The August and September meetings were beneficial and provided context for considerations leading to the system design. The questions and issues raised in these meetings are compiled in this report to help East Bay representatives make informed decisions based on the knowledge of available tradeoffs as they work to create a regional interoperable radio network.

ICTAP strongly agrees with the basic plan for an East Bay regional P25 system. Migration of the area to a standards based system is the best avenue to ensure interoperability for the entire Bay Area. The existing plan is to build out the EBRCS using available 800 MHz channels with infrastructure that can support 700 MHz channels when they become available.

ICTAP did not attempt to redesign this project. The project remains an EBRCS specified system as proposed by the manufacturer, Motorola. ICTAP, through its meetings with the manufacturer, did request review of several proposed RF sites and recommended some changes. The manufacturer adopted some of the ICTAP recommendations while rejecting others with appropriate explanation(s) to ICTAP.

Remaining items that need to be completed include optimization of the proposed installation sites by examining RF coverage and penetration from these sites and possible replacement sites. ICTAP has done some of this in Section 3.3 of this report. These efforts should be discussed and finalized with local participation. ICTAP recommends forming a small, workable group of knowledgeable local personnel with the manufacturer to complete this effort. The optimization process must be completed to allow the manufacturer to properly finalize their plans. Failure to finalize the plan in a timely manner will be very costly to the project.

The EBRCS can only ensure complete and total communications interoperability for agencies in Contra Costa County and Alameda County by obtaining comprehensive (total) user buy-in. All regional agencies and jurisdictions must seriously consider joining the EBRCS. While financial considerations may hinder migration of some users to the EBRCS, their future plans should support migration to the system. Likewise, the EBRCS Authority and the Bay Area SUASI should identify and implement funding policies and strategies that would support rapid agency migration to the EBRCS.

Implementation of this P25 standards based system and the ongoing efforts by TIA to complete the Inter RF Sub System Interface (ISSI) standard could potentially allow EBRCS to interconnect to other systems, providing communications interoperability throughout the Bay Area SUASI region.

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1. Introduction

The Department of Homeland Security (DHS), Office of Emergency Communications (OEC) supports and promotes the ability of emergency responders and government officials to communicate in the event of natural disasters, acts of terrorism, or other man-made disasters, and works to ensure, accelerate, and attain interoperable and operable emergency communications nationwide. The Interoperable Communications Technical Assistance Program (ICTAP) provides technical assistance to states and urban areas applying Urban Area Security Initiative (UASI) and other funds to voice and data interoperability projects. ICTAP works to improve local, regional, and state interoperable communications, allowing public safety agencies to communicate effectively during incidents. ICTAP also works with other federal, state, and local interoperability efforts to enhance agencies' and individuals' overall capacity to communicate with one another.

The Bay Area Super Urban Area Security Initiative Management Team asked ICTAP to provide an additional independent design review of the East Bay Regional Communications System (EBRCS) proposal submitted by Motorola[1] and comments generated by CTA Communications, Inc[2]. Motorola proposed a two-county, 800 MHz Project 25 (P25) digital trunked, five cell simulcast system. This Design Review Report addresses several identified concerns and questions that have come up from the East Bay region, CTA consultants, and ICTAP engineers. On August 30, 2007, ICTAP met with East Bay and Motorola representatives to address these issues. On September 25, 2007, ICTAP had a follow on meeting with Motorola to obtain information regarding their RF coverage tool (Hydra) and to visualize the EBRCS coverage on a cell-by-cell basis. During this meeting, ICTAP was taken through the system design from a coverage standpoint. The August and September meetings proved to be beneficial and provided context for the choice of system design. The questions/issues raised in these meetings are compiled in this design report to provide East Bay representatives information to help them make a more informed decision which considers the available tradeoffs as they attempt to create a regional interoperable radio network.

2. Background

The East Bay region began receiving Department of Homeland Security grants as part of the UASI program. The initial UASI area for these efforts was the Oakland area UASI, which includes the City of Oakland, and the Counties of Alameda and Contra Costa, including the cities located within those counties. The East Bay Region UASI Technical Advisory Committee was established as an element of the governance structure for the UASI grant funding.

The East Bay Region UASI Technical Advisory Committee began to look into short, medium, and long term goals for providing regional first responder interoperability. The need for interoperability was due to the large number of disparate radio systems used throughout the region. Table 1 shows the variety of proprietary trunked systems and multi-band conventional systems currently in use.

[1] Motorola, *East Bay Regional Communications System-Two County Design Document*, May 12, 2006.
[2] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007.

Table 1. East Bay Communications Systems and Frequency Bands

City or Agency	Communication System	Frequency
Oakland	M/A-COM EDACS trunked	800 MHz
Richmond	M/A-COM EDACS trunked	800 MHz
Bay Area Rapid Transit (BART)	M/A-COM EDACS trunked	800 MHz
County of Alameda	Motorola SmartNet trunked	800 MHz
Livermore/Pleasanton	Motorola SmartNet trunked	800 MHz
UC Berkeley	Motorola SmartNet trunked	800 MHz
Other Agencies*	Conventional	VHF Low VHF High UHF 800 MHz

* Other Agencies include Contra Costa County and some city and local agencies in Alameda and Contra Costa Counties.

M/A-COM EDACS and Motorola SmartNet are proprietary trunked systems that do not provide interoperable communications between each other, even though they both use the 800 MHz frequency band. The conventional NPSPAC Mutual Aid channels are the primary means for achieving interoperability in this region.

The Committee looked at and implemented several short and medium term solutions and came up with a long term goal of building a standards based regional trunked radio system. The proposed two-county radio system was named the East Bay Regional Communications System.

The East Bay UASI initiated a Request for Proposals (RFP) for a P25 standards based region wide system ultimately won by Motorola. The Motorola proposal is part of the documentation that ICTAP reviewed to develop this report.

The East Bay UASI has begun to implement portions of the P25 system by procuring the Master Site Controller, considered the first phase of the P25 system. The Master Site Controller manages the entire system. Once the Master Site Controller is installed, then individual communication sites and dispatch centers can be tied into the system as they are installed.

To ensure their communication needs were met by this proposed system, Contra Costa County hired an independent consultant (CTA Communications, Inc.) to review the proposal. The CTA *EBRCS Design Evaluation Report* was also reviewed prior to preparing this report. Several issues raised in their report are addressed in this review.

The East Bay UASI has been combined with the San Francisco and Silicon Valley UASIs to form the Bay Area Super Urban Area Security Initiative (SUASI). EBRCS continues to be a priority of the Bay Area SUASI.

3. ICTAP Analysis

3.1 CCC Single Simulcast Cell Option

CTA suggested that East Bay consider covering Contra Costa County with a single simulcast cell rather than the three proposed by Motorola, citing "…improved spectrum efficiency and operational simplicity…" among other reasons.[3]

ICTAP: *Although we generally agree with the advantages that CTA points out regarding a single cell design, there are additional considerations when comparing the tradeoffs between the two options. These tradeoffs are discussed below and summarized in Table 2.*

First, as already addressed by both CTA[4] and Motorola, a single cell option will require more base stations at every site compared to the three (3) cell approach. This raises the overall equipment cost and space requirements. For example, the present CCC three cell design requires a total of 138 base stations. If an approximately equivalent capacity single cell system of 20 channels was implemented, 280 base stations would be required (20 repeaters at each of the 14 sites). Additional RF equipment such as the combiners, multicouplers, and antennas would also increase. EBRCS representatives also noted that several of the selected sites do not have the physical space or tower space for a potential 20 channel system, requiring new buildings or modification of existing buildings.

Second, a multiple cell design provides greater flexibility for system expansion. Motorola's typical design limit is 15 sites per simulcast cell. If a single cell for CCC was used, there would be little room for future expansion of the 14 currently proposed sites for CCC. Also, the addition of more channels to accommodate new users could be added to the appropriate cell rather than having to add channels at all 14 sites. Furthermore, frequency availability has already been an issue for this system design. If required, CCC West frequencies could be reused in CCC East, an option not available with a single cell.

Third, coverage overlap between cells provides added reliability and redundancy should a cell go down. CTA and Motorola also agreed on the issue of system reliability. Motorola states that, "[Three cells] …provide increased reliability if one cell were to go down, the other cells will remain in wide area trunking." CTA states that, "There are some negatives to this (Single Cell) approach – a single point where simulcast control is made could make this design more vulnerable to failure or attack[5]."

Finally, a single cell approach requires precise timing for all sites within CCC. ICTAP notes that this is one place where CTA and Motorola responses differ. Motorola contends that a single large CCC cell would incur large amounts of simulcast delay interference. This is due to a large variance in site separation and site elevations. ICTAP concurs that large variances in site elevation and separation will cause potential for large amounts of delay spread distortion causing non-covered areas. CTA reasons that they have a customer with a Motorola single cell system providing service to over 2500 square miles for over 1 million users and therefore is a

[3] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.6.
[4] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.20.
[5] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.20.

feasible option[6]. There is not any information on the similarity of this customer's topography with that of CCC. A fair comparison of the systems cannot be made without more information.

Based on all of these considerations, ICTAP considers the proposed three (3) cell design to be appropriate for Contra Costa County.

Table 2. Single Cell Tradeoff Summary

Issue	Single Cell	Multi-Cell (Motorola Proposal)
Cost	• More base stations (double) • RF site expansion • Greater RF equipment cost • Less prime site equipment	• Fewer base stations • Less RF site expansion • Lower RF equipment cost • 3 times the prime site equipment
Site and Tower Space Availability	• More equipment required at each site	• Less equipment is needed per site
System Expansion	• Little room for site expansion (15 site limit)	• System can be expanded on a cell by cell basis to accommodate growth
Frequency Availability	• No frequency reuse	• Frequency reuse an option for cells with no overlap, i.e. CCC West and CCC East
Reliability/Redundancy	• Limited redundancy, reliant on hot-standby equipment (if available)	• Overlap in coverage provides added reliability for overall system performance
Timing/Interference	• CCC topography creates a challenge with significant differences in site elevation and spacing • Less potential for adjacent channel interference due to reduced number of frequencies required	• Smaller cells provide greater timing synchronization and less chance of delay spread distortion • More potential for adjacent channel interference due to number of frequencies required
Administration of the System, Operational Considerations	• Less complexity (less flexibility) • Multi-cell rules a non issue	• Must deal with rules and setup for roaming, multi-cell calls, busies, scanning across cells, etc.
Spectral Efficiency	• Less frequencies required • Wide area coverage with a single frequency • Has to use all sites for all transmissions; • Not as efficient for localized communications	• More frequencies • Multiple channels required for each wide area call (one per simulcast cell) • More efficient for localized communications
Flexibility	• Less flexibility (less complexity)	• Greater flexibility (greater complexity)

[6] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.50, Response #10.

3.2 Individual Simulcast Cell Coverage Maps

CTA mentioned[7] that seeing RF coverage maps on a cell-by-cell basis is needed to fully assess the performance of the EBRCS design.

ICTAP: *We agree and have received up-to-date (as of September 2007) individual simulcast cell coverage maps for the EBRCS system. The site names and locations are located in Appendix A. The coverage maps provided by Motorola can be viewed in Appendix B or can be examined in greater detail by opening the following high resolution images.*

Alameda County – East	*Outbound*	*Inbound*	*Alameda County – West*	*Outbound*	*Inbound*
Contra Costa County – Central	*Outbound*	*Inbound*	*Contra Costa County – East*	*Outbound*	*Inbound*
Contra Costa County – West	*Outbound*	*Inbound*	*Crane IR*	*Outbound*	*Inbound*
All Sites	*Outbound*	*Inbound*			

A review of the maps reveals that many of the cells have overlapping coverage. For example, the eastern part of Contra Costa County just north of Highway 4 is in the CCC West cell but also has coverage from the CCC Central and ALCO East simulcast cells and from the Crane Ridge repeater site. Subscriber units that are normally homed in CCC Central or ALCO East, or Crane Ridge could communicate on their home cell even though they are physically located in the CCC East cell. There are many other instances of overlap that can be seen on the coverage maps in Appendix B, for example, the CCC Central cell covers over half the two-county area spilling its coverage into portions of all of the other coverage areas.

Overlap can be viewed as a benefit in certain circumstances. For example, if a subscriber unit is required to leave its normal area occasionally to perform its tasks, it can still communicate with its normal talkgroup using its home cell if still within coverage of the home cell. If the cells were designed with little overlap, as soon as a unit left its home, it would have to register on a non-home cell. Then when it communicated with its normal talkgroup back in the home cell the conversation would be using two frequencies, one in the home cell, and one in the non-home cell. Use of two frequencies for the same conversation is inefficient and could cause congestion on the system if similar scenarios happen often.

A disadvantage of overlap is the potential for cell to cell interference. If a subscriber unit is still transmitting and receiving on its home cell when physically located in another cell it is using frequencies which are not normally used in the roam-to cell. These frequencies could interfere with the normal frequencies used in that cell. One of the criteria for determining whether interference will occur is how close the frequencies are to each other. Due to the lack of 800 MHz frequencies in the Bay Area the EBRCS system is using frequencies that are adjacent to each other (12.5 kHz separation). Adjacent frequency pairs are proposed for use in the same cell and for use in overlapping cells (one frequency of the adjacent pair in each of the overlapping cells). Adjacent frequencies are the most prone to interfering with each other. Dependent on the relative level of the signals that use adjacent frequencies, interference may or may not occur so it is generally a sporadic event. ICTAP recently discussed the potential for interference with Motorola. As an example, Motorola provided an outbound interference analysis for CCC East and ALCO East performed in November 2006. These results show that interference occurred in a small number of locations. ICTAP suggests that East Bay require Motorola to perform an interference analysis including an explanation of the parameters used. This should be done for

[7] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.5.

all overlapping cells containing adjacent channels in the final system design. ICTAP also suggests that East Bay consider replacing the adjacent frequencies with 700 MHz frequencies as soon as they are available.

It should be noted that EBRCS, as the system administrator, can program the system to either allow a talkgroup to roam or not roam. If roaming is allowed it is can be made transparent to the user, that is, the subscriber unit can automatically decide which cell to affiliate with. Motorola (and perhaps other manufacturers) has a feature built into the subscriber radios that provides some control on how a radio decides, when leaving its home area, whether to remain on its home cell or to register on a non-home cell. The feature is activated by programming a cell inside the subscriber unit to one of four settings: Least Preferred, No Preference, Preferred, or Always Preferred. This setting can be defined on a talkgroup basis. If the home cell of a subscriber unit is programmed to Always Preferred, then the unit will remain on the home cell as long as it has sufficient signal to communicate, even when outside of its normal area (i.e. in the overlap area). On the other hand, if the home cell is programmed for No Preference, then it would leave the home cell and register with a non-home cell when the non-home cell has a better quality signal. Registration with a non-home cell would almost always occur when the unit roamed out of its primary area. Thus EBRCS has some control on roaming performance of the subscriber units. For example, if interference between cells is a problem for some subscriber units that frequently roam, the units could be programmed for No Preference. Those programmed for No Preference would not continue to use their home cell frequencies while roaming. Instead they would use the frequencies of the roamed-to cell and not experience or cause interference.

3.3 EBRCS Site Selection and Added Value

Before the 30 August meetings, ICTAP had questions regarding the added value that a handful of sites brought to the overall system. The following describes ICTAP concerns about the sites in question, followed by Motorola's response, which is then followed with ICTAP's conclusion/recommendation in italics.

3.3.1 Stanley Hall and Bald Peak

ICTAP felt that these two sites have very similar coverage areas and may be redundant for the Alameda West cell. The Bald Peak site is also a cell in the Contra Costa County Central cell.

Motorola: "Stanley was selected to provide very strong building penetration into the UC Berkeley campus. Bald [Peak] was selected with a very directional antenna to provide improved coverage along the roads in the canyons and on the ridge (Strawberry Canyon and Skyline). We are in the process of using a new site that was not known during the initial design review (Lawrence Berkeley Lab). This site may replace both Stanley [Hall] and Bald [Peak]."

ICTAP: *We concur that the choice of the Lawrence Berkeley Lab would be a good replacement for the Stanley Hall and Bald Peak sites in the ALCO West cell. The Lab site should continue to provide good penetration of the UC Campus and a larger footprint than the Stanley Hall site. The Bald Peak site will continue to provide coverage of the canyons on the ridge through the CCC Central cell.*

3.3.2 San Leandro Hills and Rocky Ridge

ICTAP felt these two sites have very similar coverage areas within the ALCO West operational area and may be redundant for the ALCO West cell.

Motorola: "Rocky [Ridge] was selected to provide improved coverage along the canyons and ridge. It has a very directional antenna."

ICTAP: *In the present design, Rocky Ridge houses both ALCO West and CCC Central equipment. We recommend considering the cost to value of the Rocky Ridge site in the ALCO West cell. Any Alameda asset that travels along the canyons and ridge in the Rocky Ridge coverage area could easily communicate via the CCC Central cell. If all Alameda assets traveling in the Rocky Ridge coverage area used the CCC Central cell, a reduction of 19 base stations could be achieved at the Rocky Ridge site.*

3.3.3 Sunol Ridge and Sunol CDF

ICTAP Question: Does Sunol CDF provide coverage to the ALCO West cell?

Motorola: "Sunol CDF site is there to provide improved coverage into Niles Canyon Road. Motorola originally selected the CDF site on the [ALCO] West cell in an attempt to penetrate Niles canyon Road both from the East and the West to improve coverage. The cell that Sunol CDF is in could very well be used on the East cell based on the fact that the RF coverage from either side of the canyon does not overlap. Additionally, the CDF site provides some coverage along 680, which is in the East cell."

ICTAP Question: Are the coverage areas too similar to warrant the development of the CDF site?

Motorola: "This is a decision that EBRCS has to make."

ICTAP: *Through follow on discussions with Motorola, ICTAP learned that the Sunol CDF site has been replaced with a different site.*

3.3.4 Three Sites (Bald Peak, Rocky Ridge, Sunol/Sunol CDF) Used in Multiple Cells

ICTAP Question: What are the reasons three sites (Bald Peak, Rocky Ridge, Sunol/Sunol CDF) are used in multiple cells? We would like to discuss the reasoning and the trade offs.

Motorola: "Sunol CDF is only used in one cell. Bald and Rocky both have sites in the ALCO West cell and the Contra Costa County Central cell. There are two reasons for this design:

1. To enhance roaming within the system. The ridge that Bald and Rocky sit[s on] offers a good geographical line to distinguish between Alameda cells and Contra Costa County cells. By using directional antennas at this site, we can offer coverage without a lot of overlap between simulcast cells, thereby enhancing the roaming capabilities of the subscriber units.
2. To reduce potential frequency interference within the system. The allocated frequencies after repacking is complete provide 20 frequencies for Contra Costa County. Each of these frequencies is adjacent to an Alameda County frequency, so we have to distribute these frequencies appropriately to eliminate interference within the system between Alameda County and Contra Costa County."

ICTAP: *In the current design, the Lawrence Berkley Lab is used to replace the need for Bald in the ALCO West cell, which would eliminate this concern. The current design also removes Sunol CDF. See Section 3.3.2 above regarding our concerns for the value of the Rocky Ridge site.*

3.3.5 Walpert Ridge

ICTAP Comment: Walpert Ridge is in the ALCO East cell, however this site seems to provide better coverage into the ALCO West cell. The Walpert Ridge site is a site that is used on the existing Alameda County simulcast system.

Motorola: "The Walpert Ridge site is using a directional antenna to provide coverage along Palomares Road and 580. The P25 system recommends a site within the City of Hayward, Hayward Water Tank (aka Garin Water Tank), that provides improved coverage into the [ALCO] West cell over the existing Walpert Ridge configuration. Walpert Ridge is on the border of being an [ALCO] East cell site vs. an [ALCO] West cell site."

ICTAP: *We agree that the Walpert Ridge site did not provide adequate penetration in the existing system and there would be more value to the coverage of the ALCO West cell if a site with better penetration into the City of Hayward is utilized. In the latest design, Walpert Ridge has been moved into the ALCO West cell and the Garin Water Tank is used for coverage into the City of Hayward.*

3.3.6 Warm Springs Site

ICTAP Question: What is the value of the Warm Springs site?

Motorola: "The Warm Springs site is an RX [receive] only site on the existing configuration. This is an area that the Fremont subscribers on the existing system complained about having insufficient coverage. It is necessary to enhance the coverage in the southwestern area of the county, specifically the southern portion of Fremont. This site does have space problems on both the tower and in the equipment room."

ICTAP: *ICTAP concurs with the value of this site as a receive only location.*

3.3.7 RF Coverage for the City of San Ramon

ICTAP Comment: There is concern about the city of San Ramon and adjacent areas being directly between two cells, CCC Central and CCC East. The concern is that any small local incident in San Ramon will require activation of radios on both cells.

Motorola: "The City of San Ramon is a problem; we have been looking at ways to eliminate the two cells covering the area. We have looked at moving or removing the Highland site and hopefully finding a site that is lower that will provide better penetration into San Ramon and not interfere with the CCC East cell.**"**

ICTAP: *With the latest design using directional antennas, ICTAP feels that the issue has been appropriately addressed from the perspective of the City of San Ramon. However, ICTAP still has concerns with the value of Highland as a site in the CCC Central simulcast cell.*

3.3.8 Highland Site Separation (CCC Central)

ICTAP Comment: There is concern that the large site separation (14.6 mi) between Highland and either the Rocky Ridge or Sidney Drive sites will result in delay spread issues in the area

between these three sites. This topic has not been formally brought up to Motorola as this is a result of a recent change in site selection.

3.3.9 Southeast Alameda County Area Coverage

ICTAP Comment: Upon inspection of the portable coverage for the EBRCS system, ICTAP would like to make note of the coverage holes located in the southeastern corner of Alameda County. From our understanding, the Crane Ridge site was placed to provide some coverage to a couple of local roads in the area, and it seems to cover more area north of the site than south. ICTAP is aware that this is a low population area and would just like to make sure the East Bay doesn't have a need for coverage in the area south of Crane Ridge along the county border.

3.4 700/800 MHz Capable Infrastructure

CTA brought up the idea of using both 700 and 800 MHz frequencies.[8] ICTAP asked Motorola to provide a response regarding the proposed system's 700 and 800 MHz capabilities.

Motorola: "The system is capable of supporting 700 MHz/800 MHz channels. The base stations are capable of operating either 700 MHz or 800 MHz, and these two frequency bands can be combined into one cell. One issue is that the antennas and antenna systems are not capable of operating 700/800 [MHz] today, especially the directional antennas (there are some omnidirectional antennas that are 700/800 [MHz] capable that have just been released). The combining and multicoupler equipment is unknown at this time if it can do both. 700 MHz radios may require an additional antenna network."

3.5 Project 25 Standards and Status

East Bay representatives requested clarification on the current status of P25 standards and manufacturer equipment availability.

ICTAP Response:

As of February 2008, several new interfaces have been standardized by the Telecommunications Industry Association (TIA). The interface standards most relevant to the East Bay Regional Communications System Authority are the Inter RF Sub-system Interface (ISSI), Trunked Console Sub-system Interface (CSSI), and the Fixed Station Interface (FSI). Each of these interface standards is discussed below.

3.5.1 P25 Inter RF Sub-system Interface

The ISSI provides the messaging structure between multiple trunked systems, which will allow them to be connected into wide area networks. A standardized ISSI will allow users to communicate between multiple LMR systems without the use of traditional gateways, so long as each Radio Frequency Sub-System (RFSS) supports the ISSI specification. In the Bay Area the entire EBRCS system (all 5 simulcast cells plus the Crane Ridge site) could be designated as one RFSS. It could be interfaced to another P25 system using one ISSI connection to allow EBRCS personnel to communicate with personnel outside of their system. For example, a unit in the ALCO East cell could communicate with a unit in a P25 system in San Francisco when San Francisco installs a P25 system. Likewise an EBRCS unit could roam to San Francisco and

[8] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.6.

communicate with its talkgroup back in CCC West by transmitting to a future San Francisco 800 MHz RF site which would then relay the communications over the ISSI to the EBRCS CCC West cell. The ISSI is not needed to communicate within the EBRCS, either within a cell or between cells. For example, the ISSI is not needed for a unit that has roamed to ALCO West to talk to its talk group in CCC East. These connections that are internal to the EBRCS system are performed by Motorola's internal networking. Since presently there are no other systems in the area with an ISSI connection, EBRCS could forego the purchase of an ISSI at this time. However, EBRCS should discuss with Motorola the path to implement an ISSI in the future when other ISSI capable systems are constructed. These discussions should include the cost to install an ISSI now versus later. If the decision is to install later, then East Bay should determine if there are any enhancements that should be purchased initially to make the transition to an ISSI less disruptive or less costly in the future.

3.5.2 P25 Conventional Fixed Station Interface

The Fixed Station Interface, as published, specifies the connection of conventional (not trunked) base stations to a system using a standard interface. For example, an ICALL or ITAC or a VHF base station could be connected to the system using the FSI so that it is accessible by both dispatchers and users in the field. The FSI is defined for both analog and P25 (digital) base stations. The analog interface is identical to analog interfaces that have been used for years by the LMR industry. Therefore, the analog part of the standard is not new but now the interface is standardized and defined by a document. The interface to conventional P25 base stations is new. At present, there aren't any conventional P25 systems in the Bay Area that we are aware of, so there shouldn't be a need for a digital FSI at this time. However, in the near future, the 700 MHz band will be put to use. The FCC requires agencies that implement 700 MHz provide base stations tuned to the interoperability channels in the 700 MHz band. The FCC has mandated the use of P25 on these 700 MHz interoperability base stations. An interface between EBRCS and conventional P25 base stations could be required in the future. Again we suggest that East Bay discuss with Motorola the method by which the EBRCS can be upgraded to support the standardized FSI. By use of the FSI the EBRCS could purchase base stations from any manufacturer that supports the FSI. All of the base station manufactures are expected to support the FSI.

3.5.3 P25 Trunked Console Sub-system Interface

The trunked CSSI allows consoles from non-Motorola manufacturers to be connected into the system. Having this interface would give East Bay some flexibility in choosing consoles in the future. It should be noted that the trunked CSSI is based upon and defined as an addendum to the ISSI standard. Therefore, the deployment of this interface may also require an ISSI capable system. The trunked CSSI may not offer the same feature set available with a particular manufacturer’s console.

3.5.4 P25 Subscriber Units

In addition to the interfaces discussed above, there are several manufacturers who offer P25 trunked subscriber (portable and vehicular) radios that can be used on the EBRCS. These radios have been used on various systems around the country. There have been some problems with interfacing manufacturer A's P25 subscriber radios to manufacturer B's P25 system. These

problems are being resolved by mutual cooperation of the manufacturers and will be more formally addressed by multiple compliance assessment working groups[9]. The loopholes in the P25 standards documents that allowed these problems to occur have been, or are in the process of being, closed by modification of the documents.

There are multiple features that radio manufacturers can offer in their P25 radios. A lack of commonality of these features can have a negative impact on interoperability. For more information regarding standardized P25 features refer to the ICTAP P25 Features Matrix located on the PTIG website: www.project25.org.

When another P25 system is constructed in the Bay Area and the ISSI is used to connect the systems, some subscriber units may have to be upgraded to allow a subscriber unit to roam into another system and communicate using that system. The upgrade is necessary to implement recent changes to the P25 standard to allow for system to system roaming. East Bay should consult with the equipment manufacturer to identify the subscriber units that will have to be upgraded.

3.6 Modifications to the Coverage Acceptance Test Plan

CTA recommends that the Coverage Acceptance Test Plan (CATP) be modified to better serve the interests of the East Bay.[10]

ICTAP agrees with CTA's recommendation and notes that this is another example of a tradeoff between performance and cost. In general LMR RF coverage predictions are fairly accurate but not foolproof. Therefore, the performance of any new system should be verified by a robust CATP. ICTAP notes that EBRCS representatives may want to focus their efforts in ensuring the definition and proper execution of the CATP will provide confidence that the proposed coverage is realized. Contractual consideration also needs to be made regarding who will be responsible if the actual system coverage does not meet the predicted coverage. ICTAP has the following comments regarding the CATP, based upon industry standard test plans as specified in the TSB-88-B published by TIA/EIA:

1. The acceptable coverage area reliability is specified to be 95% in the CATP section of the proposal. East Bay should be aware that this is 95% of the area that Motorola has designed the system to cover. It is less than 95% of the area within the jurisdictional boundary since some of the jurisdictional area is not predicted to be covered by the system design.
2. The CATP tests coverage for a person on the street wearing a portable radio on their belt. It does not test in-building coverage. Normally a jurisdiction will specify certain buildings to be tested for coverage in addition to on-street coverage.
3. The CATP specifies a reliability of 95% for the entire area. East Bay may want to discuss with Motorola the cost to specify that smaller areas (e.g. each simulcast cell) are guaranteed to meet the 95% reliability. Absent this, certain areas (cells) could have

[9] The TIA TR8.25 subcommittee and the Compliance Assessment Process and Procedures Task Group (CAPPTG) and the P25 Compliance Assessment Program.
[10] CTA Communications Consultants, *EBRCS Design Evaluation Report*, April 19, 2007, p.5.

significantly less than 95% reliability and others could have higher than 95% to arrive at an overall 95% reliability.

4. The CATP is a statistical sample. Therefore the actual reliability can only be known from this test within a certain margin and with a certain confidence level. TSB-88-B states that the confidence level should be specified to be approximately 99% and that the margin should be 2%. In other words, the test should be designed such that East Bay will be 99% confident that the radio system is performing acceptably in 93% to 97% of the covered area. By specifying the confidence level and the margin above and below 95% East Bay will be, in effect, specifying the minimum number of tiles to be tested in the area under test. The proposal states in one place (B.5.2.1) that Motorola and EBRCS will jointly determine the number of tiles and in another place (B.5.2.4) that Motorola will determine the number. The number of tiles affects both the cost and the validity of the test and it should be determined prior to contract.
5. The CATP specifies a bit error rate (BER) of 2.62%. This BER corresponds to a digital audio quality (DAQ) of 3.0. TSB-88-B states that public safety systems should be designed for a minimum DAQ of 3.4 which corresponds to a maximum BER of 2%.
6. Section B.5.2.5 allows a failed tile to be retested and, if it passes the second time, to be recorded as a success without recording the failure. This is contrary to TSB-88-B and the premise of the estimate of proportions equation which provides the statistical theory for this test. All failures should be recorded.
7. The proposed CATP tests only the base to portable communication path. The East Bay should discuss with Motorola that some portable to base testing be performed. This is especially important in a simulcast system since the characteristics of the two paths differ considerably. At the very least, base to portable testing must be performed in the vicinity of receive only sites, such as Warm Springs, to ensure that those sites are functioning properly.

At the 30 August discussions, Motorola indicated that they are willing to negotiate modifications to the CATP.

4. Conclusion

First and foremost it should be noted that the East Bay Regional Communications System Authority, CTA Communications Inc., and ICTAP consider acquisition of a P25 system for the EBRCS an appropriate direction to pursue. The plan to build out the system using the available 800 MHz channels with infrastructure that can support the 700 MHz channels when they become available improves regional communications interoperability while laying a foundation that can support future growth.

With the RF communication limitations (for example, terrain, building attenuation, limited spectrum, and neighbor agency interference) and associated costs, there is no such thing as a perfect communications system. It is a series of tradeoffs with an attempt to optimize the available system. This is where ICTAP believes work remains to be finalized in the EBRCS system design.

The first step to moving this effort along is to finalize agreement on the basic structure of the system. Motorola's proposal uses a five (5) cell design with three (3) cells in Contra Costa County and two (2) cells in Alameda County. The CTA Communications, Inc. report recommends looking into the possibility of using a single cell for Contra Costa County. As discussed throughout the report, there are pros and cons to either approach. There are two key concerns with the single cell approach for Contra Costa County. The first is that the number of sites required (14 as proposed) leaves very little growth potential. The second is the larger number of base stations, RF equipment, and potential building modifications required at each radio site. After careful consideration of the available information, ICTAP believes a multiple cell approach will meet the needs of the region served by EBRCS. The natural terrain of the area fairly well defines the five cells.

Once a general system architecture has been finalized, the next issue to address is agreement on site selection. ICTAP has addressed some of this in Section 3 of this report, discussing site selection and tradeoffs. These efforts should be discussed and finalized with local participation. The East Bay Regional Communications System Authority, local agencies, and potentially their consultants, need to get together with the manufacturer and complete this effort. Failure to do so in a timely manner could be very costly to the project. ICTAP understands that some of the RF sites are either already installed or in the process of being installed. The good news is that the current work is in the Alameda County area where the 800 MHz coverage concerns are lessened by the known capabilities of the existing system.

As the East Bay continues to finalize site selection, ICTAP recommends making every effort to minimize the reliance on high level sites. The reliance on these high level sites creates dominant sites that may cross into adjacent cells. ICTAP understands that the existing terrain, especially in the Contra Costa County Central cell, may make this unavoidable. Another issue to keep in mind is that combining high level sites with low level sites in the same cell may produce unwanted distortion.

The East Bay could potentially save money by consolidating funding into specific project phases. For example, use one year of funding to procure as much equipment as possible, deferring the installation. The next year's funds could then be used to fund the installation. This approach could help avoid costs associated with ramp up/down and save money in the long run.

ICTAP recommends East Bay ensure all infrastructure that is installed during these efforts has an expansion path to 700 MHz. That includes the RF base station equipment plus antennas and couplers. Any new subscriber units that are procured should be 700/800 MHz compatible.

The current state of the P25 standards and TIA efforts to standardize the ISSI, FSI, and CSSI interfaces promises a greater potential to implement interoperable systems with multiple manufacturers. The East Bay Regional Communications System Authority should stay aware of the latest capabilities and the status of the ISSI, FSI, and CSSI interfaces. The capabilities these interfaces can bring to a P25 system could help the SUASI expand the EBRCS into an interoperable communications system capable of providing multi-manufacturer communications interoperability throughout the entire Bay Area region.

To meet the expectations of potential future EBRCS users, ICTAP recommends that a robust CATP be put in place. A high level of confidence in the performance of the new system will encourage outside users to join the EBRCS. It should be clear in the contract between East Bay and Motorola who is responsible for modifications to the system in the event it does not perform as proposed. This protects both the East Bay and Motorola.

EBRCS can only ensure complete and total communications interoperability for agencies in Contra Costa County and Alameda County by obtaining comprehensive (total) buy-in. ICTAP recommends all regional agencies and jurisdictions seriously consider joining the EBRCS. While financial considerations may hinder migration of some users to the EBRCS, their future plans should support migration to the system. Likewise, the East Bay Regional Communications System Authority and the Bay Area Super Urban Area Security Initiative should identify and implement funding policies and strategies that would support rapid agency migration to the EBRCS.

Appendix A EBRCS Site Information

Table A - 1. Site Information

Simulcast Cell	Site Name	Latitude	Longitude	Tx Antenna Ht	Rx Antenna Ht
ALCO West	Alameda Power and Telecom	37.77644	-122.252	90	100
ALCO West	Fremont PD	37.55028	-121.968	50	70
ALCO West	Garin WT	37.63167	-122.031	50	70
ALCO West	SL Hills	37.72397	-122.12	50	50
ALCO West	Warm Springs (Rx Only)	37.48483	-121.926	50	70
ALCO West	Coyote Hills	37.54056	-122.081	70	50
ALCO West	Glenn Dyer	37.8	-122.277	120	120
ALCO West	Rocky	37.81583	-122.062	40	50
ALCO West	Berkeley Labs	37.87558	-122.246	75	140
ALCO West	Skyline res	37.82031	-122.185	70	80
ALCO West	Walpert ridge	37.65536	-122.003	70	70
ALCO East	Sunol Ridge	37.61978	-121.923	70	90
ALCO East	Greenville	37.67436	-121.697	85	100
ALCO East	Doolan	37.71069	-121.818	40	40
ALCO East	Brittany	37.71264	-121.954	60	100
ALCO East	Att Altamont	37.7125	-121.662	30	50
CCC West	10900 San Pablo	37.91631	-122.311	50	70
CCC West	Pearl Reservoir	37.95756	-122.312	50	70
CCC West	Turquoise	37.99306	-122.27	30	50
CCC West	Nichol Knob	37.92028	-122.382	30	50
CCC Central	40 Glacier	37.98964	-122.089	100	120
CCC Central	Bald Pk	37.88356	-122.222	80	100
CCC Central	Cummings Peak	38.02911	-122.198	50	70
CCC Central	Rocky	37.81595	-122.062	50	70
CCC Central	Sidney Drive	37.86731	-122.052	50	70
CCC Central	651 Pine	38.01903	-122.134	50	70
CCC Central	Highland	37.81478	-121.809	50	70
CCC Central	Cummings 2nd antenna	38.02911	-122.198	50	70
CCC East	Highland Pk	37.81477778	-121.809	30	50
CCC East	Kregor Pk	37.94297222	-121.891	50	70
CCC East	Shadybrook	38.00327778	-121.949	10	10
CCC East	Antioch PD	37.98894444	-121.806	50	70
IR Site	Crane Ridge	37.60656	-121.621	45	60

Appendix B Motorola EBRCS Cell by Cell Coverage Maps

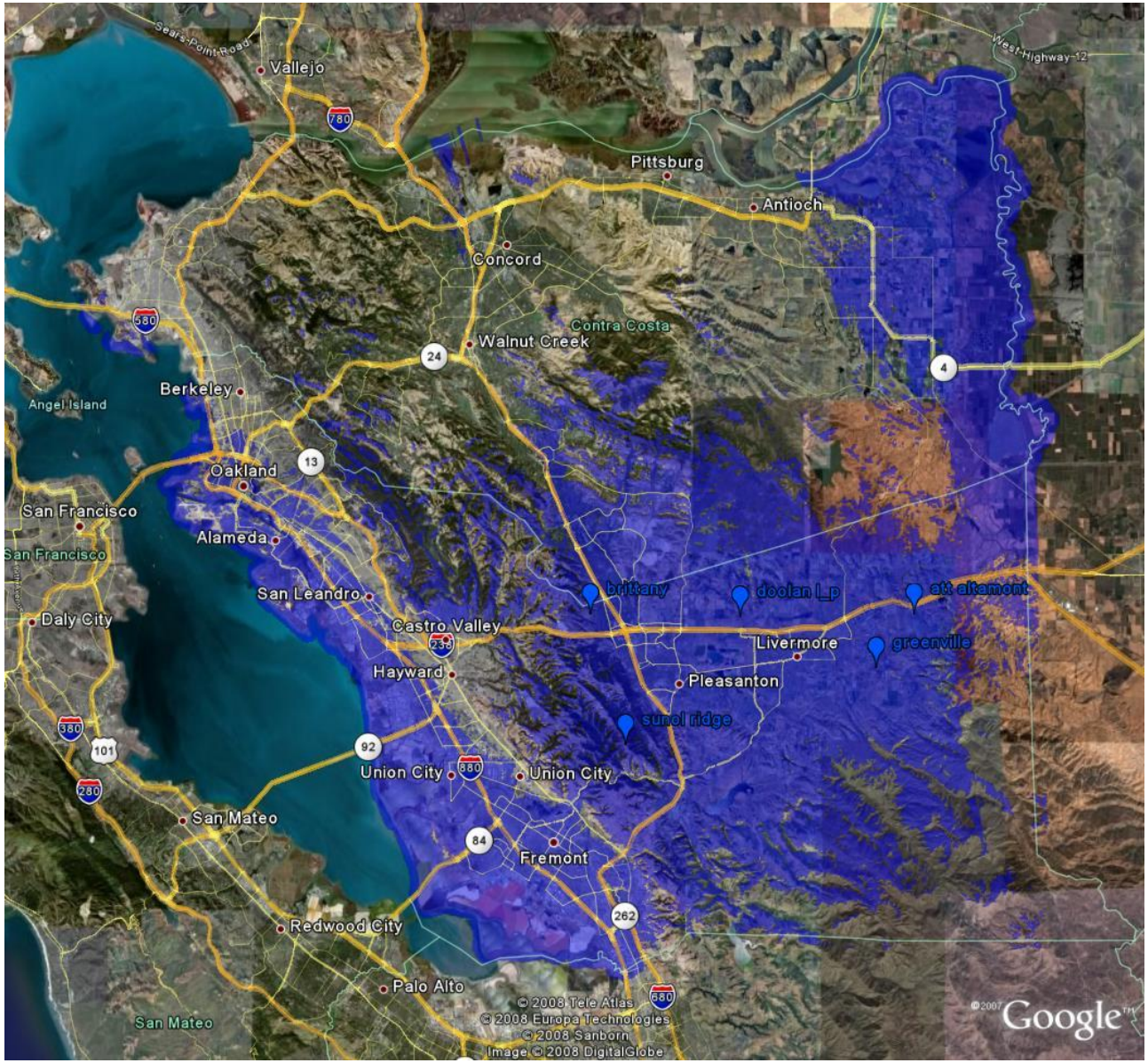

Figure B - 1 Alameda County - East

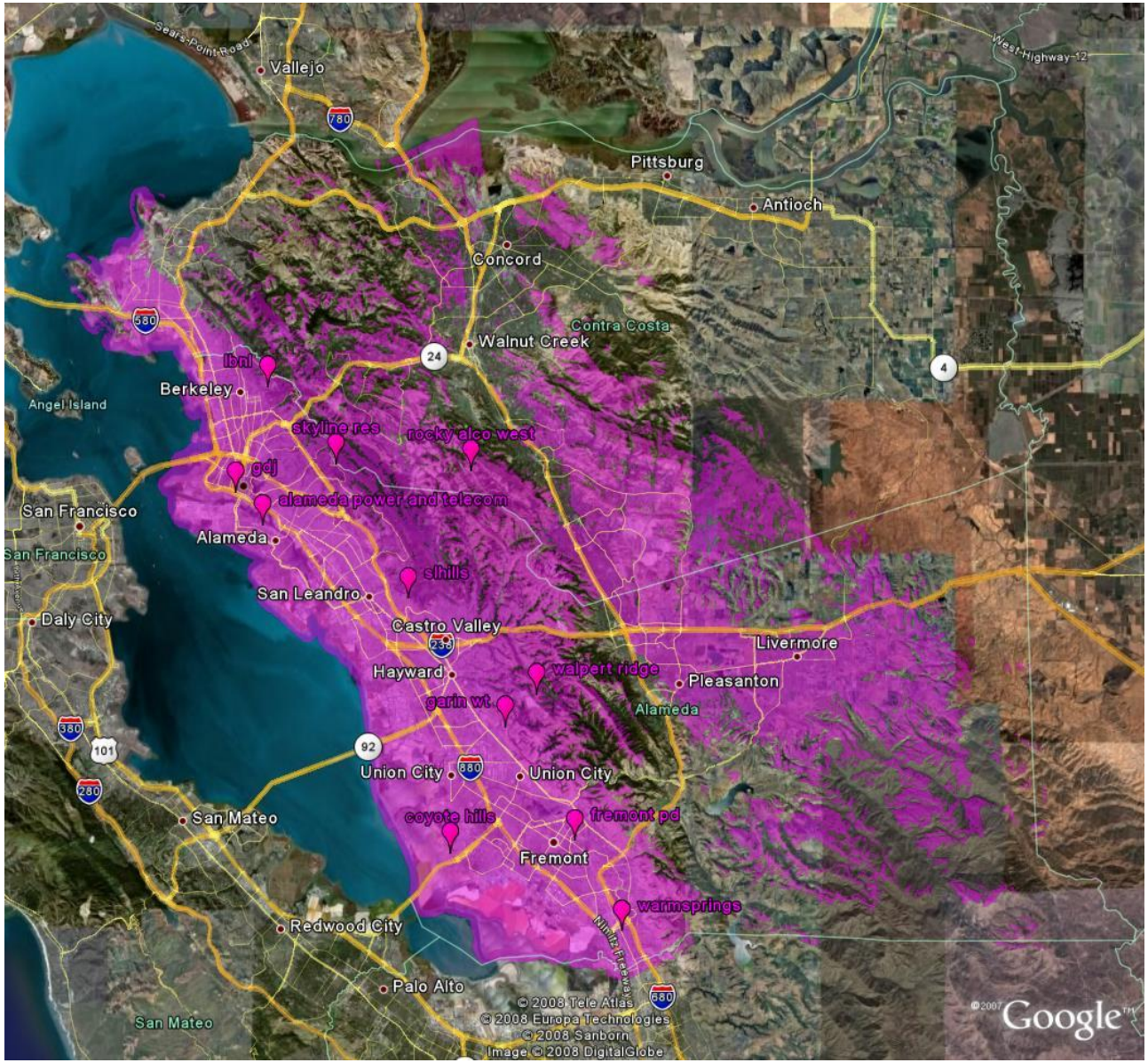

Figure B - 2. Alameda County - West

Figure B - 3. Contra Costa County Central

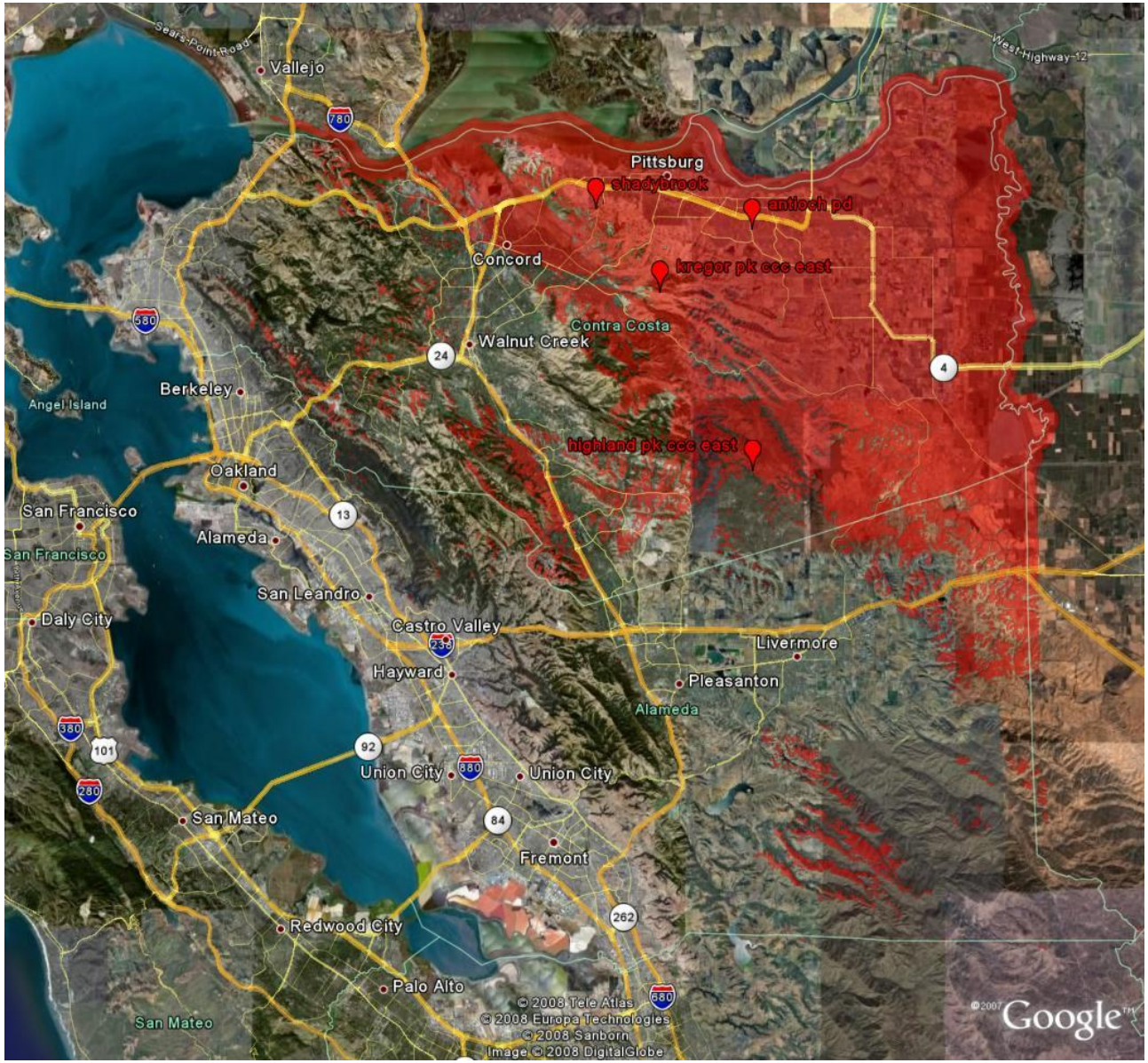

Figure B - 4. Contra Costa County East

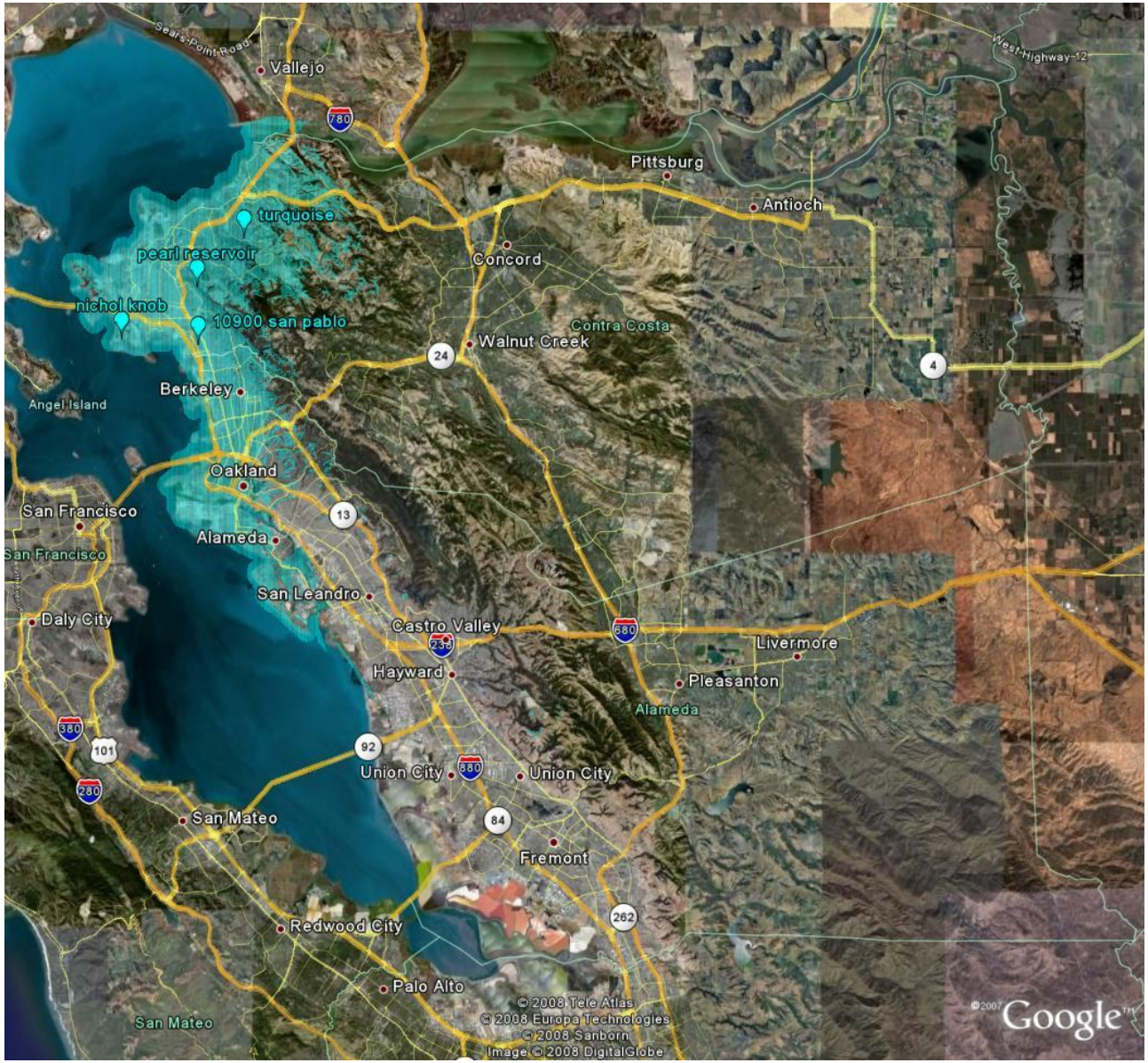

Figure B - 5. Contra Costa County West

Figure B - 6. Crane IR

Appendix C Glossary

Item/Acronym	Definition
ALCO	Alameda County
BER	Bit error rate
CATP	Coverage Acceptance Test Plan
CCC	Contra Costa County
CDF	California Department of Forestry and Fire Protection
CSSI	Trunked Console Sub-system Interface
DAQ	Digital audio quality
DHS	Department of Homeland Security
EBRCS	East Bay Regional Communications System
EIA	Electronic Industries Alliance
FSI	Fixed Station Interface
Hydra	Motorola RF Coverage tool
ICALL	International calling channel
ICTAP	Interoperable Communications Technical Assistance Program
ISSI	Inter RF Sub System Interface
ITAC	International tactical channel
LMR	Land mobile radio
NPSPAC	National Public Safety Planning Advisory Committee
NTIA	National Telecommunications and Information Administration
OEC	Office of Emergency Communications
P25	Project 25
PSIC	Public Safety Interoperability Communications
RF	Radio frequency
RFP	Request for Proposals
RFSS	Radio Frequency Sub-System
Rx	Receive
SUASI	Super Urban Area Security Initiative
TIA	Telecommunications Industry Association
Tx	Transmit
UASI	Urban Area Security Initiative